TOWARD A HOUSTON PROTOCOL CO_2 EMISSION REDUCTIONS BETWEEN NORTH AND SOUTH

Professor Udo Simonis
Science Center of Berlin
Germany

> *"The major problems in the world today are the result of the difference between the way nature works and the way man thinks."*
> Gregory Bateson

1. Preliminary Assessment

In the future, economists and development planners, diplomats and politi- cians will not only have to deal with growth and development processes, but will have to pay increasingly more attention to the reduction and redistribution processes. This is particularly true with regard to the most important global environmental problem so far, climate change. So far, this problem has been mainly caused by the industrial countries. The developing countries might, however, follow suit if they keep to the "standard development path." Ecologically, it will be the developing countries which will suffer most from the effects of climate change. Economically, cost sharing will depend on the kind of preventive or adaptive measures taken, on institutional arrangements made, and on the wisdom of global environmental diplomacy. Some of these measures, arrangements and diplomacies will be dealt with in this paper.

2. The 'Greenhouse Index'

In analyzing global climate change and in formulating a corresponding policy (global climate policy), three categories of emissions are important: absolute emissions, per capita emissions, and emissions per unit of gross domestic product.

Table 1 shows a "greenhouse index", compiled for the first time. It is an unweighted component index, based on the national emissions of carbon dioxide, methane and chlorofluorocarbons (absolute emissions). Table 2 shows the corresponding greenhouse index on the basis of emissions per capita (per capita emissions). Figure 1 shows the greenhouse emissions per unit of gross domestic product for three groups of countries (emissions per unit of GDP).

From this (and still weak) basic statistical data it already becomes clear what a formidable task the reduction of, or adaptation to, climate change will present to the world in general, and to industrial and developing countries, respectively. Negotiations are presently under way, concrete results, however, are still lacking. These negotiations center around a new distribution problem, the solution of which is extremely difficult; some points of orientation have emerged, but a final solution is not yet in sight.

Ideally, all greenhouse gases should be comprised by an international agreement on their reduction (climate convention and respective protocols). This, however, is quite unrealistic. Technical, economic, social and political aspects of emission reductions for individual gases differ quite largely. While the industrial countries are responsible for approx. 80 percent of the global CO_2 emissions (among them the USA, with their rather inefficient energy system), the developing countries are highly responsible for methane emissions (from rice fields, cattle ranching). While for some of the greenhouse gases it is easily possible to control (capture) emissions, for others this can only be achieved through adjustments of products and technologies. While for some gases a quick and complete phasing out (e.g., CFCs) seems necessary and possible, for others (e.g., methane, nitrogen oxide) a reduction is conceivable only as a slow step-by-step process.

Accordingly, in drafts for a framework convention on global warming (climate convention) the problems involved are being described, the necessary actions are to be acknowledged, and further research and monitoring programs are to be initiated. Such a convention will have to be implemented by several protocols, specifying targets and measures for the reduction of the respective greenhouse gas emissions (CO_2, CH4, N2O), the protection of the tropical rain forests, the introduction of renewable energy, etc. It is then that the real work on details will begin, including the struggle for the distribution of costs and benefits, on finance and technology transfer, and on the employment of suitable economic and regulative instruments.

3. Global Environmental Policy:-Experiences so Far

What can a discussion on a global climate convention, and the corresponding protocols, build on? What experiences have been made with regard to agreements on environmental protection involving both industrial and developing countries?

Table 1:*The Greenhouse Index: 30 countries with the highest greenhouse gas net emissions (source: World Resources, 1990-91, p.15)*

(Carbon dioxide heating equivalents 000 metric tions of carbon)

Country	Greenhouse Index rank	Greenhouse gases Carbon dioxide	Methane	CFCs	Total	Percent of total
United States	1	540,000	130,000	350,000	1,000,000	17.6
U. S. S. R.	2	450,000	60,000	180,000	690,000	12 0
Brazil	3	560,000	28,000	16,000	610,000	10.5
China	4	260,000	90,000	32,000	380,000	6.6
India	5	130,000	98,000	700	230,000	3.9
Japan	6	110,000	12,000	100,000	220,000	3.9
Germany, Fed. Rep.	7	79,000	8,000	75,000	160,000	2.8
United Kingdom	8	69 000	14,000	71,000	150,000	2.7
Indonesia	9	110,000	19,000	9,500	140,000	2.4
France	10	41,000	13,000	69,000	120,000	2.1
Italy	11	45,000	5,800	71,000	120,000	2.1
Canada	12	48,000	33,000	36,000	120,000	2.0
Mexico	13	45,000	20,000	9,100	78,000	1.4
Myanmar	14	68,000	9,000	0	77,000	1.3
Poland	15	56,000	7,400	13,000	76,000	1.3
Spain	16	21,000	4,200	46,000	73,000	1.3
Colombia	17	60,000	4,100	5,200	69,000	1.2
Thailand	18	46,000	16,000	5,500	67,000	1.2
Australia	19	28,000	14,000	21,000	63,000	1.1
German Dem. Rep	20	39,000	2,100	20,000	62,000	1.1
Nigeria	21	32,000	3,100	18,000	53,000	0.9
South Africa	22	34,000	7,800	5,800	47,000	0.8
Ivory Coast	23	44,000	550	2,000	47,000	0.8
Netherlands	24	16,000	6,900	18,000	43,000	0.7
Saudi Arabia	25	20,000	15,000	6,600	42,000	0.7
Philippines	26	34,000	6,700	0	40,000	0.7
Laos	27	37 000	1,000	0	38,000	0 7
Vietnam	28	28 000	10,000	0	38,000	0 7
Czechoslovakia	29	29,000	2,200	2 700	33,000	0.6
Iran	30	17,000	6,400	9,000	33,000	0.6

