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Beyond 2012 – evolution of the Kyoto Protocol regime

An environmental and development economics analysis

Axel Michaelowa, Sonja Butzengeiger, Martina Jung, Michael Dutschke

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1. Introduction

Anthropogenic emissions of greenhouse gases have been increasing since industrialisation started about 150 years ago. Due to the long residence time of many greenhouse gases and the ubiquity of emissions sources in an industrialised economy, international climate policy is a task for many generations. Thus the international negotiation process has started with a general framework that is specified in more detail as time passes. Each step achieved serves as stepping stone for the subsequent step. Given that climate policy started only about 15 years ago, the progress made so far is relatively good compared to other international regimes. Three major steps can be distinguished:

As its name specifies, the U.N. Framework Convention on Climate Change (UNFCCC) agreed at the U.N. Conference for Environment and Development in 1992 defines the overall framework for a global climate policy regime. Its major pillars are the

- Objective of "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system [...] within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner"
- Principle of "common but differentiated responsibilities", i.e. industrialised countries shall take the lead in mitigation and adaptation
- Reporting of greenhouse gas emissions on a national level
- Setup of an institutional structure encompassing a Conference of the Parties meeting annually, two subsidiary bodies and a permanent secretariat

The Kyoto Protocol agreed in 1997 has the following main elements

- Legally binding emission targets for a basket of six gases for the majority of OECD members and the majority of countries in transition of Eastern Europe (so-called Annex B countries). These targets apply for the commitment period 2008 – 2012 and relate to the base year 1990[1].
- Four market mechanisms for the international transfer of emission rights: Bubbles, International Emissions Trading (IET), Joint Implementation (JI) and the Clean Development Mechanism (CDM).

[1] There are some exceptions concerning the base year for countries in transition and for specific gases.

The Marrakech Accords of 2001 define the

- Use of terrestrial sinks
- Reporting requirements
- Determination of non-compliance

While many observers criticise the regime for its short-term orientation, it has always been open for further development. The institutional setting is geared towards a regular updating. Currently, the target date of 2005 is set to negotiate the rules for the regime after 2012.

As the regime becomes more mature, there is certainly a degree of path dependency. For example, a change from a target-based to a policy-based regime would become difficult. It is also unlikely that the base year for industrialised country targets will be shifted from 1990. However, there is still a high level of freedom for future development.

This paper will discuss the different options on the table and identifies issues concerning the economic efficiency, environmental effectiveness and political feasibility of those options. In chapter 2, the general options of the international community to react to climate change are presented. We also analyse different types of reduction targets. In chapter 3, approaches how to define emission targets on the international level are described. Based on the understanding that the expansion of the circle of countries with absolute emission targets is crucial from the ecological perspective, chapter 4 identifies and evaluates several threshold options that could be applied on current Non-Annex-B countries to enter Annex-B. In a next step, we elaborate on options to quantify emissions targets on the national level, also taking into account issues of equity, historical responsibility for climate change and the need for sustainable development. The latter issues lead to the discussion what incentives and barriers for current Non-Annex-B countries exist to take absolute emission targets. The discussion focuses on institutional requirements and the attractiveness of international emissions trading in comparison to the CDM. In chapter 7, options of "technical" development of the current climate regime are elaborated on. Chapter 8 gives an overview of alternative climate policies and measures, i.e. those measures that might be applied on the national level. Finally, policy recommendation are given, taking into account political feasibility.

2. Elements of a future climate regime

There are three major options of how the international community might react to the threat of global warming. The future climate regime that can be envisaged today will combine all three of the following elements:

- a strategy for adaptation to negative economical, social and ecological impacts
- the reduction of global greenhouse gas (GHG) emissions
- the sequestration of carbon dioxide by natural sinks and/or technical storage

2.1 Adaptation

As is understood today, climate change might have significant impact on economies, society and human infrastructure, although those impacts are expected to be more severe in some regions of the world than in others. Examples of areas that are expected to be effected seriously are arid regions whose inhabitants and ecological systems are threatened by the enlargement of deserts as well as regions slightly above sea-level which are threatened by potentially more intense storms and sea level increases. Thus, there undoubtedly is the need to adapt to the potential impacts of global warming – be it with technical, behavioural or social measures. However, one can imagine that funds needed to both prepare for potential impacts of climate change and to compensate for negative effects in a satisfactory way would need to be incredibly huge.

Next to the physical need to prepare for and adapt to climate change, negotiations of recent years have shown that financial and technical aspects of adaptation increasingly gain political importance. This trend results from two considerations: the ideal of global justice and the political strategy to get developing countries more actively involved in the UNFCCC process in the long term. Especially many less developed countries are those that might be most affected by the impacts of climate change. Those countries can be expected to claim financial support and compensation for natural disasters mainly caused by the emissions from industrialised countries[2].

Article 4.4 of the UNFCCC obliges Annex II Parties to "assist the developing country parties that are particularly vulnerable to the adverse effects [..] in meeting costs of adaptation"; article 11 defines a financial mechanism "for the provision of financial resources on a grant or concessional basis, including for the transfer of technology". This financial mechanism is under guidance of the Conference of the Parties (COP), which decides on its policies, eligibility criteria and priorities. Currently the Global Environmental Facility (GEF) serves as its operational entity.

[2] Next to the fact that it can be assumed to be more than diffcult to ensure a sufficient level of funding, the problem arises that it is virtually impossible to decide which weather-related disasters are caused by human induced climate change and which ones are due to natural variability.

The GEF has been established in 1991 and focuses on six environmental core issues:

- biodiversity loss,
- climate change,
- ozone depletion,
- degradation of international waters, and
- organic pollutants

Financial support is given on the basis of concrete projects. Several funding options exist (full-size projects, medium-sized projects, support for the preparation of national inventories, project preparation and development facility, small grants program the and small and medium enterprise program). So far, over 1000 projects have been supported (GEF contribution in grants: $4 billion) in 160 developing countries and transitional economies of which about 1.2 billion were pledged for the climate change area. For the period 2002-2006, $3 billion have been pledged by donor countries. However, in the climate change area only 50% of the funds pledged are really disbursed and the lion’s share of funding goes to large countries that also receive a lot of foreign direct investment (Ravindranath and Sathaye 2002). The project cycle is cumbersome and takes many years; until 1999, only 11% of approved projects in energy efficiency and renewable energy were fully operational. A GEF project in India to promote biomass energy in rural areas took almost a decade.

Based on the Buenos Aires Plan of Action of 1998, three new funds under the Convention and the Kyoto Protocol were established with the Bonn Agreements in 2001:

- the special climate change fund
- the least developed countries fund, and
- the adaptation fund

The *adaptation fund* is based on the income generated by the "share of proceeds" of the Clean Development Mechanism (CDM) - which is a 2% tax on generated certified emission reductions (CERs). Thus, the volume of the adaptation fund is strongly dependent on the market share of the CDM as well as market prices for emission certificates. Given the low demand for CERs that currently is predicted for the first commitment period (see e.g. Jotzo and Michaelowa, 2002), one can expect the adaptation fund to suffer a serious lack of capital. This situation would change with more stringent reduction targets in future commitment periods. Nevertheless, it is strange why developing countries have to finance adaptation themselves, as in a competitive market the adaptation tax cannot be charged on the buyers of CERs and reduces the revenue of CER sellers.

The *least developed countries fund* is supposed to assist least developed countries (LDCs) to conduct work programmes, as for example National Adaptation

Programmes of Action. One still has to agree on how funds will be shared between LDCs.

The *special climate change* fund shall finance activities, programmes and measures related to adaptation, technology transfer, energy, transport, industry, agriculture, forestry and waste management as well as to assist developing countries which economies are highly dependent on exports of fossil fuels in diversifying their economies. Those activities should be complementary to those originally financed by the GEF.

As part of the political agreement reached in Bonn, Annex II Parties have pledged to make available US $ 410 million annually for the latter two funds by 2005. On a global scale, however, this amount is negligible - it will by far not be enough to perceivably improve the situation of developing countries, especially given the wide range of tasks of the funds.

Due to the funding problem, a relatively old idea to raise funds currently re-enters the debate: insuring against negative impacts of climate change. The idea is to establish a climate-change-insurance on a multi-national or national level to help compensating the poorest people after e.g. floods, storms or draughts. Such insurance systems obviously would need to be established as private-public partnerships – with ensurance companies, financial institutions, governments and potentially emitters involved. One might even apply the polluters pays principle in obliging emitters of GHGs – be it nations or companies – to contribute to finance insurance fees according to their contribution to global warming. Some of Europe´s large reinsurance companies as Munich and SwissRe recently have started a first dialogue on this issue.

The major political element of providing adaptation funds is that many developing countries see the willingness of industrialised nations both to effectively reduce emissions at home and to compensate for the impacts of their present and past emissions by providing sufficient funds as a prerequisite for any own future commitments. This did not only become obvious during the negotiations in Bonn, Marrakech and Delhi, but will be a central element of future negotiations.

2.2 Reduction of global greenhouse gas emissions

Whereas adaptation measures only touch the symptoms/physical consequences of climate change, a substantial reduction of global GHG emissions is crucial to effectively combat global warming. As we discuss in chapter 4, a significant inclusion of developing countries – in terms of taking absolute emissions targets - will be the most crucial factor of any future climate regime. But let us first elaborate on different types of emission targets.

2.2.1 Absolute vs. relative emissions targets

GHG emissions targets can be of absolute nature [e.g. Mio t $CO_{2\text{-eq}}$ per year] or relative to another variable such as GDP or population. Many observers have argued that GDP-related targets (commonly called intensity targets) would be appropriate for countries with strong economic growth (Hargrave 1998, Baumert et al. 1999, Philibert 2000). In general terms, countries with significant economic growth favour relative targets whereas shrinking economies favour absolute targets which then create the so-called "hot air".

Although politically attractive, pure intensity targets have significant drawbacks compared to absolute targets from the ecological perspective. If the corresponding variable (as economic output) increases, the emissions budget is enlarged respectively. What finally counts to avoid/reduce climate change is the absolute reduction of GHG emissions. Additionally, dealing with relative targets significantly complicates the handling of emission trading schemes. The emissions budget of a party can only be determined ex-post, i.e. after the value of the corresponding variable has been determined for a certain year or period.

Another basic problem is that relative targets might give credits for "virtual reductions". This is the case if the emission intensity decreases (slightly) while the output/value of the corresponding variable increases. **figure 1: problem of relative targets** shows that in this scenario a party can claim emission reductions while actual emissions have increased (situation 2). Only in case the value of the corresponding variable remains constant, changes in emission intensity match with real emission changes (situation 1).

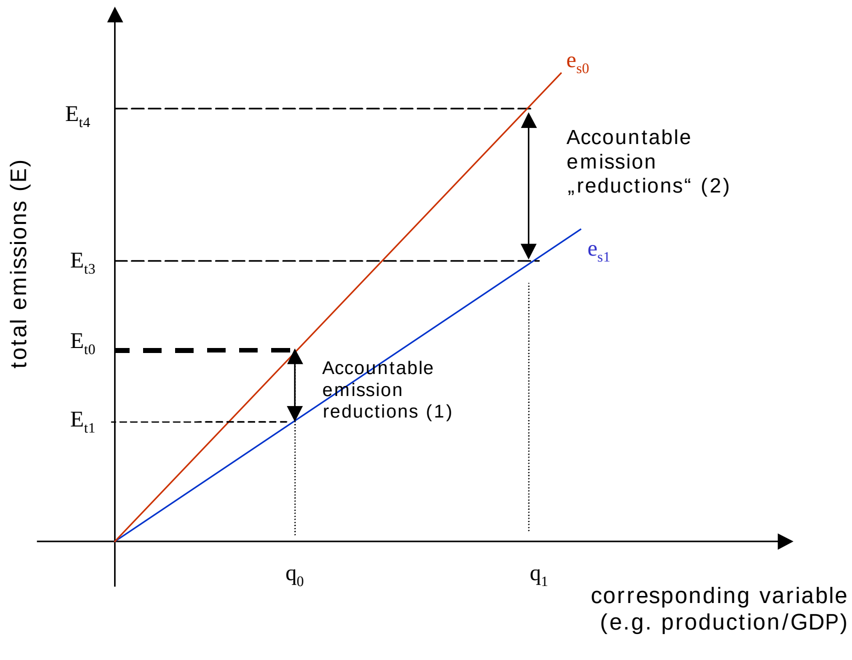


figure 1: problem of relative targets

Consequently, purely relative targets do not prove to be environmentally effective if the value of the correlating variable increases over time.

Frankel (1999) proposes an absolute target adjusted for GDP development at end of a commitment period. Müller et al. (2001) evaluate intensity targets in the Kyoto context. They argue that intensity targets are pro-cyclical as intensity tends to decrease in a phase of strong growth (e.g. in China during the full period of economic reform and in India in the second half of the 1990s) whereas it increases in phases of economic distress (e.g. in Russia and other countries in transition during the economic slump of the 1990s). However, if flexible instruments as emissions trading are to be applied, an ex-post determination of emission budgets can be expected to restrict the global GHG-market.

Argentina proposed an elaborate intensity target in 1998 when it prepared COP 4. For a discussion of its genesis see Bouille and Girardin (2002) who criticise the lack of stakeholder consultation about the definition of the target and its inappropriateness in the face of an economic crisis. However, their criticism seems too strict as the research input to derive the Argentinean target compares favourably with many ad-hoc target setting processes in Annex B countries.

After denouncing the Kyoto Protocol, the U.S. defined a voluntary target to reduce greenhouse gas intensity by 18% from 2002 to 2012. Van Vuren et al. (2002) consider this target as “modest at best”: since 1990, a decrease of 17% in GHG intensity could be observed in the US. At the same time, absolute emissions increased by 12%. This shows the risks of intensity targets for environmental effectiveness.

2.2.2 Voluntary vs. mandatory targets

The strongest type of targets are mandatory targets with onerous financial sanctions in case of non-compliance. On the level on installations, such targets are envisaged in the EU emissions trading system and have led to almost 100% compliance in U.S. SO_2 trading. This has not been achieved by the Marrakech Accords which just define an in-kind penalty of 30% payable in the subsequent commitment period. Several more lenient target variants have been proposed.

The weakest form of targets are purely voluntary ones as specified for the Annex I countries in the UNFCCC. They were not successful and thus substituted by the Kyoto targets.

2.3 Sequestration of greenhouse gases from the atmosphere

Sequestration of greenhouse gases might be classified as a sub-category of reduction options. However, since the discussion on natural sinks has played a special role in past negotiations and since it is not clear yet what relevance sinks will have in a long-term climate regime, we discuss them separately.

2.3.1 Carbon sequestration by natural sinks

The inclusion of natural sinks in the Kyoto regime was one of the most contentious issues in the recent negotiation process. Environmental NGOs have strongly been fighting against their inclusion due to the issue of permanence and the fact that natural GHG sequestration decreases the pressure on emitters to reduce their GHG emissions. One might also pose the question if the inclusion of natural sinks does overload the UNFCCC process - both in ecological and political terms. Concerning the future development of the UNFCCC-regime, one can expect increasing efforts to include sinks by many parties the more stringent emission targets become. Therefore, it is crucial that scientifically sound and ecologically integer rules are defined and applied.

While “natural carbon sinks”, as e.g. forested areas, were not included in the voluntary UNFCCC targets, the Kyoto Protocol allowed Annex B countries to use terrestrial sinks for political reasons. Many stakeholders see natural sinks as a cheap option to comply with emission targets while supposingly contributing to `save the world’s large forests´. At the same time, the inclusion of terrestrial sinks is seen as a chance for many developing countries to participate at the global market for emission certificates by means of the Clean Development Mechanism (CDM).

In the long-term, the way in which natural sinks are included might change with increasing “active” participation of developing countries. One will need to ensure that no double-counting of CDM-projects and national inventories occurs. This also reinforces the need for functioning national registries and monitoring systems as the prerequisite for taking Annex-B-status (see also chapter 6.1).

Natural sinks can be classified in terrestrial sinks and marine sinks.

Terrestrial sinks

The decision which sink types are eligible almost scuppered the subsequent negotiations and still leaves many questions open. The main “technical” problems of sinks are the issue of permanence and monitoring. The very point about permanence is the following: while any non-emissions of greenhouse gases for energy use are assumed to be of permanent benefit, carbon uptake in soils and vegetation will be reverted at some time in the future. This can happen incidentally, as e.g. due to non-sustainable forest management, cessation of replanting after harvesting, or natural fires and pests. In any case, stored carbon will be released after the natural death of a given tree by biological degradation processes.

The resulting question then is: what is the benefit of temporal carbon storage for the global climate system? Several accounting proposals have been developed to deal with non-permanence. The so-called *ton-year-approach* handles the issue in discounting the amount of credits that can be earned depending on project duration. However, it still has some shortcomings and not much political backing especially by project developers (reduced financial attractiveness). Inspired by the so-called *Columbian Proposal,* there currently is increasing support for *temporary CERs (T-CERs)* as proposed by the EU group. These credits are only created for a certain period of time – e.g. 5 years - after which they expire and need to be replaced by other emission rights. If the project still subsists after this period, the same amount of new credits can be re-expended (Dutschke 2003).

Terrestrial sinks can be divided in vegetation and soils. The debate so far has focused on the former, but the latter category increasingly takes prominence.

For Annex B countries, the Marrakech Accord has decided a jumbled forest sinks accounting, including several caps, and still leaves many questions open. Overall, the regime is relatively unbalanced. Afforestation and reforestation can be accounted for in full whereas forest management is capped at ad hoc levels. It is also not clear how a natural increase in forest carbon stocks is to be separated from planned/human induced increase. This task becomes even more complicated if indirect effects of human action – e.g. atmospheric carbon fertilisation or increased temperatures due to global warming – are to be taken into account.

Due to the negotiators´ focus on forest sinks, soil sinks in Annex B were not capped in the Marrakech Accords. Potentially, soil sinks can become highly important but monitoring and introduction of policies addressing many dispersed actors remains problematic.

Sinks in the CDM have been capped and limited to afforestation and reforestation. Decisions of COP 9 on sink rules are expected for the end of 2003.

Marine sinks

While some experience has been gathered with carbon uptake in forestry, the science around marine sinks is only just in its infancy. A series of experiments has been made where iron is used to fertilise nutrient-poor surface areas of the oceans. The resulting plankton bloom would capture CO_2 and some companies have already started to market this as sink. However, the permanence of this sink and ecological side effects are uncertain and monitoring challenges are huge (Chisholm et al. 2001).

Another type of marine sink is the disposal of liquid CO_2 in the deep sea. Due to natural processes, submarine CO_2 bubbles can exist under high pressure and stable temperatures. Similar caveats apply as to the surface sink. With a rise in sea temperatures, these large deposits may bubble up. As temperature variation of deep sea water is a very slow process, the duration of the marine sinks may thus be longer. However, their ecological effects have not been explored at all.

2.3.2 Geological storage

Aquifers, coal seams and empty oil and gas reservoirs constitute large potentials for technical storage of greenhouse gases. For example, carbon dioxide could be separated from the effluent gas of fossil fuel fired plants, collected and stored in those reservoirs. This would allow a “CO_2-free” power production with fossil fuels.

Research policy in several Annex B countries tries to assess the overall scale of these sinks and costs for sequestration. Currently, only in specific circumstances such as offshore oil and gas exploration or generation of coal bed methane geological sequestration is viable. This situation might change in the long-term, if stricter reduction targets are negotiated and cheaper mitigation options are exhausted. Geological storage might therefore become an attractive option for sectors/economies based on fossil fuel burning. Similar to natural sinks, permanence might become a problem if places for CO_2-storage are not selected and monitored carefully.

3. Definition of global emission targets

After the international community (more or less) agreed that global warming is a serious threat that should be responded to appropriately, the major question is which emission reductions are necessary. Several scientific studies and recommendations on appropriate target level exist (e.g. WBGU, IPCC). This chapter analyses methodological approaches how to determine reduction targets from the economical point of view while considering scientific and political issues.

3.1 Minimising costs of climate change and policies

An economist would frame the task of international climate policy as follows: minimise net costs of climate policy. Costs would be generated by the mitigation of greenhouse gases and adaptation to climate change while benefits would accrue from reducing impacts of climate change. Minimisation of costs would mean that marginal costs of mitigation and adaptation would have to be equal to marginal benefits from avoided climate change (figure 2).

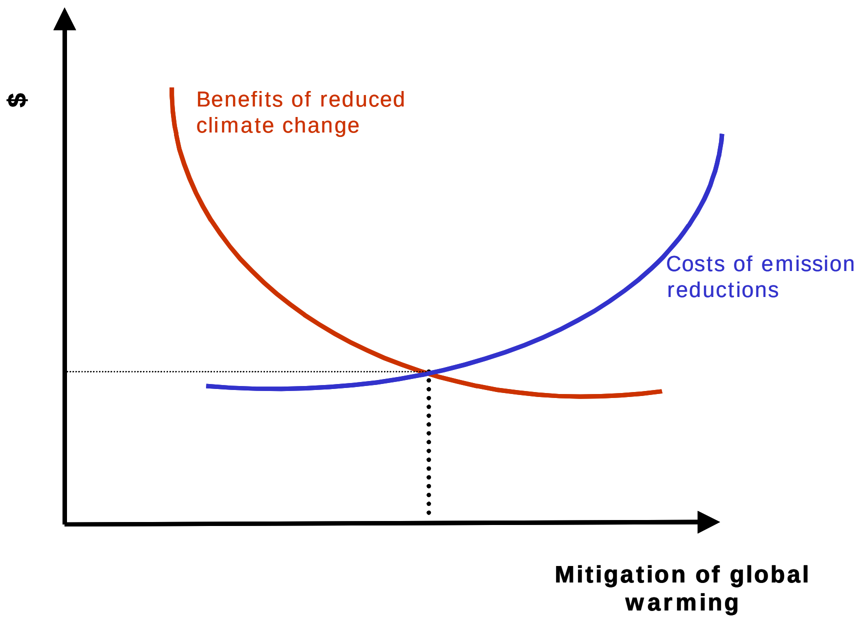


figure 2: definition of global GHG-reduction targets (minimum-cost-approach)

This seemingly easy task becomes complex due to several factors:

- Discounting of future costs and benefits leads to interminable debates among economists about the appropriate level of the discount rate (for a good overview see Bayer 2000). Given the multi-century nature of climate change, even a tiny difference in the discount rate leads to hugely differing outcomes.

- Uncertainty about costs and benefits
  - Uncertainty of current mitigation costs on an aggregated level. Detailed information on costs and potential only is available to emitters themselves, not to national/international bodies.
  - Development of mitigation costs over time is uncertain due to the unpredictable course of technological progress. If for example a technological breakthrough occurs that allows greenhouse gas emission-free electricity generation at costs below those of fossil fuel plants, mitigation costs fall dramatically.
  - Adaptation costs depend on the overall level and pace of development of a society that is uncertain over the long run.
  - Impacts of climate change depend on non-linearities that are currently not well understood.

Many analysts have thus proposed a *hedging approach* that allows policy adjustments over time. This would be consistent with the current policy regime. However, in the short run, marginal costs of mitigation will be high due to premature retirement of greenhouse gas-intensive capital stock whereas marginal costs of adaptation and benefits from reduced impacts would be relatively low. Thus a hedging approach would lead to an under-provision of mitigation compared to a long-term approach.

3.2 Willingness to pay

An alternative methodology is the willingness to pay approach. Here, countries negotiate up to which level of marginal costs of mitigation and adaptation they are prepared to pay. Once this level is fixed, policy instruments are introduced that provide a corresponding incentive. This approach is well-suited to a hedging strategy but incurs the risk of wild swings in incentives if political pressure depends on the level of past perceived damages from climate change. Damages would be the more discounted, the earlier they occurred. A catastrophe could lead to a sudden increase in willingness to pay while a long period with low impacts would erode it. Further problems are that the willingness to pay strongly depends on the specific situation of a given country - both its economic situation and its exposure to the effects of climate change. Consequently, this approach is extremely unstable and does not seem applicable for a long-term solution of the underlying problem.

3.3 Concentration targets

If economists cannot use a cost-benefit approach, they use the standard-price approach as a second best (Baumol and Oates 1971). The standard has to be set by the political process (which obviously generates an opportunity for lobbies to influence the standard level) and then instruments are introduced to equalise marginal costs of reaching the standard.

The Kyoto Protocol has many features of a standard-price approach. The emissions targets define the standard and the Kyoto mechanisms allow marginal cost equalisation. However, the targets only cover a part of global emissions and are uncertain beyond 2012 which makes long-term marginal cost equalisation impossible.

A pure standard-price approach for international climate policy would consist of the following elements:

- Political definition of a *maximum tolerated level of climate change* at a specific time. Usually, global temperature change is used as a parameter.
- Political definition of a *maximum tolerated rate of climate* change until the maximum level is reached. This is necessary because damages from climate change increase with its rate.
- Derivation of a *maximum concentration* and a *concentration path*
- Definition of a *global emissions path* that generates the concentration path

The German Advisory Council on Global Change (WBGU) has used this approach to define a “tolerable window” of a temperature increase beyond 16.6°C global average temperature and a maximum rate of 0.2°C per decade. This would approximately mean a stabilisation at 450 ppm (WBGU 1995, p. 111 ff). Bruckner et al. (2001) further elaborate this approach. They not only define a temperature “guard-rail” which is set at a temperature increase of 2°C and the decadal rate specified by WGBU (1995) but also an economic one expressed as a maximum global emission reduction rate of 4% per year. Continuation of a global business-as-usual scenario until 2010 leads to Annex B countries having to implement the maximum reduction rate for three decades.

A famous controversy about the shape of the emissions paths leading to a stabilisation of concentrations arose between Wigley et al. (1996) and Ha Duong et al. (1997). The former argue for delayed mitigation action due to the high economic costs of premature retirement of emissions-intensive capital stock while the latter contend that early action is warranted as current capital stock can only be replaced after a time lag of several decades. Thus the Ha Duong et al. emissions path is flatter that the Wigley et al. one.

figure 3 visualises the steps necessary following the concentration path – approach.

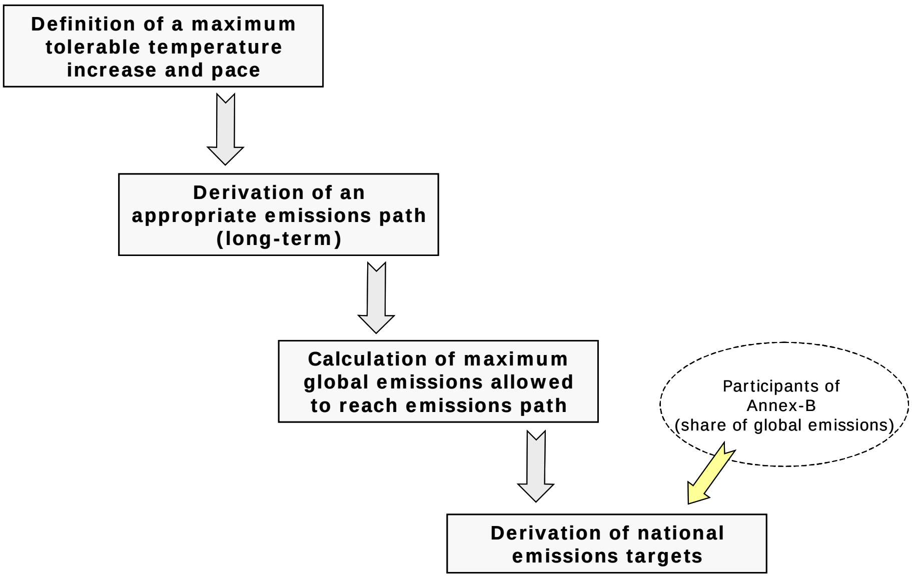


figure 3: steps to define national emission targets (based on concentration-path approach)

In the political debate, concentration targets so far have taken a back seat, the only exception is the 1997 EU proposal of a stabilisation at 550 ppm. This might be due to a fear of stringent future emission targets: once a concentration target and the target path has been defined, the maximum level of global GHG emissions in a given period is quantified. This sets the base for negotiations about the allocation of emission targets to all countries. One might imagine the political explosiveness of resulting negotiations as in a given group of countries with emission targets the only option to reduce the stringency of one nation's reduction target would then be to shift burdens to other nations. In this context, one should also be aware that the share of emissions of countries with an absolute emissions target - - the Annex-B-countries of the Kyoto Protocol - in relation to total global emissions also might influence the target stringency for Annex-B countries as a whole. If only a few countries take reduction commitments, there is a great extent of uncertainty about global emissions caused by Non-Annex-B countries. Regardless the fact that one might question the effectiveness of such a system, one might agree on more stringent targets for those few Annex-B countries to create a safety margin. Of course, it is very doubtful if such a regime is politically feasible in the long term and if it makes sense from the ecological perspective. Set into the context of the Kyoto regime, the above said visualises the need to expand the circle of Annex-B-countries.

To conclude, the concentration-path approach theoretically is a very suitable one in ecological terms if effective targets are agreed on and if it can be ensured that the resulting emission path is complied with. To reach this, the following strategy seems necessary:

- Maximise the share of global GHG emissions (i.e. countries) covered by absolute targets and
- Define realistic, economically and politically feasible emission targets on the national level.

4. Expanding the circle of countries with obligations under the UNFCCC

In the past, developing and newly industrialised countries refused to accept any emission targets under the UNFCCC; they only consented to establish national inventories - which in practice often proves difficult due to limitations in financial and personnel resources. Despite funding by the Global Environment Facility (GEF), most developing countries submitted their first National Communication with considerable delay.