The number of effective international agreements on environmental protection comprising more than a certain region (like, for example, river basins) and more than individual projects (like debt-for-nature swaps or the tropical forest action plan), and having been signed both by industrial and developing countries, i.e., agreements whose structure is relevant with regard to a climate convention, is rather limited. Volkmar Hartje who has worked on this question names only four of them (Hartje, 1989): the London Dumping Convention (1972), the Convention for the Prevention of Sea Pollution by Ships (1973, and 1978), the UN Conference on the Law of the Sea (1973-1982), the Vienna Convention (1985) and the respective Montreal Protocol on the Protection of the Ozone Layer (1987).

Table 2: Per capita Greenhouse Index: the 30 countries with the highest per capita greenhouse gas net emissions, 1987 (Source: World Resources, 1990-91, p.17)

Country	Rank	Tons per capita
Laos	1	10.0
Qatar	2	8.8
United Arab Emirates	3	5.8
Bahrain	4	4.9
Canada	5	4.5
Brazil	6	4.3
Luxembourg	7	4.3
United States	8	4.2
Ivory Coast	9	4.2
Kuwait	10	4.1
Australia	11	3.9
German Dem. Rep.	12	3.7
Oman	13	3.5
Saudi Arabia	14	3.3
New Zealand	15	3.2
Netherlands	16	2.9
Denmark	17	2.8
Costa Rica	18	2.8
Germany, Fed. Rep.	19	2.7
United Kingdom	20	2.7
Singapore	21	2.7
Finland	22	2.6
U. S. S. R.	23	2.5
Ireland	24	2.5
Belgium	25	2.5
Switzerland	26	2.4
Nicaragua	27	2.4
Colombia	28	2.3
Trinidad and Tobago	29	2.3
France	30	2.2

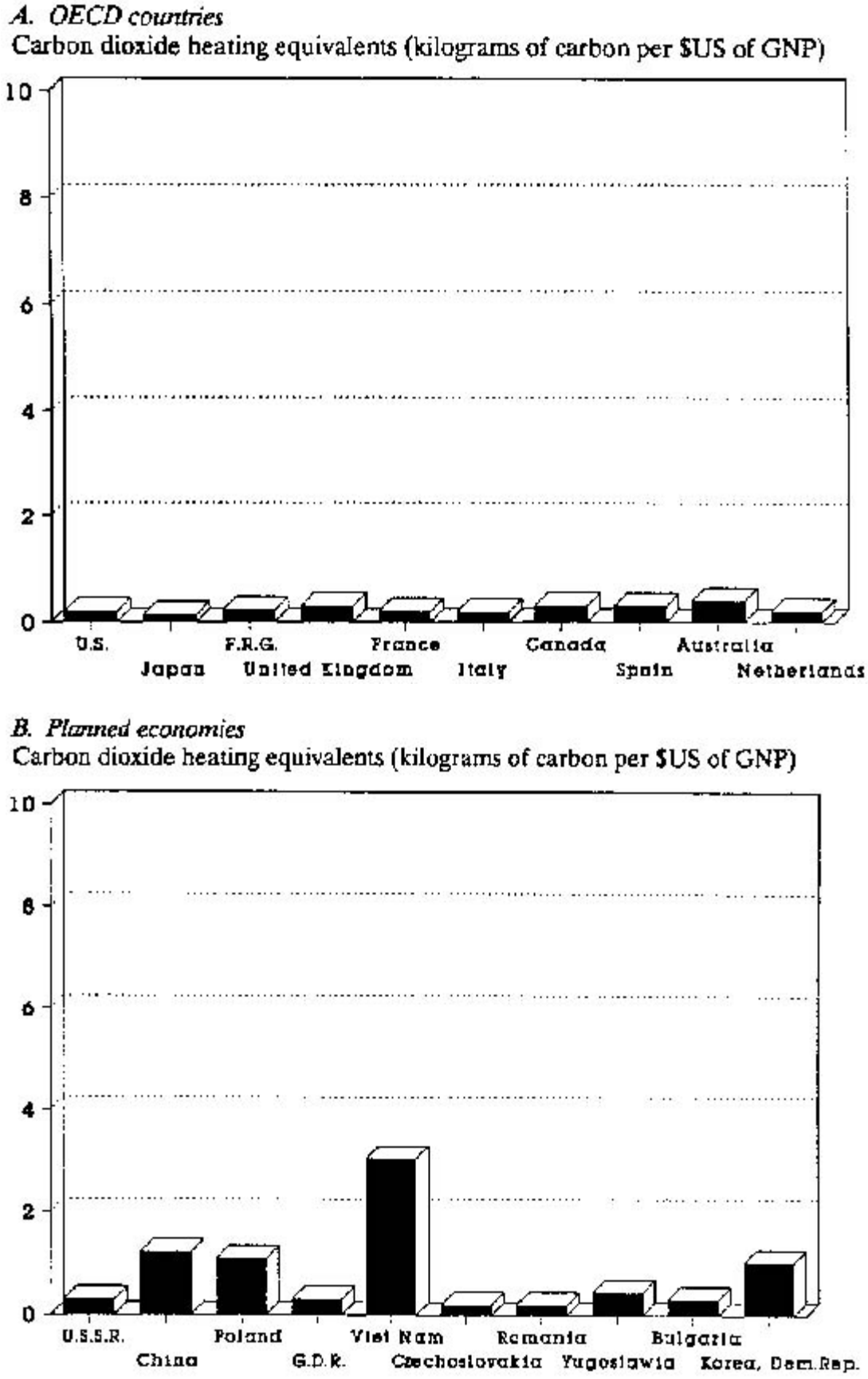

Figure 1: Net greenhouse gas emissions per U.S. Dollar of Cross National Product, 1987 (Source: World Resources, 1990-91, p.19

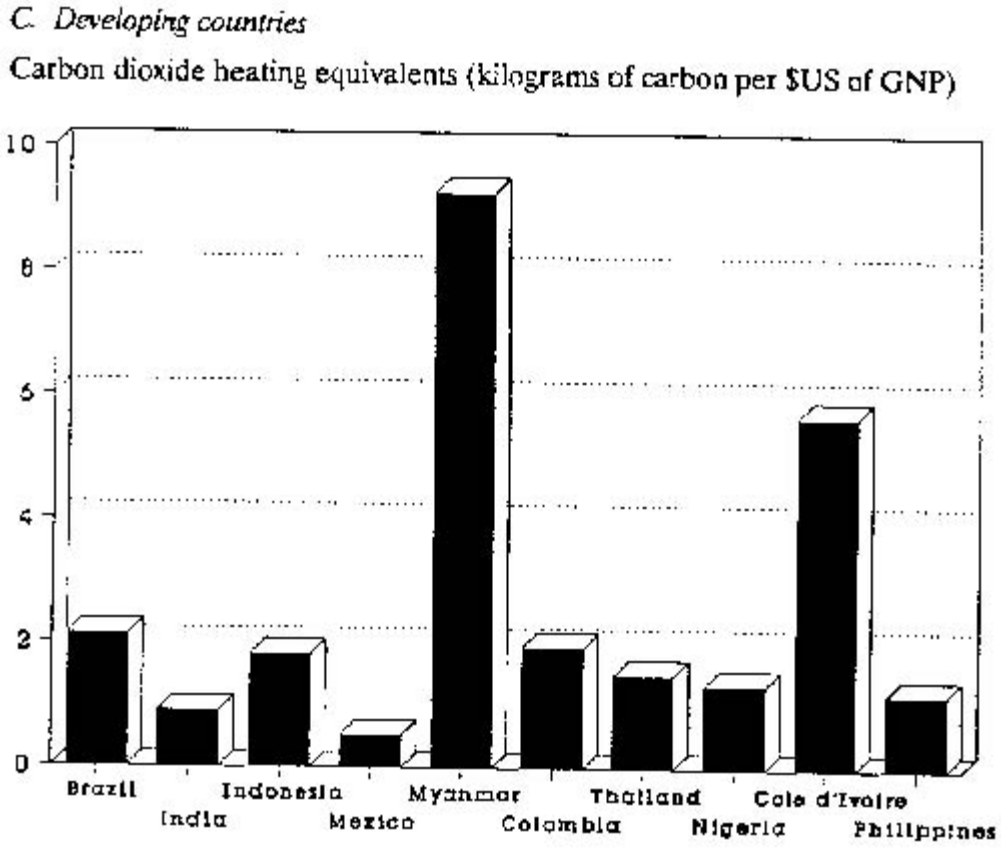

Figure 1: (Continued)

These agreements contain innovative regulations and instruments, not only technical provisions, but also fiscal incentives and quota systems. The Montreal Protocol (with the succeeding revisions) is even considered a model blueprint as regards international environmental regimes (Gehring, 1990), an example of intelligent "ozone diplomacy" (Benedick, 1991).

Up to the present, however, these agreements were only of minor significance for developing countries in that they barely had to fulfill any strict obligations for the reduction of harmful emissions. In this respect the Montreal Protocol is a new beginning modified, though, by a ten-year grace period and by provisions for information and technology transfer. A global climate convention, by contrast, will mean significant economic adjustments for the developing countries, with regard to production as well as technology.