The main arguments of those nations not to take absolute emission targets were that they could simply not afford to pose any potential burdens on the development of their economies and that they historically are not responsible for the greenhouse gas effect. Consequently, they want industrialised nations to take responsibility for their historical emissions and to take the leadership in reducing GHG emissions. Some countries even feared that the availability of emissions data would be the first step towards an emission target. Although this argumentation is traceable, it poses two problems:

First, although past emissions of the developing world have been relatively low, emissions have been rising and are expected to increase significantly in the next decades. As can be seen in figure 4, emissions from developing countries are predicted to surpass those of industrialised countries in about 2025. Consequently, a quantitative inclusion of developing countries is essential for a long-term, effective climate regime.

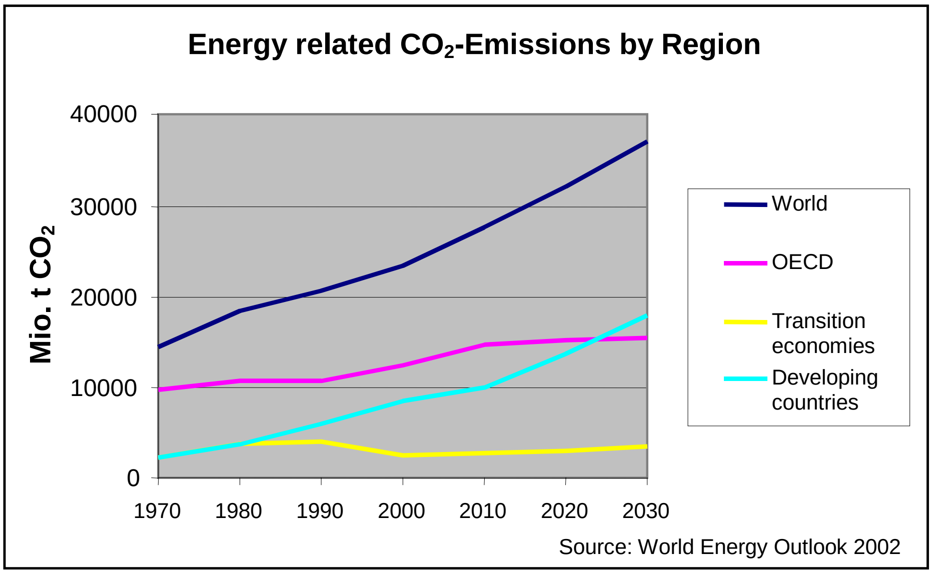


figure 4: Projected emission paths of different country groups

The second problem is of political nature. While developing countries call for leadership of the industrialised world, the world's largest emitter – the US - withdrew from the Kyoto Protocol arguing that a climate regime which excludes developing countries does not make sense. Perversely, at COP 8 in New Delhi it made a U-turn and declared that it would be unfair if developing countries would have to take up targets. The major challenge of future negotiations will therefore be to solve this impasse and to define effective contributions for developing nations while industrialised countries continue to take the lead.

The **principle of common but differentiated responsibilities** that has been adopted in Art. 3 of the UNFCCC calls for taking up emission targets once countries reach e.g. a level of wealth or of emissions comparable to the current Annex B countries. Such a threshold approach might help to ensure that countries contribute to fight global warming in a "fair" way. Since the exact definition of "fairness" or "equal contribution" not only is a very complex task but also a very sensitive one in political terms, there so far has not been reached consensus on a concrete definition. It will become a core element of future negotiations, though. Major indicators might be a country's

- historical responsibility, its
- need for (sustainable) development, its
- capability in terms of finance (Jansen et al. 2001), and its
- capacity in terms of (cheap) mitigation potential (Cluassen/McNeilly 1998)

Consequently, there are several options how to define thresholds triggering target negotiations for Parties:

- financial indicators, as e.g. GDP/GNP per capita,
- emissions per capita
- cumulative past emissions ("historical responsibility for climate change"), and
- institutional indicators

In the following, we discuss the major proposals that have recently been developed, further elaborate them and quantify their consequences concerning the expansion of "Annex-B".

4.1 GDP per capita

If thresholds are to be based on financial indicators, one can – to a certain extent – take into account the capacity of a country to contribute to global GHG-emission reduction or limitation. Financial indicators can be expressed in GDP per capita or in purchasing power parities of a reference period or averages of past periods per capita. This idea was first developed by Claussen/McNeilly 1998 but only applied in a fairly rough manner. We elaborate it in detail. The data source used for the following calculations is IEA (2002) and is limited to fossil fuel CO_2. Reliable emissions data for the Kyoto basket do not exist for many countries. Micro states of less than 100,000 inhabitants such as San Marino and dependent territories (e.g. Bermuda) are not analysed. The latter should in any case be taken into account as part of their respective Annex B country.

Variations of the GDP threshold would be:

- Absolute threshold, e.g. 10,000 $\$_{1995}$ in 2000. Such a threshold would be easy to understand but is rather arbitrary. One would also need to define time intervals in which those "even numbers" are updated and in which countries are evaluated. Our analysis shows that 16 Non-Annex B countries with 10.7% of Annex B emissions would lie above the 10,000 $ threshold (see Table 1).
- Absolute threshold based on the income of the poorest current Annex B country (Ukraine), with 3528 $\$_{1995}$ in 2000. As Table 1 shows, the Ukraine is currently surpassed by 46 Non-Annex B countries accounting for 27.5% of Annex B emissions.
- Absolute threshold based on the income of the poorest Annex II country (Philibert/Pershing 2002, p. 104f) which is Greece at 15,019 $\$_{1995}$ in 2000. Still 9 Non-Annex B countries with 3.4% of Annex B emissions lie above.
- Absolute threshold based on the income of the Annex-B-average (population weighted) which would amount to 20,218 $\$_{1995}$ in 2000. This is only surpassed by two countries. Berk and den Elzen (2001) simulate triggers of 75% of average 1990 Annex I income. This would be very similar to the poorest Annex II country.

Table 1 summarises the impact of these thresholds.

Table 1: GDP thresholds for graduation to Annex B (2000 data)

	GDP/capita	Emissions (million t CO_2)	Share of current Annex B (> 1%)	Emissions change 1990-2000 (%)
Qatar	26,051	35.1		+150.4
Singapore	22,716	42.0		+46.0
Average Annex B	***20,218***	***77.1***	***0.6***	***+80.2***
Cyprus	19,197	6.3		+63.1

	GDP/capita	Emissions (million t CO_2)	Share of current Annex B (> 1%)	Emissions change 1990-2000 (%)
Taiwan	18,547	215.3	1.6	+88.9
Israel	18,454	62.4		+85.8
United Arab Emirates	18,182	68.7		+68.0
Oman	17,667	23.5		+120.1
Brunei	16,264	5.1		+57.8
Malta	15,333	2.3		-0.9
Lowest Annex II	***15,019***	***460.7***	***3.4***	***+83.3***
Bahamas[1]	15,000	1.9		NA
Kuwait	14,833	62.6		+213.1[2]
Barbados[1]	14,500	2.2		NA
Bahrain	14,203	14.1		+20.7
Korea	13,790	433.6	3.2	+91.7
Argentina	11,506	130.2		+33.1
Saudi Arabia	10,452	260.6	1.9	+54.1
Even number	***10,000***	***1461.8***	***10.7***	***+88.4***
Mauritius[3]	9940	1.8		NA
Chile	8898	48.1		+58.9
South Africa	8754	295.8	2.2	+16.2
Uruguay	8452	5.3		+25.4
Trinidad and Tobago	8446	15.1		+38.7
Mexico	8358	359.6	2.6	+23.1
Malaysia	8195	106.1		+123.9
Costa Rica	7630	4.6		+74.3
Botswana[3]	7170	3.1		NA
Brazil	6949	303.3	2.2	+57.0
Turkey	6299	204.1	1.5	+58.4
Thailand	6020	147.2	1.1	+89.0
Tunisia	5986	17.8		+45.4
Gabon	5878	1.4		+32.0
Colombia	5843	57.2		+27.8
Namibia	5744	1.9		+55.8[4]
Dominican Republic	5728	17.8		+132.6
Equatorial Guinea[3]	5600	NA		NA
Panama	5580	4.9		+98.8
Iran	5567	292.1	2.1	+83.7
Venezuela	5518	128.6		+25.4
Bosnia and Herzegovina	5452	15.4		-21.6[5]
Kazakhstan	5194	122.8		-50.75
Peru	4518	26.4		+37.7
Macedonia	4729	8.4		-8.1
El Salvador	4177	5.2		+141.7
Paraguay	4115	3.3		+70.6
Philippines	3845	68.9		+91.4
Guatemala	3577	8.8		+166.5
Turkmenistan	3548	34.3		+17.6[5]

	GDP/capita	Emissions (million t CO_2)	Share of current Annex B (> 1%)	Emissions change 1990-2000 (%)
Lowest Annex B	***3528***	***3766.2***	***27.5***	***+49.6***

[1] Data from national communication and World Bank

[2] very low 1990 level due to Iraqi occupation; compared to 1989 level, the increase is only 22.7%

[3] Philibert/Pershing (2002) and respective national communications

[4] compared to 1991

[5] compared to 1992

Source: IEA (2002)

4.2 CO_2-emissions per capita

The idea of this threshold is that countries take an absolute emissions target once a certain level of per capita emissions is reached. The threshold could be fixed at a certain (more or less arbitrary) value. If one wants to reach a global emissions path, the level of the threshold and the stringency of targets for countries that have passed the threshold are two distinct variables that can be set.

We discuss the following variations of the current per capita emissions target (see Table 2):

- Lowest current Annex B country (Latvia, at 2.8 t CO_2). 39 non-Annex B countries lie above accounting for 26.9% of Annex B emissions.
- Lowest Annex II country (Switzerland at 5.8 t CO_2). Here, still 21 countries lie above and emit 13.9% of Annex B values.
- Absolute threshold (e.g. 10 t CO_2) with 9 countries above accounting for 4.1% of Annex B emissions
- Annex B average (11.2 t CO_2) with 7 countries beyond that emit 3.4% of Annex B figures.

Table 2: Per capita emissions thresholds

	t CO_2/ capita	Emissions (million t CO_2)	Share of current Annex B (> 1%)	Emissions change 1990-2000 (%)
Qatar	60.0	35.1		+150.4
Kuwait	31.5	62.6		+213.1[1]
United Arab Emirates	23.7	68.7		+68.0
Bahrain	20.4	14.1		+20.7
Brunei	15.0	5.1		+57.8
Saudi Arabia	12.6	260.6	1.9	+54.1
Trinidad and Tobago	11.6	15.1		+38.7

	t CO_2/ capita	Emissions (million t CO_2)	Share of current Annex B (> 1%)	Emissions change 1990-2000 (%)
Average Annex B	***11.2***	***461.3***	***3.4***	***+71.0***
Singapore	10.5	42.0		+46.0
Israel	10.0	62.4		+85.8
Even number	***10.0***	***565.7***	***4.1***	***+70.3***
Taiwan	9.7	215.3	1.6	+88.9
North Korea	9.5	167.3	1.2	-15.7
Korea	9.2	433.6	3.2	+91.7
Cyprus	8.4	6.3		+63.1
Barbados[2]	8.2	2.2		NA
Oman	9.8	23.5		+120.1
Kazakhstan	8.3	122.8		-50.7[2]
Bahamas[3]	7.5	1.9		NA
Libya	7.3	38.9		+46.5
South Africa	6.9	295.8	2.2	+16.2
Turkmenistan	6.6	34.3		+17.6[2]
Malta	5.8	2.3		-0.9
Lowest Annex II	***5.8***	***1909.9***	***13.9***	***+31.6***
Venezuela	5.3	128.6		+25.4
Malaysia	4.6	106.1		+123.9
Iran	4.6	292.1	2.1	+83.7
Uzbekistan	4.6	114.9		+2.3[4]
Macedonia	4.1	8.4		-8.1
Yugoslavia	4.1	43.2		-22.8[5]
Bosnia and Herzegovina	3.9	15.4		-21.6[4]
Jamaica	3.7	9.8		+35.9
Mexico	3.7	359.6	2.6	+23.1
Azerbaijan	3.5	28.2		-37.4[4]
Argentina	3.5	130.2		+33.1
Iraq	3.3	77.2		+35.4
Lebanon	3.3	14.2		+121.8
Syria	3.2	52.3		+68.9
Chile	3.2	48.1		+58.9
Turkey	3.1	204.1	1.5	+58.4
Jordan	2.9	14.3		+55.4
Cuba	2.8	31.4		-1.1
Lowest Annex B	2.8	***3673.9***	***26.9***	***+36.6***

[1] very low 1990 level due to Iraqi occupation; compared to 1989 level, the increase is only 22.7%

[2] 1997 data

[3] 1994 data

[4] compared to 1992

[5] compared to 1991

4.3 Combined financial and emission thresholds: graduation index

A combination of GDP and per capita emissions thresholds would be promising as it captures both ability to pay and the polluter pays principle. If a "graduation index (GI)" is calculated where both figures are weighted with 50%, we get the results shown in Table 3. Each 10,000 $ GDP per capita and each 10 t CO_2 per capita give the graduation index value 1.

For example, Qatar has a GDP of 26,051 $ per capita (Graduation index = 2,6) and annual per capita emissions of 60 t CO_2 (Graduation index = 6). The graduation index of Qatar sums up to

$$GI_{Qatar} = \frac{2,6 + 6}{2} = 4,3$$

Table 3: Combined GDP and emissions per capita thresholds (2000 data)

	Graduation index[1]	Emissions (million t CO_2)	Share of current Annex B (%)	Emissions change 1990-2000 (%)
Qatar	4.3	35.1		+150.4
Kuwait	2.3	62.6		+213.1[2]
United Arab Emirates	2.1	68.7		+68.0
Bahrain	1.7	14.1		+20.7
Singapore	1.7	42.0		+46.0
Brunei	1.6	5.1		+57.8
Average Annex B	***1.6***	***227.6***	***1.7***	***+92.0***
Israel	1.4	62.4		+85.8
Taiwan	1.4	215.3	1.6	+88.9
Cyprus	1.4	6.3		+63.1
Oman	1.4	23.5		+120.1
Bahamas	1.3	1.9		NA
Saudi Arabia	1.2	260.6	1.9	+54.1
Korea	1.2	433.6	3.2	+91.7
Lowest Annex II	***1.2***[3]	***1231.2***	***9.0***	***+81.9***
Barbados	1.1	2.2		NA
Trinidad and Tobago	1.0	15.1		+38.7
Malta	1.0	2.3		-0.9
Even number	***1.0***	***1250.8***	***9.1***	***+80.9***
South Africa	0.8	295.8	2.2	+16.2
Argentina	0.7	130.2		+33.1
Kazakhstan	0.7	122.8		-50.7[4]
Libya	0.6	38.9		+46.5
Malaysia	0.6	106.1		+123.9
Mexico	0.6	359.6	2.6	+23.1

	Graduation index[1]	Emissions (million t CO_2)	Share of current Annex B (%)	Emissions change 1990-2000 (%)
Mauritius	0.6	1.8		NA
Turkmenistan	0.5	34.3		+17.6[4]
Venezuela	0.5	128.6		+25.4
Iran	0.5	292.1	2.1	+83.7
Uruguay	0.5	5.3		+25.4
Turkey	0.5	204.1	1.5	+58.4
Botswana	0.5	3.0		NA
North Korea	>0.4	167.3	1.2	-16.7
Lowest Annex B	***0.5***	***3139.7***	***22.9***	***+37.7***

[1] 10,000 $ and 10 t CO_2 give the graduation index value 1.

[2] very low 1990 level due to Iraqi occupation; compared to 1989 level, the increase is only 22.7%

[3] Switzerland

[4] compared to 1992

The graduation index approach leads to a de facto convergence of the lowest Annex II and even number threshold. The countries above the threshold account for 9% of current Annex B emissions and should be fully integrated into Annex B, especially as their emissions growth has been rapid. For the category between the even number threshold and lowest Annex B threshold a less stringent target regime should be envisaged given the diverse development status of the members of this group and the relatively low emissions increase in the last decade (also see proposal of Baumert et al as described in chapter 5.9).

4.4 Multi-year graduation index

Instead of using a single base year, the triggers could be based on *averages over a distinct period*, e.g. from 1991-2000 (see Table 5). This would better describe overall responsibility of a country and lead to a higher ranking of countries with a longer history of industrialisation and relatively slow growth.

Table 4: Triggers based on decadal averages 1991-2000

	t CO_2/ capita	GDP/capita	Decadal graduation index	Graduation index 2000
Qatar	54.1	22,981	3.9	4.3
United Arab Emirates	23.2	19,307	2.6	2.1
Kuwait	30.2	15,618	2.3	2.3
Bahrain	21.1	13,689	1.7	1.7
Brunei	14.5	16,660	1.6	1.6
Singapore	10.4	18,830	1.5	1.5

	t CO_2/ capita	GDP/capita	Decadal graduation index	Graduation index 2000
Average Annex B	***11.07***	***18,259***	***1.5***	***1.6***
Israel	8.4	16,936	1.3	1.4
Oman	7.9	17,092	1.2	1.4
Cyprus	7.3	16,721	1.2	1.4
Saudi Arabia	11.7	10,980	1.1	1.2
Taiwan	7.7	15,107	1.1	1.4
Malta	6.3	13,023	1.0	1.0
Even number	***10***	***10,000***	***1.0***	***1.0***
Korea	7.8	11,338	0.9	1.2
Trinidad and Tobago	9.8	7263	0.9	1.0
Lowest Annex II	***5.9***[1]	***13,329***[2]	***0.9***	***0.9***
Kazakhstan	10.3	4945	0.8	0.7
South Africa	7.0	8575	0.8	0.8
Argentina	3.3	11,101	0.7	0.7
Libya	6.9	5465	0.6	0.6
Venezuela	5.3	5876	0.6	0.6
Mexico	3.7	7408	0.6	0.6
Malaysia	3.8	7178	0.5	0.6
Chile	2.8	7637	0.5	0.5
Uruguay	1.6	8078	0.5	0.5
Turkmenistan	6.7	3809	0.5	0.5
Iran	3.9	5134	0.5	0.5
Macedonia	4.6	4503	0.5	0.4
North Korea	8.5	NA	>0.4	>0.4
Brazil	1.5	6610	0.4	0.4
Yugoslavia	4.4	3829	0.4	0.4
Thailand	2.2	5686	0.4	0.4
Turkey	2.6	5825	0.4	0.5
Lowest Annex B	***3.8***[3]	***4378***[4]	***0.4***	***0.4***

[1] Switzerland

[2] Greece

[3] Latvia

[4] Ukraine

Using the CDIAC dataset (CDIAC 2002) for the period since 1950, the results could be even smoothened further and more strongly reflect historical responsibility. Obviously, questions of data quality would arise.

4.5 Absolute emission thresholds

A further option would be to define absolute GHG-emissions of a nation as the threshold (not related to population or GDP). This would of course "disadvantage" large countries while sparing small countries regardless their economical situation or per capita emission and thus cannot be expected to be politically feasible. However, a country ranking based on absolute emissions provides a good overview on which countries should be included in the short term because of the magnitude of their impact on global climate. Table 6 provides data of all non-Annex B countries emitting more than 50 million t CO_2 in 2000.

table 5: Emitters above 50 million t CO_2

	Emissions (million t CO_2)	Share of current Annex B (> 1%)	Emissions change 1990-2000 (%)	t CO_2/ capita
China	***3035.5***	***22.1***	***+32.6***	***2.4***
India	***937.3***	***6.8***	***+60.7***	***0.9***
Korea	433.6	3.2	+91.7	9.2
Mexico	359.6	2.6	+23.1	3.7
Brazil	303.3	2.2	+57.0	1.8
South Africa	295.8	2.2	+16.2	6.9
Iran	292.1	2.1	+83.7	4.6
Indonesia	***269.3***	***2.0***	***+100.1***	***1.3***
Saudi Arabia	260.6	1.9	+54.1	12.6
Taiwan	215.3	1.6	+88.9	9.7
Turkey	204.1	1.5	+58.4	3.1
North Korea	167.3	1.2	-15.7	9.5
Argentina	130.2		+33.1	3.5
Venezuela	128.6		+25.4	5.3
Kazakhstan	122.8		-50.7[2]	8.3
Uzbekistan	114.9		+2.3[4]	4.6
Egypt	***108.5***		***+48.0***	***1.7***
Malaysia	106.1		+123.9	4.6
Pakistan	***98.0***		***+66.1***	***0.7***
Iraq	77.2		+35.4	3.3
Philippines	68.9		+91.4	0.9
United Arab Emirates	68.7		+68.0	23.7
Algeria	***66.6***		***+21.8***	***2.2***
Kuwait	62.6		+213.1[1]	31.5
Israel	62.4		+85.8	10.0
Colombia	57.2		+27.8	1.4
Syria	52.3		+68.9	3.2

One can see that only six countries are found on this list that do not figure on any of the previous graduation thresholds. Those are China, India, Indonesia, Egypt, Pakistan and Algeria.

However, these countries account for a combined 33 % of Annex B emissions and in the sum had an emission increase of 41.4% during the last decade. They thus combine more emissions than the entire set of graduating countries and thus should be subject of a special agreement which entitles them to a considerably less stringent target, if at all, or defines a special instrument such as a country-wide CDM (also see discussion in chapters 6 and 9).

4.6 Institutional thresholds

Other than being derived from quantitative thresholds, graduation could also be linked to institutional parameters. An simple institutional graduation scheme could look like as depicted in table 6:

table 6: Institutional graduation

Institutional characteristics	Graduation
EU, OECD, IEA membership	Automatic inclusion in Annex B
OPEC membership	Graduation depending on index as defined above
LDC, IDA and food aid recipients	Exempt

4.7 Comparison of approaches

Above, we have discussed several threshold triggers.

table 7 compares the results of the options, ranking countries by their current absolute emissions. An "x" indicates that the country passes the respective threshold and thus would be included in a future Annex B. The last row of the table summaries how often a given country surpasses the thresholds analysed. For example, China - accounting for 13% of global emissions in 1999 - only passes the threshold "more than 50 million tons CO_2 emissions". Consequently, the value of the last row is 1.

table 7: Comparison of threshold triggers

	Emissions 2000 [million t CO2]	Share of global emissions (1999)	GDP/capita > lowest Annex II	GDP/capita > 10.000 $	GDP/capita > lowest Annex B	t CO2/ capita > 10	t CO2/ capita > lowest Annex II	t CO2/capita > lowest Annex B	GI_2000 > lowest Annex B	GI_2000 > lowest Annex II	GI_2000 > 1	GI_decadal > lowest Annex B	GI_decadal > lowest Annex II	GI_decadal > 1	total emissions > 50 mio t	total of positive decisions
China	3035,5	13,0%													x	1
India	937,3	3,8%													x	1
Korea	433,6	1,8%		x	x		x	x	x		x	x	x		x	9
Mexico	359,6	1,5%			x			x	x			x			x	5
Brazil	303,3	1,3%			x							x			x	3
South Africa	295,8	1,3%			x		x	x	x			x			x	6
Iran	292,1	1,2%			x			x	x			x			x	5
Indonesia	269,3	1,1%													x	1
Saudi Arabia	260,6	1,1%		x	x	x	x	x	x		x	x	x	x	x	11
Taiwan	215,3	0,9%	x	x	x		x	x	x	x	x	x	x	x	x	12
Turkey	204,1	0,8%			x			x	x			x			x	5
North Korea	167,3	0,9%					x	x	x			x			x	5
Thailand	147,2	0,6%			x							x			x	3
Argentina	130,2	0,6%		x	x			x	x			x			x	6
Venezuela	128,6	0,5%			x			x	x			x			x	5
Kazakhstan	122,8	0,5%			x		x	x	x			x			x	6
Uzbekistan	114,9	0,5%						x							x	2
Egypt	108,5	0,4%													x	1
Malaysia	106,1	0,4%			x			x	x			x			x	5
Pakistan	98,0	0,4%													x	1
Iraq	77,2	0,3%						x							x	2
Philippines	68,9	0,3%			x										x	2
United Arab Emirates	68,7	0,3%	x	x	x	x	x	x	x	x	x	x	x	x	x	13
Algeria	66,6	0,3%													x	1
Kuwait	62,6	0,3%		x	x	x	x	x	x	x	x	x	x	x	x	12
Israel	62,4	0,2%	x	x	x	x	x	x	x	x	x	x	x	x	x	13
Colombia	57,2	0,2%			x										x	2
Syria	52,3	0,2%						x							x	2
Chile	48,1	0,2%			x			x	x			x				4
Yugoslavia	43,2	0,2%						x				x				2

	Emissions 2000 [million t CO2]	Share of global emissions (1999)	GDP/capita > lowest Annex II	GDP/capita > 10.000 $	GDP/capita > lowest Annex B	t CO2/ capita > 10	t CO2/ capita > lowest Annex II	t CO2/capita > lowest Annex B	GI_2000 > lowest Annex B	GI_2000 > lowest Annex II	GI_2000 > 1	GI_decadal > lowest Annex B	GI_decadal > lowest Annex II	GI_decadal > 1	total emissions > 50 mio t	total of positive decisions
Singapore	42,0	0,2%	x	x	x	x	x	x	x	x	x	x	x	x		12
Libya	38,9	0,2%					x	x				x				3
Qatar	35,1	0,2%	x	x	x	x	x	x	x	x	x	x	x	x		12
Turkmenistan	34,3	0,1%			x		x	x	x			x			x	6
Cuba	31,4	0,1%														0
Azerbaijan	28,2	0,1%				x	x	x	x	x	x					6
Peru	26,4	0,1%			x											1
Oman	23,5	0,1%	x	x	x		x	x	x	x	x	x	x	x		11
Dominican Republic	17,8	0,1%			x											1
Tunisia	17,8	0,1%			x											1
Bosnia and Herzegovina	15,4	0,02%			x			x	x							3
Trinidad and Tobago	15,1	0,1%			x	x	x	x	x		x	x	x			8
Jordan	14,3	0,1%						x								1
Lebanon	14,2	0,1%						x								1
Bahrain	14,1	0,1%		x	x	x	x	x	x	x	x	x	x	x		11
Jamaica	9,8	0,04%						x								1
Guatemala	8,8	0,04%			x											1
Macedonia	8,4	0,04%			x			x				x				3
Uruguay	5,3	0,03%			x				x			x				3
El Salvador	5,2	0,02%			x											1
Brunei	5,1	0,02%	x	x	x	x	x	x	x	x	x	x	x	x		12
Panama	4,9	0,02%			x											1
Costa Rica	4,6	0,02%			x											1
Cyprus	3,6	0,03%	x	x	x		x	x	x	x	x	x	x	x		11
Paraguay	3,3	0,02%			x											1
Botswana3	3,1	0,01%			x				x							2
Barbados1	2,2	0,01%		x	x		x	x	x		x					6
Bahamas1	1,9	0,01%		x	x		x	x	x		x					6
Namibia	1,9	0,01%			x											1
Mauritius3	1,8	0,01%			x				x							2
Gabon	1,4	0,01%			x											1
Malta	1,3	0,01%	x	x	x		x	x	x		x	x	x	x		10
Equatorial Guinea		0,00%			x											1

GI_2000 = graduation index based on 2000 data

GI_decadal = graduation index based on data from 1990-2000 figure 5 compares the amount of global emissions covered by the individual approaches.

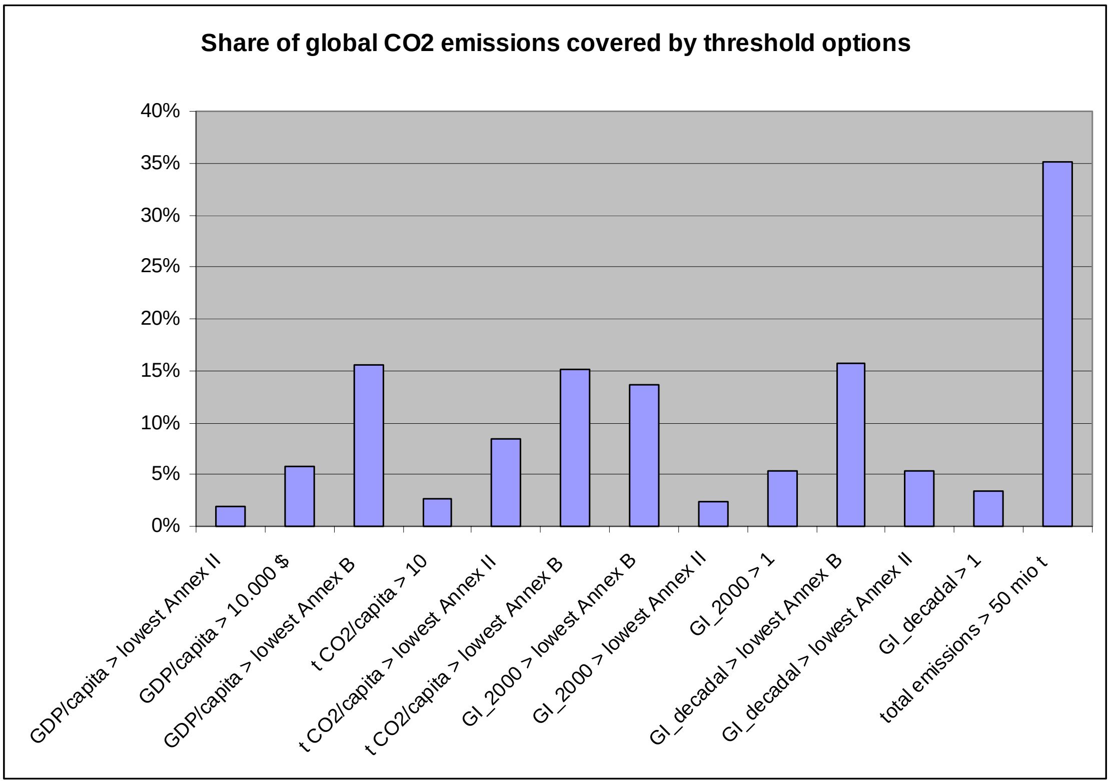


figure 5: share of global CO_2-emissions covered by the individual threshold options

Important questions that are relevant for *all* threshold approaches include:

- How often is the ranking conducted?
- Are threshold values (especially financial ones) updated and, if so, how often?
- Will countries that have passed the threshold once have to be reclassified to "nations without targets" as soon as they fall below the threshold, e.g. for a certain period?