Theoretically speaking, a relative or an absolute reduction of all the greenhouse gases is to be aimed at. Doing so, basically all conceivable mechanisms and instruments could be used: negative lists (London Dumping Convention), technical provisions (Marpol Agreement), property rights (the Law of the Sea Conference), rates of reductions or cancellation of production (Vienna Convention, Montreal Protocol), etc. In view of a continuing high population growth in the developing countries, on the one hand, and urgent economic needs (i.e., necessary increases of income), on the other hand, relative limitations (with regards to population or gross domestic product) or absolute limitations of greenhouse gases would generate quite different consequences. These consequences, of course, will influence the readiness of countries to cooperate in or to oppose the process of negotiating an agreement on a climate convention, and the respective protocols. Taking into account only the major greenhouse gases, these are probably the most important measures to be considered:

- relative or absolute limitation of carbon dioxide emissions (CO_2) resulting from the combustion of fossil fuels;
- cancellation or conversion of the trends of CO_2 emissions from biotic sources (i.e., reduction of the rate of deforestation and reforestation, respectively);
- phasing out consumption and/or not taking up production of chlorofluoro-carbons (CFCs);
- relative or absolute limitation of methane emissions (CH_4);
- relative or absolute limitation of the use of nitrogen fertilizers (N_2O).

Taking the formulation of the CFC reduction plan (not its implementation) as solved, the further negotiations on a global climate convention will focus on a CO_2-, a CH4- and a N2O - Protocol, or a combination of them, and a supplementation by other protocols (on reforestation, bio-diversity). At this point in time, there is only one "greenhouse gas" which has been discussed seriously on the international level (leaving aside detailed individual suggestions regarding other factors) and whose regulation can possibly be achieved in the current decade, and that is

carbon dioxide (CO_2). In the following, I shall, therefore, concentrate on this gas.

4. Reduction and Redistribution Processes: Theoretical Considerations

In the process of the Montreal Protocol three steps, or targets, emerged: freeze, reduction, and phasing out. The endeavors centered on rules to reach a quantitative reduction, while a solution via fiscal disincentives (`CFC tax') was not pursued. The volume of funds made available (`CFC Reduction Fund') is rather modest and sufficient at best to cover the costs of information transfer. With regard to the other greenhouse gases, especially CO_2, however, a further growth of emissions must be expected; freezing or reduction seem feasible, phasing out seems impossible.

With regard to global environment policy, solutions via price and quantitative regulations are basically `ideal', as far as mechanisms of stimulation or sanctioning are concerned (Bonus, 1991). At the very start of all environment policy, the market mechanism is being changed: There is either a fixation of prices for the utilization of the environment, while it is left to the market mechanism to decide how much emission is economical (price solution); or a quota is fixed for the quantity of emissions allowed, while the prices for using the environment are left to develop in the market (quantity solution). Both basic solutions are symmetrical to one another, but they are not equivalent. One parameter, price or quantity, is fixed while the other is left to the market mechanism. The real question is which of these parameters should be fixed with regard to which environmental problem!

The crucial point with price solutions (taxes, charges) is the correct level of the price to be fixed (shadow price). The crucial point with quantity solutions is that by fixing a quantitative ceiling (quota) emissions of a certain amount are actually permitted. These permitted emissions, however, may be higher than the absorption capacity of the ecological system (in our case, the climate system). Price as well as quantity solutions may, therefore, miss the actual target, i.e., conservation, stabilization or restoration of the ecological system.

With regard to a CO_2 protocol it is to be expected that in the course of the negotiations, both types of solutions will be introduced. Up to date, quantity solutions are in the foreground, while the discussion on price solutions (global resource tax, national CO_2 charge, "climate tax") has only begun.

Moreover, with regard to quantity solutions, legal rules (reduction duties) do prevail. However, market-based instruments (certificates or tradeable permits) seem to gain ground, envisaging the implementation of certain framework parameters (for example: a certain rise in temperature) by emission quotas, (see Tietenberg, 1985). These systems would have to be transformed into specific certificates which entitle the holder (country, group of countries) to an (annual) emission of a certain amount of a specified pollutant (in this case: CO_2). These certificates (or tradeable permits) could be regionally or globally transferable (exchange). They would be exchanged in the market at prices corresponding to their scarcity, and the ensuing income might then be used for substituting high emission products and technologies by low emission products and technologies. The certificates would add up to the set framework parameters (global emission limit). The certificates traded could thus be interpreted as a compensation for partial renouncement of production or use, respectively.

A special problem with regard to the implementation of a global climate convention is the uncertainty as far as cause-effect-relations between emissions and impacts on climate (rise in temperature) are concerned. This problem could, however, be forestalled by corresponding (yearly) devaluations of the certificates, which would lead either to curb emissions or to purchase additional certificates.

It had to be demonstrated that CO_2 emissions qualify very well for a quantity solution, in the sense of certificates to be traded at the national, regional or even the international level. Specific conditions, however, would have to be met to smoothly implement this theoretical option in actual practice. There are also alternative instruments of global climate policy, like a tax on fossil fuels or a CO_2-charge. The related questions of these solutions, however, cannot be addressed in this paper.

5. Global CO_2-Emission Reductions: Three Scenarios

In the following, three global emission reduction-studies shall be presented (Bach; EPA; Mintzer), which include all important greenhouse gases. For reasons of clarity, however, only the CO_2 data shall be considered. Bach derives drastic reduction duties from the (catastrophic) projections of climate models, whereas Mintzer and EPA define the emission reductions from possible, respectively probable, changes of relevant parameters (especially energy intensity, mileage efficiency, energy tax). Accordingly, the three scenarios differ quite significantly (see Table 3).

- Scenario A can be called a strict "preventative strategy", i.e., a drastic reduction of CO_2 emissions from the burning of fossil fuels and also from biotic sources (clearing of forests, burnings, losses of vegetation);
- Scenario B holds a "middle position." A reduction of CO_2 emissions from fossil fuels of less than 40 percent is expected, and an active reforestation policy is envisaged, leading to negative net emissions (e.g., enlargement of the CO_2 sinks);
- Scenario C may be regarded as "modest policy." Prevention fails, emissions from the burning of fossil fuels double, changes in land use have only minor relieving effects; the resulting increase of average temperature (2075/1860: = 2.3 up to 7°Celsius) makes far-

reaching adaptive measures necessary.

Of course, it is difficult to predict which of these scenarios will be taken as reference for the global climate convention, and the respective protocols. According to recent climate conferences of scientists and politicians, a limitation of average global warming to below two degrees Celsius might develop as a reference point. The implied "mixed strategy" of precaution (prevention) and adaptation (cure) actually will be determined by three major factors: (1) the real or supposed costs and benefits of the corresponding measures, (2) the perception of the irreversibilities implied by climate change, and (3) the institutional and instrumental measures which can be agreed on in the North-South-context.

Table 3: Scenarios of CO_2 Reduction (1975-2100) (Source: Compiled from Hartje, 1989)

Scenario A: »Preventive Strategy«, Bach, 1988

	Emissions	
	1980	2100
CO_2 (million tons)		
- Fossil fuels	18.000	6 - 9
Change of land use	4.000	0 - 4
Total	22,000	6 - 13

Δ T 2100/1860 = 1.5 to 4.5 degrees Celsius

Scenario B: »Intermediate Position«, EPA, 1989

	Emissions				
	1985	2025	2050	2075	2100
CO_2 (billion tons)					
- Fossil fuels	19.4	20.5	n.a.	n.a.	12.2
- Change of land use	3.0	-1.1	n.a.	n.a.	-0.4
Total	22.4	19.4	16.0	14.1	11.8

Δ T 2100/1860 = 1.4 to 2.8 degrees Celsius

Scenario C: »Modest Policy«; Mintzer, 1987

	Emissions			
	1975	2025	2050	2075
CO_2 (billion tons)				
- Fossil fuels	17.1	21.3	28.3	34.6
- Change of land use	3.8	3.0	2.7	2.5
Total	20.9	24.3	31.0	37.1

Δ T 2075/1860 = 2.3 to 7 degrees Celsius

If one takes the current discourse over the reduction of CO_2 emissions as an indicator of an already existing common interest in a sustainable future of industrial society while at the same time respecting the need for further economic growth in the developing countries, there are interesting and surprisingly coinciding plans, which shall be reported upon in the following.

6. CO_2-Emission Reduction Plans: Three Examples

At the Second World Climate Conference in Geneva 1990, two plans on CO_2-emission reduction for the time until 2050 were presented: the IPCC proposal and the Ministers' proposal. The "International Panel on Climate Change" (IPCC) called for drastic and rapid reductions of CO_2 emissions in the OECD member countries, whereas global emissions decrease only after the year 2005, and shall then fall by 46 percent until 2050, below the level of 1987 (see Table 4).

The Ministers' proposal was less drastic and involved some temporary delay (see Table 5). The ministers, however, followed the scientists' notion, whereupon a further increase of CO_2 emissions should be accorded to the developing countries.

The plan of the `Enquete-Kommission' of the German Parliament might be taken as another reference (see Table 6). The proposal differentiates the industrial countries according to their gross domestic product and suggests CO_2-emission reductions to be realized more quickly and more thoroughly. Again, a preference is accorded to the developing countries.

Thus, implicitly, criteria for the allocation of reduction duties, and the related redistribution goals, between industrial and developing countries, North and South, have already been mentioned. In the following, the special features of these probably sensitive questions of a global CO_2 protocol are to be addressed more explicitly.

Table 4:CO_2 Emissions Plan Second World Climate Conference IPCC proposal (base year 1987, in percent) (Source: WMO/UNEP, 1990)

Year	Industrial countries		Developing-total	World countries total
	OECD	others		
1990	+5	+5	+5	+11	+6
1995	+7	+8	+7	−24	+11
2000	-4	+5	+1	−37	+7
2005	-20	-10	-16	+50	-3
2020	-50	-30	-43	+60	-21
2050	-80	-70	-76	+70	-46

7. Possible Criteria for the Distribution of CO_2-Emission Reductions between North and South

The allocation of the duties of a climate convention, and the accompanying protocols, between industrial and developing countries depends on various factors. Especially, to what degree should a certain greenhouse gas be reduced in relation to other gases, and what criteria should be applied for the reduction? A strategy for reducing all greenhouse gases would probably focus on their relative importance for climate change, respectively on the global benefits of a climate stabilization. A partial strategy for one single greenhouse gas will probably focus less on possible benefits but more on the technical options, the costs of emissions reduction, or on the substitution of the reduction duties vis a vis other gases.