5. Quantification of national emission targets

Once the methods to determine which countries take up a target and the global emission target in a given period (e.g. by means of a GHG-concentration path) have been defined, the target level has to be specified for every country. Several principles have been developed over the last decade to avoid an ad-hoc “oriental bazaar” bargaining.

Once again, the notion of equity is important. While some analysts argue that “existing theories provide little or no guidance to the equity of any particular international allocation of carbon emission permits” (Beckerman and Pasek 1995), others (Grubb 1995, New Economics Foundation 2002) see some clear recommendations emanating from the equity principles discussed.

Table 8 shows main equity principles suggested in the last years that allocate targets dependent on different criteria.

Table 8: Equity principles

Principle	Criterion
Need for economic development[1]	Equal per capita emissions budget
Responsibility for the problem[1]	Stringency of reduction proportional to cumulated emissions
Capacity, i.e. ability to pay[1]	Stringency of reductions proportional to GDP per capita
Opportunity[2]	Stringency of reductions proportional to availability of cheap reduction potential

[1] Jansen et al (2001)

[2] Claussen and Mc Neilly (1998)

Closely connected to the above named principle of "capacity" is the question if and what kind of targets (in terms of stringency) are economically viable especially for developing countries. One must be aware, however, that there is no universal answer to this question. A country-specific approach seems necessary since national circumstances and economic needs differ strongly regardless their classification as industrialised or developing country.

A seemingly easy option would be to correlate target stringency to economic parameters such as GDP per capita or power purchase parities, with the latter accounting for national differences. Another option would be to use “standard of living” as the correlating parameter – but to do so, indicators would need to be defined on a global scale and applied first.

Factors that could also be taken into consideration are:

- standards of public infrastructure (social, health, infant mortality),
- availability of natural resources,
- recent pace of development,
- international debts,
- international development aid received, etc.

Overall, a fair allocation of target stringency seems a very complex task. Further research seems necessary to provide a solid foundation for discussion and international negotiations .

In the sum, the task to define national emissions targets based on the degree of development is a very complex one and a highly political issue. Objective criteria / formulas should be worked out to serve as the starting point for international negotiations. In the following, we present the methodological approaches that have been proposed in recent years.

5.1 Grandfathering

“Grandfathering” allocates emission budgets cost-free according to emissions in a specified base year. It was the basis of the UNFCCC targets and is found to a great extent in the Kyoto targets (base year 1990/1995). Grandfathering under a strongly declining emissions path due to a tough concentration target will lead to extremely challenging targets for countries with strongly rising business-as-usual emissions. Thus Non-Annex B countries will stiffly oppose global grandfathering. At the same time, grandfathering advantages countries with high emissions in the reference year/period chosen, which basically are industrialised countries. Grandfathering by itself does not take account of the equity issue.

However, initial grandfathering is a crucial dimension of most compromise proposals.

5.2 Per capita allocation

Equal per capita allocation has been argued for by representatives of developing countries from the start of the climate negotiation process (Agarwal and Narain 1991). As immediate per capita allocation would lead to an enormous shortfall in Annex B emissions budgets and a corresponding surplus in Non-Annex B budgets, it is not suggested by any serious proposal. However, many proposals contain elements of per capita allocation at a future date. The question is how the transition process is managed. A promising approach is the Contraction and Convergence model described below.

5.3 Contraction and convergence

The ethically appealing and easy-to-understand approach "contraction and convergence" has been developed and marketed by the Global Commons Institute and increasingly attracted supporters (see the interesting description of its history in Meyer 2000). On the basis of a concentration target, a global emissions budget path is developed. A date is negotiated by which budgets are derived on an equal per capita basis. Until then, budgets decrease proportionally from current emission levels (see **figure 6**).

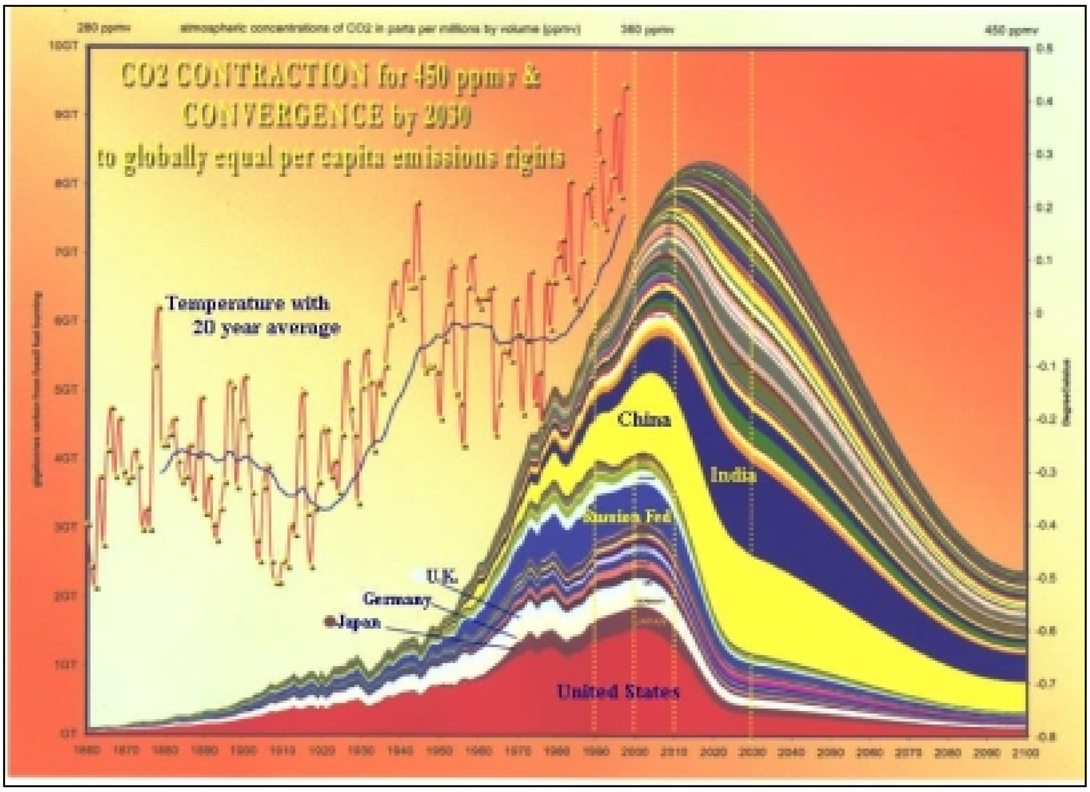


figure 6: Contraction & Convergence model of Aubrey Meyer. Emissions in Gt C for each country/region between 1800-2200, for convergence of per capita emissions in 2030 and concentration goal 450 ppm.

Resulting emissions reductions for Annex B countries are the sharper, the earlier convergence takes place and the lower the target concentration level. The Global Commons Institute provides the model free of charge. Emissions targets for major countries / country groups for different years as well as some sensitivity analysis (variation of stringency levels expressed in concentration targets) is shown in table 9.

table 9: Contraction and convergence targets for 2020 under different concentration targets and convergence dates (%, base year 1990)

Contraction and Convergence targets for 2020 under different concentration targets and convergence dates (% reduction of 1990 emissions)				
Concentration target 2100	**450 ppmv**			
Convergence Year	**2030**	**2050**	**2070**	**2090**
Russia	-55.9	-36.4	-30.5	-27.8
India	+432.8	+283.3	+237.5	+216.6
China	+114.6	+100.4	+95.9	+93.8
Brazil	+220.1	+147.7	+125.4	+115.3
Qatar	+29.7	+129.5	+160.0	+173.9
Kuwait	-54.4	-32.4	-25.6	-22.5
UA	-45.2	-12.0	-1.9	+2.8
Bahrain	-24.2	+20.4	+34.0	+40.3
Brunei	-33.3	+9.6	+22.7	+28.7
Saudi Arabia	+13.5	+44.2	+53.8	+58.2
Trinidad and Tobago	-39.6	-18.8	-12.5	-9.6
Singapore	+21.4	+103.4	+128.5	+139.9
Israel	+7.0	+36.3	+45.3	+49.4
Taiwan	+10.0	+51.6	+64.2	+69.9
North Korea	-29.0	-7.2	-0.6	+2.5
Korea	+18.8	+53.9	+64.6	+69.4
Cyprus	-8.5	+10.6	+16.4	+19.1
Barbados	-7.8	-8.9	-9.3	-9.5
Oman	+65.0	+85.3	+92.1	+95.3
Kazakhstan	-59.9	-44.3	-39.6	-37.5
Bahamas	+29.2	+58.8	+67.8	+71.9
Libya	+71.2	+95.2	+102.9	+106.5
South Africa	-6.7	+5.2	+8.9	+10.6
Turkmenistan	-46.9	-42.2	-40.7	-40.1
Malta	-3.4	+1.6	+3.0	+3.6
Venezuela	+53.0	+95.8	+108.9	+114.9
Malaysia	+129.6	+162.1	+172.1	+176.6
Iran	+108.1	+100.4	+98.4	+97.6
Uzbekistan	+4.8	+0.1	-0.7	-1.3
Macedonia	-56.0	-50.5	-48.9	-48.2
Yugoslavia	-37.6	-41.9	-43.3	-44.0
Bosnia & Herzeg.	+293.8	+167.7	+128.0	+109.8
Jamaica	+36.2	+30.9	+29.3	+28.5
Mexico	+46.1	+43.1	+42.1	+41.7

Contraction and Convergence targets for 2020 under different concentration targets and convergence dates (% reduction of 1990 emissions)				
Concentration target 2100	**450 ppmv**			
Convergence Year	**2030**	**2050**	**2070**	**2090**
Azerbaijan	-35.4	-28.9	-26.9	-26.0
Argentina	+46.7	+47.8	+48.1	+48.2
Iraq	+296.9	+323.6	+332.4	+336.6
Lebanon	+68.2	+71.1	+72.0	+72.4
Syria	+159.3	+125.1	+115.3	+111.0
Chile	+79.3	+66.5	+62.5	+60.6
Turkey	+77.8	+47.4	+38.1	+33.8
Jordan	+200.9	+127.8	+106.2	+96.6
Cuba	+27.3	+13.8	+9.4	+7.4
Major global emitters / regions				
USA	-43.5	-13.5	-4.4	-0.2
Japan	-37.7	-17.7	-11.6	-8.9
Western Europe	-36.3	-17.2	-11.5	-8.9
Rest Annex I	-40.3	-13.8	-5.8	-2.1
FSU	-53.8	-33.6	-27.4	-24.6
EET	-43.1	-29.3	-25.1	-23.2
Rest FSU	-36.0	-28.9	-26.7	-25.8
South East Asia	+308.7	+222.0	+195.4	+183.3
East Asia	+94.7	+89.9	+88.2	+87.5
South Asia	+536.0	+341.5	+282.4	+255.4
Middle East	+75.2	+73.1	+72.7	+72.6
Latin America	+148.1	+118.7	+109.7	+105.6
Africa	+360.6	+219.5	+177.5	+158.6
Population cutoff 2050, exponential convergence mode, speed of convergence parameter 4, planned 110-year emissions (in GtC) = 590 for 450 ppmv				

Some argue that there are other factors influencing the amount of per capita emissions, e.g. a colder climate or lower availability of renewable resources of a country which could lead to differences of cross-country CO_2 emissions and should therefore be considered to adjust allocation of emissions permits.

Neumeyer et al. (2002) have analysed those factors. However, they come to the conclusion that natural factors can help to explain these differences, but only to a limited extent. A country´s income level remains the main explanatory variable. Consequently, they have not proposed a target allocation based on these factors.

5.4 Cumulative emissions

A more complex proposal calculates the cumulative warming impact of country emissions and assigns more stringent targets to those countries with the highest cumulative emissions. For a more detailed discussion see Brazil 1997, La Rovere et al. 2002.

5.5 Preference scores

The preference scores approach asks countries to specify their preference for either grandfathering or per capita allocation. The preferences are globally weighted with country population (Bartsch/Müller 2000, p. 259ff). The overall budget is derived from the emissions path that reaches the desired concentration target. On the basis of a 550 ppm concentration target a global target of 31.5 billion t $CO_{2\text{-eq}}$ is derived for 2020, leading to a global reduction of 14.4% from business-as-usual. The calculation of the preference scores gives a weighting of 75% of per capita and 25% of grandfathering (see Table 10).

Table 10: Preference score calculation

	Per capita score[1]	**Grandfathering score**[1]	**2020 target (% change, base year 1995)**[2]
US	0	292	-46.1
Japan	0	127	-21.7
Europe	0	390	-18.3
Other EITs	0	391	-26.5
Middle East and North Africa	0	335	+18.8
Latin America	471	0	+92.7
China	1304	0	+84.3
Asian NICs	473	0	+80.2
India	1082	0	+370.0
Rest of developing countries	1569	0	+320.0
World	**4900**	**1591**	**+33.3**
Weights	**75%**	**25%**	**NA**

[1] Population projections for 2005

[2] Energy-related greenhouse gas emissions only

Source: Bartsch/Müller (2000, p. 262f).

5.6 Triptych

The Triptych approach defines three sectors – electricity generation, heavy industry and households (Groenenberg et al. 2000). For each sector, a variable is deemed to linearly converge to a uniform global value at a future date – greenhouse gas intensity of electricity production, energy efficiency of industry and per capita emissions. So the Triptych is essentially a sectoral and linear contraction and convergence approach. It has been successfully used within the EU to reallocate targets within the bubble. Groenenberg (2002) defines a global Triptych for 2020. A decisive input necessary to apply a Triptych are estimates for the growth rates of electricity generation, production of heavy industry and population; Groenenberg uses World Energy Council and U.N. projections. One needs to be aware that uncertainties are the higher, the farther the target year is in the future. Key elements of the approach are shown in table 11.

table 11: Determinants of global Triptych

	Electricity generation	**Heavy industry**	**Households**
Variable addressed	Emissions intensity[1]	Energy efficiency[2]	Per capita emissions[3]
Convergence year	2050	2050	2050
Convergence level	200[4]	0.67[5]	2[6]
US 1995	580	1.8	10.3
Japan 1995	400	1.3	4.6
Western Europe 1995	390	1.2	4.6
Former Soviet Union 1995	700	2.0	4.1
Middle East 1995	640	1.6	2.6
Latin America 1995	230	1.5	1.7
East Asia 1995	790	1.9	1.0
South East Asia 1995	610	1.6	0.8
South Asia 1995	860	1.7	0.5
Africa 1995	590	1.6	0.6

[1] g CO_2/kWh

[2] Best practice in 1995 = 1

[3] t CO_2.