For example, a total phasing out of CFC production in the industrial countries theoretically would allow for a less strict reduction of CH_4 or N_2O, which is technically difficult to achieve in the developing countries. At this stage, however, there is no need to go into this possibly complex "substitution dispute." Instead, I shall focus on CO_2 only which, as reminded, causes more than 50 percent of the greenhouse effect, and will illuminate the range of possible and realistic criteria for CO_2 reduction policies.

Table 5:CO_2 Emissions Plan Second World Climate Conference The Minister's Proposal (base year 1987, in percent) (Source: WMO/UNEP, 1990)

Year	Industrial countries	Developing countries	World total
1990	+5	−11	+6
1995	+8	-24	+11
2000	+5	−37	+12
2005	0	−50	+10
2020	-25	-60	-4
2050	-60	-70	-33

Table 6:CO_2 Emissions Plan The EnquÙte-Kommission (base year 1987, in percent) (Source: EnquÙte-Kommission, 1990a)

Year	Industrial countries			total	Developing countries	World total
	economically strong	economically less strong	economically weak			
1990	-5	+5	+5	+5	+11	+6
1995	−5	-7	+8	+6	+24	+10
2000	-10	-4	+5	-4	+37	-4
2005	-30	-15	-5	-20	+50	-6
2020	-50	-35	25	-40	+60	-20
2050	-80	-80	-80	-80	+70	-50

Two successful international environmental agreements may be the points of departure for the decision on such criteria: The ECE Convention on Long-Range Transboundary Air Pollution (1979), and the Montreal Protocol (1987). With the signing of the EEC convention a small number of ECE countries joined a "30 Percent Club" as regards the reduction of sulfurdioxide (SO2); other ECE countries joined the `club' successively. Decisive for this success in preventing acid rain was not only the pressure from local and regional damage to the forest ecosystems ("Waldsterben"), the formation of the electorate, the generation of technical and financial solutions, but also the consensus achieved by the "club" over a simple distribution criterion: "Every country shall reduce its SO_2 emissions by the same rate of 30 percent!" (This consensus had been reached after an intense discussion of the questions, whether the current or the accumulated emissions, the size of the country, its emission export/import situation etc. should be taken into account or not). In this way, the given departure point was "legitimized", prior accomplishments or geographic and other peculiarities were not considered. Thus, this is the

Distribution criterion I:
A proportionally equal reduction rate for all countries referring to the starting point (and a base year)

The Montreal Protocol also requires a proportionally equal reduction rate (50 percent at first, later on 100 percent), but permits a temporary limited exemption from this rule for the developing countries. The developing countries were relieved from the reduction duties, because they judged them as being unfair; the industrial countries had caused the damage to the ozone layer with their accumulated CFC emissions, so developing countries could not be expected to assume a proportional part of the duties, they might even have a right to emit in the future. On this argumentation is founded the

Distribution criterion II:
A proportionally equal reduction rate for a group of countries (industrial countries), and fixation of a limit, respectively a rate, of a still permissible increase of emissions for the other group (developing countries)

The Montreal Protocol concedes the developing countries a CFC production of up to 0.3 kilogram per capita for ten years, and then requires a reduction to 50 percent. In comparison with the reduction of CO_2 emissions, the reduction of CFC emissions needs but slight adjustment measures (because of quasi monopolistic production, low level of departure). The adjustments necessary regarding a CO_2 protocol will be much more extensive and need vigorous action, as many technologies, products and economic branches are at stake. The industrial countries may bargain their own absolute reduction duties against the relative reduction duties (rate of growth of CO_2 emissions) of the developing countries. Apart from current emissions, the developing countries might point as well (or even especially) at the historical emissions accumulated in the Earth's atmosphere. The more such (and further?) distribution arguments are brought into the arena, the higher the probability that no common (mutual) reduction can be agreed on. This makes a criterion of equal treatment attractive, which could be accepted as fair by the developing countries, i.e., equal CO_2 emissions per capita of population. This is the

Distribution criterion III:
Every country has a right to emit, resulting from the set (reduced) global limit of emissions per capita of the world's population, multiplied by the country's population number.

According to this criterion, countries exceeding the fixed limit of emissions per capita (the industrial countries) would have to reduce emissions drastically; countries falling below this limit (the developing countries) could emit additionally. This criterion is geared to fairness, not legitimizing the present emissions situation but requiring redistribution in the North-South-context.

Out of the difference between the contracted emission rights (limits) and the current emissions originate duties of reduction, respectively adaptive requirements, which, for varying differences between the participating countries, would lead to different rates of emission reduction (industrial countries), respectively growth of emissions (developing countries). By introducing this criterion, peculiarities like the geographic situation, size of the country, resource endowment, differences in costs, etc. would not be taken into consideration. This, again, might open up corridors for bargaining in the negotiations of a CO_2 protocol.

Applying the distribution criteria I to III on the three scenarios presented in Table 3, reveals the different magnitudes of the reduction duties and, respectively, the resulting redistribution between industrial and developing countries, as summarized in Table 7.

Technically speaking, there exists a wide range of possible measures to reach a reduction of current CO_2 emissions (cf. Goldemberg, et al., 1987; Kats, 1989; EnquÙte-Kommission, 1991); the most important of them probably being the following ones:

Table 7: Distribution of Admitted CO_2 Emissions from Fossil Fuels between Industrial and Developing Countries: Three Scenarios, Three Distribution Criteria (Source: Compiled from Hartje, 1989)

	Global emissions billion tons	Admitted emissions of Industrial countries billion tons	percent	Developing countries billion tons	percent
Scenario A: Bach, 1988					
Departure point 1982:17.4		12.6	72.4	4.8	27.6
Target 2100: 0.008					
Distribution according to					
Criterion I		0.0054	72.4	0.0021	27.6
Criterion II		0.0022		5.3[a]	
Criterion III[b]		0.0019	25.3	0.0056	74.7
Scenario B: EPA, 1989					
Departure point 1982:17.4		12.8	72.4	4.8	27.6
Target 2100: 12.2					
Distribution according to					
Criterion I		8.8	72.4	3.4	27.6
Criterion II		6.8	56.5	5.3[a]	43.5
Criterion III[c]		3.1	25.3	9.1	74.7
Scenario C: Mintzer, 1987					
Departure point 1982:17.4		12.6	72.4	4.8	27.6
Target 2075: 34.6					
Distribution according to					
Criterion I		25.1	72.4	9.5	27.6
Criterion II		19.0	54.9	15.6	45.1[e]
Criterion III[d]		8.7	25.3	25.9	74.7

Notes:
a = absolute increase of 10%; b = 1.6 kilogram CO_2 per capita; c = 2.5 tons CO_2 per capita;
d = 7.2 tons CO_2 per capita; e = increase of share by 100%.

- Reduction in the use of fossil fuels by way of energy saving, or increase in the efficiency of energy use, especially with regard to transport, electricity, heating;
- substitution of high-emission fuels by low-emission fuels;
- installation of new power generating technologies, like co-generation, district heating, district cooling, gas turbines;
- substitution of fossil fuels by renewable energy, like biomass, wind energy, photo-voltaics, solar hydrogen;
- technical improvement or refitting of fossil fuel based power plants and engines.

That is to say, more is needed than just a relative decoupling of energy consumption from economic growth. For ecological reasons, economic growth in the medium and long term is possible only if the reduction in energy consumption and in environmental damage is absolute. (I don't think it to be the task of the present paper to address these basic questions of economic structure, technology, and lifestyle.)

Up to now, only CO_2 emissions from fossil fuels have been dealt with. In their case, freezing and reduction are the issues. With CO_2 emissions from biotic sources, however, phasing out and a reversion of trends, i.e., negative growth rates come into the picture. To strive for a reduction in emissions only would be too modest in view of a possible net-assimilation of carbon in the biomass. Even the introduction of distribution criterion III mentioned above does not make sense here, as positive emissions fall very much behind the possibility of negative per capita emissions (by enlarging carbon-sinks, reforestation). An additional criterion might therefore consist in linking the obligation to stop deforestation in the developing countries with the obligation of reforestation in the industrial countries. Another possibility consists of a direct link with the right to CO_2 emissions from fossil sources: Biotic emissions (resulting from slash-and-burn agriculture, deforestation, changes in land use) reduce the right to per capita emissions of CO_2 from fossil sources - and vice versa: reforestation increases it.