[4] Derived from the estimate that 50% of the gap between the current best practice and the thermodynamic minimum can be closed.

[5] Derived from an assessment of basic energy needs on European consumption level of the 1970s that leads to an average of 1.5 kW per capita

[6] Derived from the assumption of 60% renewables and 13.3% each of oil, gas and coal.

Evaluation of the proposal: an optimistic assumption is that non-CO_2 emissions in both heavy industry and the household sector will be reduced by 100% and methane from fossil fuel production by 90% until the convergence year. Agricultural emissions of methane and nitrous oxide are estimated to stabilise while per capita emissions from deforestation are assumed to linearly decrease to zero until 2050.

Table 12 shows the resulting emissions targets for 2020 and some sensitivity analyses.

Table 12: Emission targets under global Triptych compared to 1995 (%)

	Base case[1]	**Energy efficiency strengthened[2]**	**Electricity intensity relaxed[3]**	**Per capita emissions relaxed[4]**
US	-27, -27	-28	-25	-23
Japan	-21, -21	-23	-18	-14
Western Europe	-19, -19	-21	-16	-12
Former Soviet Union	-23, -21	-21	-19	-14
Middle East	+33,+34	+33	+36	+54
Latin America	+10,+29	+28	+31	+46
East Asia	+36,+47	+45	+49	+68
South East Asia	+59,+77	+76	+79	+115
South Asia	+187,+213	+210	+218	+296
Africa	+95,+140	+139	+144	+208
World	**+19,+24**	**+23**	**+27**	**+44**

[1] First value: with deforestation, second value without. Sensitivity analyses are done without deforestation and should be compared with the second value.

[2] Convergence level 0.5

[3] Convergence level 300g CO_2/kWh

[4] 3 t CO_2/capita

One clearly sees the importance of the household sector as the impact of changes in household per capita emissions is much higher than the one in the other sectors. The base case achieves an emissions path leading to a concentration of about 600 ppm. Nevertheless, the targets for Annex B countries in the second commitment period are quite tough compared to the first commitment period. Obviously, several developing country regions would still hold substantial surplus that could be sold.

The Triptych has already shown its usefulness in the EU. It avoids the extremes of grandfathering and per capita allocations and thus is a suitable compromise candidate, especially if the growth assumptions are regularly checked and recalculations done accordingly. Some assumptions may be too optimistic but convergence dates and levels can be adjusted.

5.7 Multi-sector convergence

The multi-sector approach (Jansen et al. 2001) has some similarities with the Triptych. It starts with the definition of seven sectors – power generation, households, transport, industry, services, agriculture and waste. For these sectors global "emission standards" are set on a per capita basis derived from a set concentration target; they converge at a set future year. The sectoral standards are then converted into indicative national targets; all countries that have a per capita emission above the world average have to make that target binding. Specific national circumstances can be addressed through ad hoc adjustments, which of course reopens the whole regime and is not advisable. Countries that have to take up targets can apply an adjustment period of one commitment period before the targets become binding.

table 13: 2020 targets for multi-sector convergence at 3.6 t CO_2/capita in 2100

	2020 target (% change, base year 1990)
US	-17.3
Japan	-19.3
EU	-20.0
Russia	-25.0
China	+146.6
India	+176.5
Brazil	+212.6
Tanzania	+309.5

A practical problem concerning both the Triptych and the multi-sector approach will probably be data availability on a global scale. Whereas one can expect needed data to be available in Annex-B and most Annex-II countries, data availability might be insufficient in many developing countries – with the situation getting worse the lower the degree of development of a given country is. For example, in some African countries researchers have encountered severe problems to gather sufficient data for a project baseline in the electricity sector (PROBASE 2003). As data demand for such baselines is similar to the one for the Triptych and/or Multi-Stage approach, one might doubt the applicability of such complex formulas on a global scale in the short term. Although one might expect many developing countries favour such a "fair" approach, those countries that oppose it may easily boycott its application by not providing needed data.

5.8 Differentiated methodology according to degree of development

Taking into account the industrialised countries political power and their interest not to impose extraordinary burdens on their economy as well as the developing countries´ call for equity and historical responsibility, an attractive alternative might be a two-fold-approach. After the global emissions budget has been determined for a certain year or period, emission targets for the group of industrialised countries and for the group of developing countries would be defined (categorisation of countries according to internationally accepted definitions, i.e. UN definitions / country ranking). Allocation within the group of industrialised countries could e.g. be based on the grandfathering principle or on the emissions targets of the first Kyoto period (which would avoid the perverse incentive for countries not to reach their targets which exists if a future base year was chosen). Allocation within the group of developing countries could then be based on a different criterion as e.g. per capita emissions.

The first major issue would then be the allocation of emission budgets to the groups industrialised / developing countries.

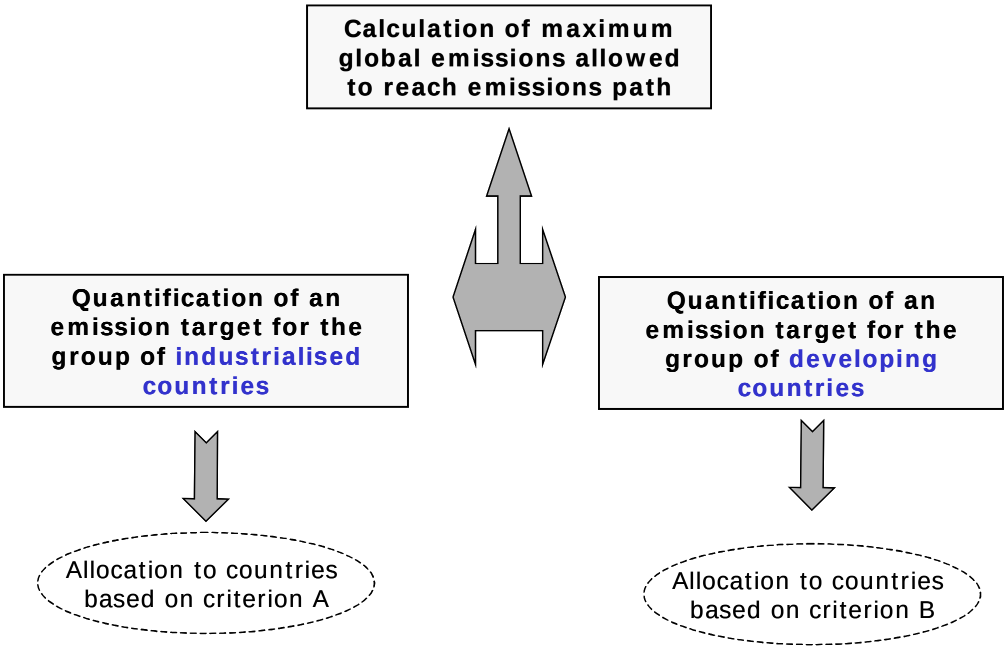


figure 7: differentiated target definition developing – industrialised countries

5.9 Other approaches

Baumert (2002) proposes a *dual target* consisting of a stringent target from which emissions trading can be done, and a considerably weaker target that triggers non-compliance procedures. Targets could be linked to an international price cap per tonne of CO_2 equivalent. This presumes an international emissions trading system. When the market price rises above the threshold value, governments can issue an unlimited quantity of additional allowances (Kopp et al. 1999, Victor 2001, Philibert/Pershing 2002).

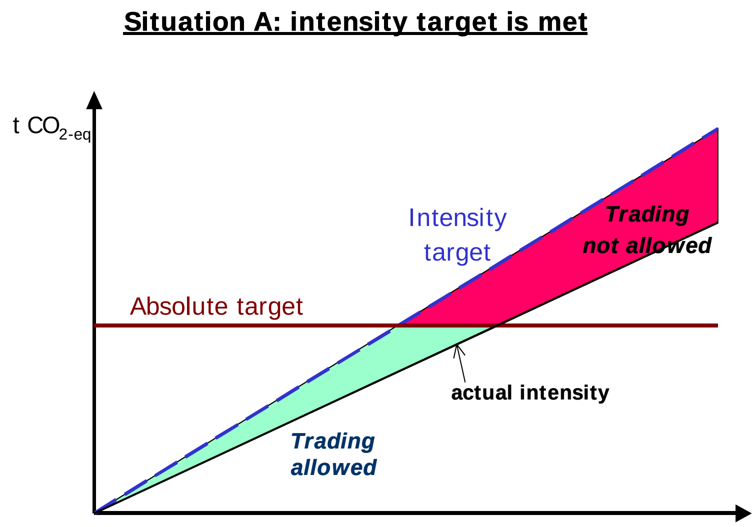
A *mix of absolute and relative targets* could also be envisaged. As an example, Parties with a two-tired target would be in compliance as long as either their relative or their absolute emissions are below the negotiated intensity/absolute level. Participation in trading would be allowed if intensity targets are met as long as the absolute threshold is not passed (, situation A). If the intensity target is not met, emissions trading would not be allowed (situation B). Non-compliance sanctions would only become effective if both intensity targets and absolute thresholds are passed[3].

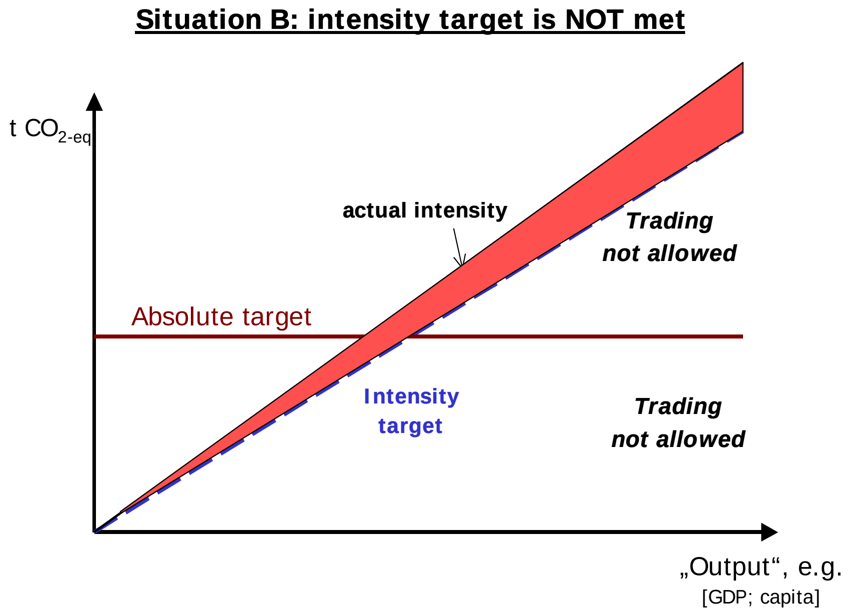
Such a two-tiered approach might be a politically promising approach to encourage developing countries to take obligations under the UNFCCC. The decisive question again is what reference figure/corresponding value is chosen to define intensity targets.

If a system combines absolute and relative targets, one would need to establish special structures to "translate" relative targets and emission rights into absolute ones. A good example is the "Gateway" that was established in the UK emissions trading scheme.

[3] Note that this is only one possible design option.

figure 8: Combination of absolute and relative targets





5.10 Acceptability of approaches

If developing countries were to take on emission targets, one would argue that the targets should not lead to an undue economic burden. As described, numerous approaches and variants of formulas to calculate national emissions targets for future Annex-B parties exist, many further can be thought of. However, the evaluation of which formula is a fair one and/or acceptable will strongly depend on national circumstances and priorities. One must be aware that each country's understanding of what kind of target is economically viable is highly subjective. As the president of the U.S. has stated clearly, he does not believe the world's leading nation can afford to accept an absolute emissions targets. Also, the awareness that there is a need to reduce global GHG reductions can be expected to correlate to the country's exposure to negative impacts of climate change.

Nevertheless, one could imagine the definition of indicators and setting of thresholds that would define a maximum burden. Possible indicators are:

- Costs relative to GDP
- Costs relative to GDP growth during a specified period, i.e. the last decade
- Costs relative to export earnings

Similar indicators have been used in the context of determining debt alleviation.

A general problem with these indicators is that the calculation of costs is not straightforward and depends on a number of assumptions. Moreover, it would be unlikely that developing countries are willing to accept higher burdens than industrialised countries did during the first commitment period. Assuming a fully functioning international greenhouse gas market with a price of 5 \$/t CO_2, and the maximum cost accruing if one buys the total reductions needed on the international market, the following burden would accrue (see table 14).

table 14: Annual climate policy burden in 2010 for industrialised countries

Region	Emission reduction need (Mt CO_2)	Gross costs (billion \$)	GDP 2000[1] (billion \$)	Costs/ GDP (%)	Costs/GDP growth in 1990s (%)	Costs/export earnings 2001 (%)
United States	2,141	10.7	8987	0.12	0.43	1.46
Western Europe	693	3.5	8594	0.04	0.22	0.14
Japan	330	1.7	3144	0.05	0.41	0.42
Other OECD Annex B	337	1.7	2014	0.08	0.36	0.38
Russia, Ukraine, non-OECD Eastern Europe	-1,162	Negative	1517	Negative	NA	Negative

[1] Obviously, one should use a date as close to the target date as possible. Using a past date overestimates costs if the economy is growing

Source: emission reduction data from Jotzo/Michaelowa, (2002), GDP purchasing power data from IEA (2002), export earnings from WTO (2003)

Given that developing countries would not accept higher relative burdens than industrialised countries, the threshold of the cost indicator should be defined by the lowest value for a region in the industrialised world excluding the regions endowed with hot air[4]. If one then calculates backwards from developing country data by using the same market price as used above, one arrives at the reduction target from business-as-usual. table 15 provides numerical values derived from the thresholds of table 14 for the countries with an emission of more than 50 million t CO_2.

table 15: Developing country reduction targets from business-as-usual under different thresholds (million t CO_2 and % of 2000 emissions)

Country/Region	GDP 2000[1] (billion $)	Reduction under costs/GDP threshold	Reduction under costs/GDP growth threshold	Reduction under costs/export earnings threshold
Threshold level		**0.04%**	**0.22%**	**0.14%**
China	4721	378 (12.6%)	1286 (42.9%)	74 (2.5%)
India	2247	180 (19.2%)	497 (53.0)	12 (1.3%)
Korea	652	52 (12.0%)	128 (29.6%)	42 (9.7%)
Mexico	813	65 (18.1%)	104 (28.9%)	45 (12.5%)
Brazil	1184	95 (31.4%)	92 (30.4)	16 (5.3%)
South Africa	375	30 (10.1%)	25 (8.4%)	8.2 (2.8%)
Iran	355	28 (9.6%)	52 (17.8%)	7.0 (2.4%)
Indonesia	576	46 (17.1%)	86 (32.0%)	16 (5.9%)
Saudi Arabia	217	17 (6.5%)	19 (7.3%)	19 (7.3%)
Taiwan	412	33 (15.3%)	81 (37.7%)	34 (15.8%)
Turkey	421	34 (16.7%)	55 (27.0%)	8.7 (4.3%)
North Korea	NA	NA	NA	NA
Argentina	426	34 (26.2%)	68 (52.3%)	7.5 (5.8%)
Venezuela	133	11 (8.5%)	11 (8.5%)	7.7 (6.0%)
Kazakhstan	77	6.2 (5.0%)	Negative	2.4 (2.0%)

[4] If one would include this region, the threshold would be zero and developing countries would not accept any burden; they could even ask for likewise benefits.

Country/Region	**GDP 2000[1] (billion $)**	**Reduction under costs/GDP threshold**	**Reduction under costs/GDP growth threshold**	**Reduction under costs/export earnings threshold**
Uzbekistan	55	4.4 (3.8%)	Negative	NA
Egypt	220	18 (16.7%)	34 (31.4%)	1.1 (1.0%)
Malaysia	191	15 (14.2%)	41 (38.7%)	25 (23.6%)
Pakistan	249	20 (20.4%)	35 (35.7%)	2.6 (2.7%)
Iraq	32	2.6 (3.3%)	Negative	4.4 (5.7%)
Philippines	291	23 (33.3%)	32 (46.4%)	9.0 (13.0%)
United Arab Emirates	53	4.0 (5.8%)	4.9 (7.1%)	12 (17.4%)
Algeria	152	12 (17.9%)	11 (16.4%)	5.6 (8.1%)
Kuwait	29	2.3 (3.7%)	5.3 (8.4%)	4.5 (7.1%)
Israel	115	9.2 (14.8%)	20 (32.3%)	8.1 (13.1%)
Colombia	247	20 (35.1%)	26 (45.6%)	5.4 (9.5%)
Syria	50	4.0 (7.7%)	9.5 (18.3%)	1.3 (2.5%)
Sum	**14293**	**1144**	**2755**	**379**
% of world emissions		**4.9%**	**11.8%**	**1.6%**

Data sources: see table 14

One can easily see that the GDP-related approaches lead to high reduction rates, especially for quickly growing countries while the trade-related approach generates low rates except for a few countries with a high export value. As the market price enters the calculation on the side of the threshold calculation as well as the conversion of the threshold into the emissions target, it does not play a role.

A generic formulation of this approach would be:

$$C_{IC} = p * R_{bau-IC}$$

with C_{IC} = costs for industrialised country, p = international price for emission permits, R_{bau-IC} = average emission reduction during the commitment period compared to business-as-usual

$$C_{IC-GDP} = \frac{C_{IC}}{GDP}$$

with GDP = most current value of purchasing-power GDP

$$C_{DC-GDP} = \min(C_{IC-GDP})$$

with C_{DC-GDP} = cost threshold for developing country. C_{IC-GDP} is preferably defined on the basis of multi-country regions to avoid undue influence by outliers.

$$R_{bau-DC} = \frac{C_{DC-GDP}}{p}$$

with R_{bau-DC} = emission reduction target compared to business-as-usual.

Critical parameters are the region definition for threshold determination and the definition of business-as-usual emission paths.

At the same time it must be recognised that many countries currently having a Non-Annex-B status will ask for incentives to commit themselves to an emissions target. Such incentives can be of direct or indirect financial or of political nature. Next to those extra incentives, Non-Annex-B countries might find some intrinsic advantages to "voluntarily" join Annex-B. Chapter 6 elaborates on hurdles and incentives to do so.

6. Hurdles and incentives to join Annex B

In preparation for upcoming international negotiations, many developing countries will need to evaluate for themselves if they prefer to enter Annex B or to remain in the Non-Annex-B group.

It can be expected that developing countries will demand “incentives” from the international community to take emission targets. The extend of incentives needed will obviously depend on target type and stringency. The developing countries evaluation should contain an assessment of the benefits and drawbacks but also of the barriers and existing incentives to join Annex B. In the following, we discuss major elements that should be taken into account.

6.1 Institutional requirements

The capacity of many Non-Annex B countries to implement even the basic requirements of the UNFCCC is limited (UNITAR/North-South Dialogue on Climate Change 2001). Thus the question arises whether they will be able to implement targets or the much easier step to participate in the CDM.

6.1.1 Capacity for target implementation

Countries interested in reaping the benefits of joining Annex B should be very realistic in assessment of their possibilities to sell assigned amounts. If a country has not assessed its situation properly and adopted a challenging target it will pay a penalty due to non-compliance with its commitments at the end of the budget period. Therefore, it has:

- to assess the growth and emission reduction potential of the different sectors of its economy and to define priorities;
- to develop a national strategy on GHG-emission reduction;
- to assess the investments and time needed for realisation of the measures on GHG-emission reduction;
- to assess whether the funds received from selling of assigned amounts will be able to cover the expenses for GHG-emission reduction.

Countries with a differentiated industrial sector should be able to reduce overall energy intensity provided the sectoral structure does not change. China is a good example. A successful reduction of energy intensity needs a prior abolition or strong reduction of subsidies. In democratic countries with strong interest groups this is not easy as examples from both the industrialised (coal subsidies in Germany) and the developing countries (electricity subsidies for Indian farmers) show. Countries where a large part of the population has not yet moved up the energy ladder are likely to exhibit a growing domestic energy intensity. (This would call for a Triptych approach where the household sector still has room to grow but the industrial sector intensity ho be reduced.)

6.1.2 Capacity for implementation of CDM

Even if the CDM in principle provides an opportunity for developing countries, will they be able to use it? Several institutional requirements and needs exist here as well. The experience of the AIJ pilot phase has shown that only few developing countries were able to immediately profit from this opportunity. Only after several years, the participation of developing countries grew considerably (see table 16).

table 16: The AIJ pilot phase over time

Number of projects	1995	1996	1997	1998	1999	2000	2001
Accepted projects	10	16	61	95	122	143	152
Projects actually being implemented*	0	3	13	60	86	n.a.	n.a.
Investing countries	3	3	5	8	11	12	12
Host countries	7	7	12	24	34	38	41
Developing countries	2	2	5	14	23	27	30
Share of developing countries in transition in all projects (%)	40	50	26	28	35	42	44
Planned emission reduction (mill.t.CO_2)**	23	111	140	162	217	366	442
Share in developing countries (%)	43.5	60.5	67.4	68.7	75.7	84.4	87.4

* These are estimates as no reliable information exists. The implemented projects tend to be small projects in countries in transition.

** The emission reduction actually implemented is much lower (see previous note).

Sources: UNFCCC reports on AIJ, national AIJ programmes

Both the sluggish processes of finalising national communications and implementing GEF projects show that institutional structures and human capacities are lacking in many developing countries. However, some success stories show that these obstacles can be overcome. Latin America participated intensively in the AIJ pilot phase. Several countries set up JI offices. The Costa Rican office “OCIC” set standards of efficient marketing and project approval. Costa Rica was also exemplary in setting a supportive legal framework. The excellent framework was crucial in attracting nine AIJ projects. However, a period of low demand between 1996 and 2000 lead to difficulties to finance OCIC and it degenerated into a consultancy.

Latin America also intensively used the National Strategy Study programme of the World Bank to enhance its capacity. Given these circumstances, it was no accident that Latin America now leads in the establishment of Designated National Authorities for the CDM as well as projects approved by the Prototype Carbon Fund. What is still lacking everywhere is a domestic capacity to set up Operational Entities. Here, CDM investor countries should provide capacity building funding. This will pay off very quickly as developing country Operational Entities will be much cheaper than those of the North.

Overall, capacity for CDM implementation seems to be well correlated with overall capacity to attract FDI. This in turn means that small LDCs without any striking CDM potential should not try to put any of their scarce resources in CDM development. They are better off in looking for adaptation funding. Large countries have to avoid internal squabbling for competences in CDM approval. This so far has inhibited large Asian countries to close the gap that separates them from Latin America.

6.2 Future role of the flexible mechanisms

6.2.1 Reduction of global GHG emissions and the CDM

The Clean Development Mechanism enables developing countries to participate in "emissions trading" in a project-based approach. Emission reductions resulting from a project activity, as e.g. increasing the energy efficiency of a given plant or a fuel switch, can be quantified and certified. Generated reduction certificates ("certified emission reductions, CERs") can be used by Annex-B countries to comply with their own targets.

If the CDM is conducted properly, it can help Annex-B Parties to reach their emission targets cost-effectively while supporting developing countries in a sustainable development. From the environmental point of view, a major benefit is that the long-term emission path of developing countries can be influenced in a positive way by an increased transfer of efficient technology.

In practice, however, the CDM bears some significant problems concerning its environmental integrity. The major concern is that "business-as-usual-projects" might be declared as CDM projects, generate reduction credits and consequently reduce the need to mitigate emissions in Annex-B countries. The problem is that there currently are no strict UNFCCC - eligibility rules for projects concerning their "investment additionality". Even conservative countries as Germany do not seem to impose strict rules on investment additionality and/or eligibility requirements. Sceptics often state that it is impossible to determine whether a project is investment additional or not because project developers would be able to “produce any figures” they need to pass the test. Nevertheless, several proposals for investment additionality checks have been developed. For a more detailed discussion see for example Langrock et. al (2001) or Bode, Michaelowa (2002). In order to establish an environmentally integer system in the long term, one of the major tasks will be to ensure that no business-as-usual projects are accredited.

Another point is that climate benefits of a given project might be overestimated. This danger can be reduced by means of high-quality, conservative baseline determination and certification.

6.2.2 Attractiveness of IET compared to CDM

Developing countries so far have opposed absolute emission targets due to their overall economic situation and the understanding that emission targets bear costs that are non-viable. However, just entering Annex B does not necessarily cause costs[5]. Costs to comply with commitments depend on the emission targets themselves and the emissions path of the joining countries, i.e. the stringency of emission targets. As one has seen from the Russian example, emission targets can even become a source of income. The allocation of surplus emission budgets does, of course, not serve the environmental objective of the UNFCCC regime.

From developing countries point of view, the second major question is whether there are benefits from joining Annex B compared to their current status.

One major benefit of joining Annex B is the chance to directly participate in international emissions trading. This avoids the higher transaction costs of the project based mechanisms, due to:

- Project identification and baseline selection;
- Project approval;
- Monitoring and verification of project performances;
- Certification of GHG emission credits obtained as a result of CDM activities
- Negotiating sharing of achieved credits.

A country taking Annex-B status needs to establish additional institutions, as discussed above. If a Party joins Annex B after having served as a host country for a CDM project, it also has to define a procedure how to treat ongoing CDM projects on its territories (as the country loses its CDM status). There are the following possibilities

- No compensation for CER loss is given
- Projects are converted into JI and generate the same amount of ERUs
- The investors receive AAUs equal to the CERs
- The investors are bought out

[5] Costs resulting from institutional requirements are neglected here

On the other hand, it is quite obvious that for many developing countries and countries in transition climate change does not belong to the priority tasks and they do not intend to implement measures exclusively aimed at GHG emission reduction. For such countries, CDM might be the instrument of choice as it helps to introduce new environmentally sound technologies in key economic sectors. That will promote both GHG emission reduction and sustainable development. In addition to these benefits, the participation in the CDM will further help to create national institutions, and promote markets.

In the past, many developing countries have been afraid that with the CDM many “cheap” mitigation options are exploited – giving credits to foreign investors while leaving the host country with more expensive mitigation options for future commitments. Such an argumentation of course neglects other benefits for the host country caused by a foreign investment. Moreover, CDM project possibilities cannot be “banked” indefinitely due to technological progress and the need to replace obsolete plants.

Zalayova, Michaelowa (2000) further discuss the advantages and disadvantages for Non-Annex-B countries to take emissions targets.

6.2.3 The CDM market – real participation of developing countries?

Even if there is no expansion of Annex B, the CDM already now could lead to a considerable involvement of developing countries in mitigation activities. However, the Kyoto Mechanisms are competing against each other due to the decision taken at Marrakech that all types of emission rights are fully fungible. While CERs and ERUs formally can only be banked up to a limit of 2.5% of a country´s emissions budget and RMUs are not bankable, countries will just use up RMUs, CERs and ERUs first and bank AAUs. Moreover, there is no formal supplementarity threshold; in principle countries can buy as many emission rights abroad as they like.

The shares and revenues of the different mechanisms strongly depend on demand and supply. If one takes the targets for the first commitment period only and assumes the US and Australia stay at the sidelines, the market is very lopsided. The withdrawal of the US has reduced demand by over two thirds. Russian hot air covers the residual demand alone; Ukrainian and Eastern European hot air add about the same amount. Thus the CDM and JI market depends on voluntary export restrictions of the hot air countries. Under a rational behaviour, only one third of hot air would be exported and the price reaches about 4 Euro/t CO_2. If the CDM involves a strict additionality test and high transaction costs, its share would be minor while if profitable projects are registered by the Executive Board low-priced CERs could compete with hot air (also see Jotzo, Michaelowa (2002)). JI supply depends on the willingness of hot air countries to embark on positive cost measures. JI demand depends on the willingness to buy hot air. For example, the EU could prohibit the import of hot air but would be unlikely to block JI.

The situation changes substantially if the targets of the second commitment period are known well in advance of the first period, involve more countries and are relatively tough. Then banking of hot air as well as CDM (and to a smaller extent JI demand) will increase.

The introduction of price caps can destroy the market completely as the price cap is always binding and acting as a tax or not impact at all as the cap is not reached. It is relatively unlikely that an intermediate scenario applies where the cap only binds from time to time.

6.2.4 Model estimates for market shares and revenues

The 1999 model comparison of the Energy Journal is no longer relevant for policy analyses as both the U.S. withdrawal and the loosening of targets due to the Marrakech Accords were not known at the time.

After the U.S. decision not to ratify the Kyoto Protocol and the Marrakech Accords, astonishingly few model runs on the global greenhouse gas market have been done and even fewer address the CDM[6]. Their results are summarised in table 17; they strongly depend on the assumptions about CDM transaction costs and hot air sales from the countries in transition.-

table 17: Estimates of total CDM revenue until the end of the first commitment period

	Jotzo/Michaelowa 2002[1]	**DenElzen/Both 2002[2]**	**Eyckmans et al. 2001[3]**	**Blanchard et al. 2002[4]**
CDM revenue ($US billion)	7.0	1.5	10.7	1.8
Adaptation tax ($US million)	141	30	214	36
Market price ($/t CO_2)	3.8	2.5	4.9	4.6

[1] CDM transaction costs 0.75 $/t CO_2, 35% of hot air sold

[2] CDM transaction costs 20%, 10% availability, 100% of hot air sold

[3] CDM transaction costs 10%, 60% availability

[4] CDM transaction costs 20%, 10% availability, 10% of hot air sold

[6] Several papers (Manne/Richels 2001, Löschel/Zhang 2002) model intricacies of Annex B permit supplies but completely leave aside the CDM. Sijm et al. (2001) do not consider the US absence.