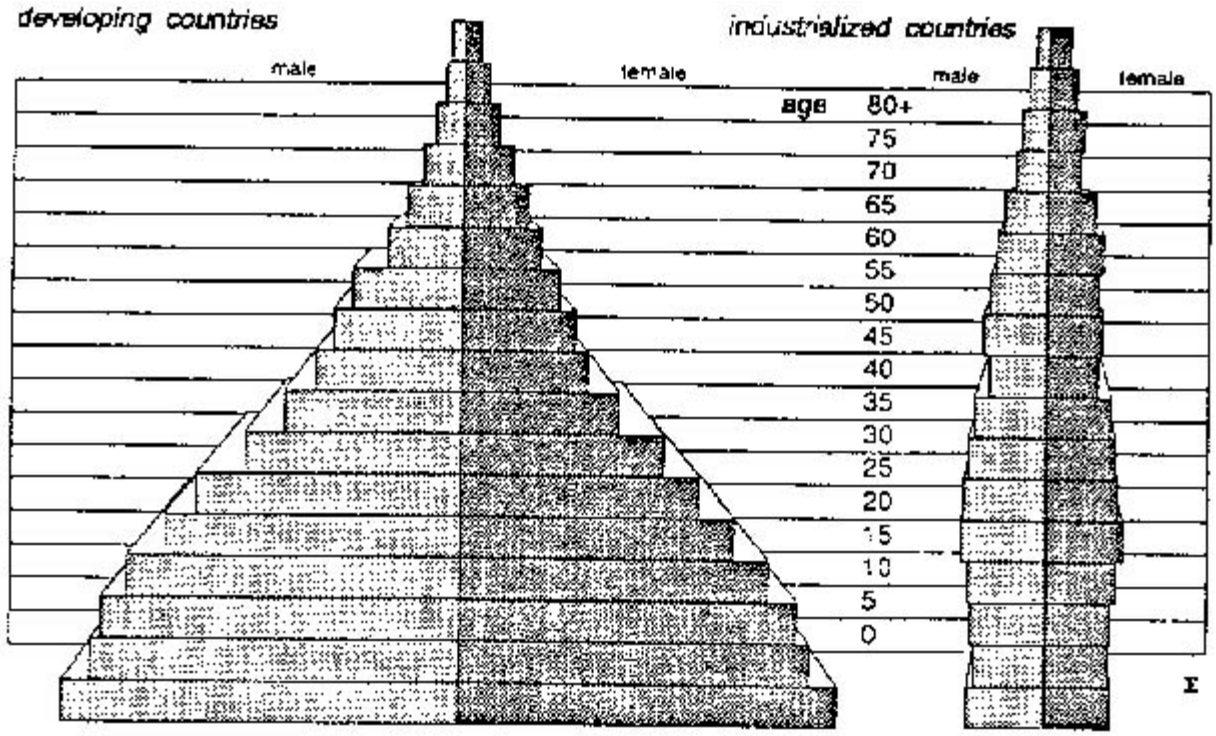

Figure 2: Population Pyramid, mid 1980s

There is another distribution criterion which might come into prominence in the process of negotiating the CO_2 protocol, an age criterion (cf. Grubb, 1989). As is well known, the population structure of the developing countries differs widely from that of the industrial countries; Figure 2 shows the dimensions involved.

In view of the fact that the population of the developing countries on average is much younger, an equal per capita emission right might prove ecologically counterproductive, i.e., giving an incentive to keep a high level of population growth. The industrial countries might, therefore, tend to introduce a minimum age criterion ("adults emission right"), by which their CO_2 reduction duties could be reduced, or their per capita emissions be increased.

Figure 3 gives an impression of the dimensions that are at stake if an age criterion is to be considered in the negotiations of a CO_2 protocol between North and South.

Of course, questions of distribution are questions of power. The problem of climate change is so complex that debates on distribution may never come to an end. Therefore it seems to me that a guiding criterion has to be postulated which should be as simple as possible and, at the same time, generally convincing. Some of the respective options have been presented above.

8. From Here to There: Confrontation or Cooperation?

With regard to global environmental problems Peter M. Haas recently formulated a "theory of epistemic consensus" (Haas, 1990, pp.347ff.). According to his (and my) view, substantial changes have occurred in the process of negotiating international agreements. This evolution of environmental policy competence can be understood as a collective learning process, an evolution that might refute Hardin's thesis of the "tragedy of the commons" (Hardin, 1968). Within this process, "epistemic communities" have formed transnational networks which are politically relevant because of their authoritative knowledge. If such networks develop, and if they get and maintain access to policy makers, global conventions and protocols might have an "efficiency guarantee." Neither "common interests" per se (upon which the Brandt Report was based), nor the notion of "sustainable development" (the Brundtland Report), nor "responsibility for the own future" (the Nyerere Report) alone will sufficiently enlarge the chances for international cooperation; rather, cooperation depends upon the kind and strength of consensus within the "epistemic" community.

This theory, it seems, has been verified by the Montreal process: Political action was prompted by an ecological crisis ("ozone hole"); international experts established the scope of political alternatives, then negotiated with diplomats; and when the members of this community had consolidated their position with the national governments, the latter supported the agreements.

Figure 3: Per Capita Emissions, Permit Rations and the Effect of a Minimum Age Restriction (Source: Grubb, 1989, p.38)

Whether this theory will hold true for the "greenhouse effect", and can be verified by the formulation and implementation of a CO_2 agreement the "Houston Protocol" remains to be seen. While a loosely cohering epistemic community does exist, the internal consensus is not nearly as strong as in the ozone case. There is a rift within the greenhouse community: There are the preventionists, pleading for immediate and drastic action in order to avoid or at least confine climate change, and there are the adaptionists, arguing for slow and gradual adaptation to a climate change which cannot be avoided anyway.

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Professor Udo Simonis is a research professor in environmental policy at the Science Centre Berlin and former member of the German Advisory Council on Global Environment Change. He studied economics at the University of Mainz and the University of Freiburg, and received a Ph.D. from the University of Kiel. His previous positions include Personal Advisor to the President of Zambia, Research Fellow at the University of Tokyo, Professor of Economics at the Technical University of Berlin, Visiting Professor at the Chinese University of Hong Kong and Director of the International Institute for Environment and Society at the Science Centre Berlin. Professor Simonis is the Chairman of the Association of German Scientists and a member of the Advisory Committee of the Development and Peace Foundation.