Obviously, net revenue to CDM host countries is substantially smaller depending on the actual abatement costs. The results are relatively robust inasmuch CDM revenue is seen to be one order of magnitude smaller than official development assistance flows. Distribution of CDM flows is likely to be much more correlated with private foreign direct investment than ODA.

7. Technical issues of evolution of the climate regime

7.1 Consistent reporting and verification regime

Any regime based on emission targets needs to ensure a consistent reporting and verification. Otherwise, free riding can occur. The past experience with in-depth reviews of national communications of Annex B countries shows that there was a strongly varying quality of reporting. The quality of Non-Annex B country reports is even more variable but no independent review has been done. This led to agreement on relatively strict reporting and verification rules in the Marrakech Accords (see **figure 9**).

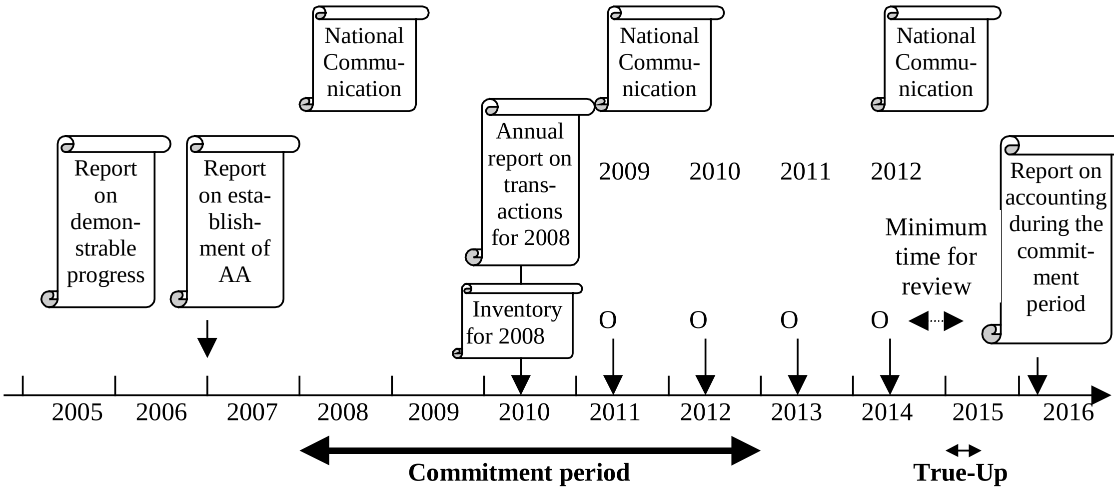


figure 9: Reporting of Annex B countries before, during and after the commitment period

For Annex-B countries, the report on the establishment of the national Assigned Amount (AA) is due Jan. 1, 2007 and describes the national system to derive emissions inventories. A national entity co-ordinates

- Responsibilities for methods used to set up the inventory and collect data
- A quality assurance plan
- A procedure for official approval of the inventory
- The national system should "preferably" undergo third party review.

The national system will be reviewed by an expert review team (ERT) once. The report on establishment of AA will be reviewed within one year. The ERT makes an in-country visit, identifies flaws and suggests adjustments to the reported figures. Adjustments accepted by the country or mandated by the enforcement branch of the compliance committee will be used to calculate the final volume of AA that remains unchanged for the commitment period. The annual inventories will also be reviewed. If changes in national systems or national registries have been made, an in-depth review including an in-country visit will be done. Here, adjustments can be revised if the ERT that did the adjustment or the compliance committee accepts.

Reporting requirements are deemed not to be fulfilled if

- the inventory is more than 6 weeks late.
- a source category is missing which encompassed more then 7% of the total emissions in the last submitted inventory
- adjustments lead to an increase of more than 7% in total reported emissions
- the sum of adjustments since the start of the commitment period is bigger than 20 percentage points
- for three years in a row adjustments are calculated for a key source category that is responsible for over 2% of total emissions. This trigger does not apply if the country has asked the facilitative branch for help to resolve this problem, is thus weaker than it appears.

As Annex B countries will find it difficult to fulfil these rules, it would be much more difficult for developing countries (also see discussion in chapter 6.1). Only countries with a reliable civil service and developed data collection can develop inventories of a minimum standard. This is not the case for most of sub-Saharan Africa and LDCs in general. Countries that fulfil the graduation thresholds discussed below should not have more problems than countries in transition.

7.2 Development of the compliance regime

Prior to COP 7., compliance rules were an intensely debated issue (see e.g. Goldberg et al. 1998a,b, Wiser/Goldberg 1999, Hargrave et al. 1999). Wiser (2002) summarises the compliance-related decisions in the Marrakech Accords. He finds that there is no realistic way to force parties who exceed their Kyoto emissions targets to remedy the problem. Trade sanctions used under the Montreal Protocol are not part of the Marrakech Accords. The "legally binding" nature of consequences for non-compliance remains to be resolved; an amendment or other formally ratified legal instrument would provide the highest possible expression of the intent of parties to respect the results of an enforcement branch proceeding.

Nevertheless, procedures and institutions for the compliance system as well as sanctions for non-compliance were agreed. According to Wiser (2002), “that is a politically potent accomplishment that makes the protocol's compliance system the most robust ever adopted for a multilateral environmental agreement". He sees the declaration by the enforcement branch that a country has violated its treaty obligations by exceeding its emissions target as potentially effective public "shaming".

Further development of compliance-related issues can take two paths:

Internal stabilisation means that co-operative behaviour is achieved without additional instruments because the members of the climate treaty form a stable coalition in the sense that no country wants to leave it. Co-operating countries can exploit the fact that climate policy measures are repeatedly taken by making future abatement efforts dependant on the - potentially defecting - behaviour of other countries. Reciprocity in that sense is a possible instrument to stabilise a climate treaty because it imposes future costs on the breaching country when the remaining countries retaliate.

External stability requires various compliance tools that can be evaluated according to the criteria 'environmental effectiveness' and 'economic efficiency'. Given the profit-maximising behaviour of all involved actors, the punishment associated with sanctions and transfers should counterbalance the gains from non-compliance. Regarding the alternative approaches, the performance should be assessed on the basis of their ability to prevent a profit-maximising seller from over-selling its allowances. Economic efficiency requires that the environmental goal – compliance – is achieved at least compliance costs, i.e. the costs to participants that meet their commitments should be minimised. This applies to buyers as well as sellers of emission permits. In the following, the various compliance tools are compared to the least-cost, full-compliance equilibrium: compliance is achieved voluntarily and the permit market is fully competitive.

7.2.1 Economic sanctions

Economic sanctions decrease the net benefit from non-compliance. To be effective, the sanction must be credible and it must counterbalance the gain from non-compliance. Hence, the expected impact of the financial sanction – which is smaller than the actual impact if the probability that the sanction will be executed is smaller than one – must at least match the benefit from the defecting behaviour (Heister et al., 1997). The gain from non-compliance corresponds to the excess emissions – irrespective of their cause – multiplied by the market price for the emission allowances. Therefore, a financial sanction is an effective threat if the penalty per exceeding emission unit times the probability is greater than the market price. The credibility of trade sanctions is relatively small because trade sanctions may not only hurt the target country but also the sanctioning country. Since increasing the impact of trade sanctions renders their execution even more improbable (Heister et al., 1997), it is unlikely that the expected impact of trade sanctions is high enough to deter non-compliance.

Sanctions are intended to work as a threat. Therefore, effective sanctions will not be executed. Their execution means that they have missed their primary aim, that is to deter non-compliance. Hence, economic sanctions do not impose any additional costs on parties that meet their commitments. Furthermore, economic sanctions do not restrict the efficiency of the market for emission allowances, because neither the number of trading parties nor the number of allowances is reduced as compared to the reference case. Consequently, compliance costs correspond to the least-cost solution, i.e. effective sanctions fulfil the efficiency criterion. But, if the sanction is not high enough to prevent excess emissions, it will impose additional costs on non-compliant parties. These costs including reduced compliance costs must be lower than compliance costs in the reference case because otherwise the parties would chose to comply. This is true for financial sanctions that do only affect non-compliant parties. But it is not true for trade sanctions that will also impose costs on the sanctioning country. As trade sanctions will probably not fulfil the incentive compatibility condition due to their lack of credibility, financial penalties are superior to trade restrictions regarding the efficiency criterion.

7.2.2 Trading-related sanctions

In the following, only the loss of eligibility to trade will be discussed as a trading-related sanction. The traffic light approach works as a sanction in such a way that the liability rule is changed as a consequence of non-compliant behaviour. Therefore, it will be analysed in the context of the other liability rules.

The loss or limitation of the right to engage in emission trading is not a suitable instrument to prevent net buyers from exceeding their emission limits. This is because buyer non-compliance is a result of not using the right to buy allowances. But the suspension of selling rights in future commitment periods could be a possibility to ensure seller compliance. The effectiveness of this compliance strategy depends on whether the gain from over-selling is outweighed by the expected loss of profits in the future suspension period. Therefore, the duration of the suspension period, past and future market prices for allowances as well as the discount factor (assessment of future rewards compared to present gains) matter. If the above condition is met, seller compliance would be established. But the environmental effectiveness of the trading-related sanction would nevertheless be restricted by under-buying of emission allowances.

The economic efficiency of the suspension of selling rights is restricted due to the fact that the number of trading parties is reduced. On the one hand, buyers do not have an incentive to engage in emission trading and on the other hand, sellers might be excluded. Therefore, the liquidity of the permit market is decreased, which leads to a higher market price and higher costs for buyers (Haites and Missfeldt, 2001). Apart from this, compliance costs are the same as in the least-cost reference case if the sanction is an effective deterrence. Hence, the net effect on costs will be negative so that environmental effectiveness and economic efficiency cannot be obtained simultaneously.

7.2.3 Reduction of emission budget in future periods

If the reduction corresponds to the excess emissions times (1 + x) where x represents the discount factor, this is technically equivalent to borrowing (under the assumption that the future market price for allowances will be the same). Hence, a reduction to this extent does not mean a punishment for non-compliant parties. The Marrakech Accords set x=0.3 We have a financial penalty if the interest rate is below 5.2%. Since this kind of sanction only imposes costs on non-compliant parties, compliance costs will be lower than in the least-cost solution if ecological effectiveness is not reached.

7.2.4 Compliance fund

Wiser and Goldberg (1999) propose a compliance fund. The underlying idea is that parties are required to purchase offsetting or more than offsetting emission allowances at the end of the commitment period. This approach is limited due to the fact that there could be a global shortage of emission allowances at the end of the commitment period – especially if several countries were non-compliant. On this account, a compliance fund should be set up. If a party’s emissions exceed its AA, it has to pay a fee proportional to its overage into the fund. Fees collected by the fund are used to finance GHG mitigation projects that generate the credits needed for compliance purposes. The compliance fund thus combines the advantages of financial sanctions with those of the reduction of future period emissions.

The fee can be seen as a financial penalty. If its expected impact is high enough to outweigh the gain from non-compliance, it will be an effective deterrence. Hence, the compliance fund will ensure environmental effectiveness as well as cost efficiency. This is especially true if the party had to pay inflated prices for emission allowances being in short supply at the end of the commitment period. If for any reason the fee does not surpass the benefit from non-compliance, the compliance fund will at least compensate a part of the excess emissions. The fund approach will in principle not be able to ‘make the climate whole’ because a fee that is not high enough to deter non-compliance cannot be sufficient to finance emission reductions in the amount needed to bring the party into compliance. If this were the case, there was no reason for the non-compliant party not to undertake the mitigation projects by itself.

The preceding analysis has shown that sanctions can be an effective deterrence of non-compliant behaviour if they counterbalance the gain from non-compliance. The only exception is the suspension of selling rights which is not effective in preventing buyers from exceeding their emission limits. If a sanction is an effective threat, it will not be executed and will thus not impose any additional costs. Cost efficiency thus applies to all effective sanctions. Sanctions that are not an effective deterrence may imply lower costs provided that the market for allowances is not restricted and the execution of the sanction does not imply additional costs to the sanctioning parties. Since trade restrictions and the suspension of selling rights do not fulfil this requirement, they are inferior to the other approaches with respect to cost efficiency. Regarding environmental effects in the case of non-compliance, protocol-related sanctions do have the advantage that they at least partly compensate the excess emissions. Since borrowing implies the possibility to shift the burden to future generations, the compliance fund seems to be the superior strategy from the point of view of environmental and economic efficiency.

7.2.5 Transfers

Transfers can prevent parties from exceeding their emissions, if any possible gain from non-compliance is outweighed by the loss of the transfer the countries were previously entitled to (Heister et al., 1997). If this condition is met, compliance is always the best option and the environmental goal is fulfilled.

In contrast to sanctions, transfers provoke costs for the donor countries only if compliance is achieved, whereas compliance costs for the recipient countries are reduced. The additional costs for the complying countries (who pay for the compensations) depend on the number of ‘opportunistic parties’ (that receive the transfer) and on the way the transfer scheme is financed. If the transfers have to be supported by an international tax and if the number of opportunistic countries is large, such a tax-transfer-scheme could be very costly (Heister et al., 1997). Therefore, looking at aggregate compliance costs, successful sanctions are a cheaper way to deter non-compliance than monetary transfers.

The linkage of different and otherwise independent issues is another possible transfer strategy. Concerning the compliance problem, issue linkage involves the combination of compliance with the CO_2 reduction targets and other policy questions in which the opportunistic parties have a strong interest. The concessions in other policy issues, e.g. development assistance or R & D programmes, increase the benefit from compliance and thus imply an implicit transfer between countries. The withdrawal of the concessions can therefore be used as a sanction, provided that the approval can be taken back afterwards. If this is not the case, issue linkage is inappropriate to prevent countries from breaching their commitments. Provided that the subsequent withdrawal is possible and also credible, the linkage of compliance to other policy questions is an effective deterrence, if the concession and the gain from non-compliance are at least of equal value for the receiving country. Like monetary transfers, issue linkage implies costs for the party making the concessions since this country has to agree to a policy it would reject otherwise. Nevertheless, the linkage of issues is cheaper than monetary transfers, because the latter ones often involve additional costs, such as raising taxes (Heister et al., 1997). Moreover, the concession may be of less value for the donor country than for the receiving country, implying less costs compared to monetary transfers. Since all kinds of transfers must compensate the opportunistic party for the potential gain from non-compliance, issue linkage and monetary transfers can be of equal value for the receiving country. Therefore, aggregate compliance costs (including the costs of the concessions) will be smaller than with monetary transfers.

7.3 Coverage of gases and other substances

The Kyoto basket of six gases does not cover all known greenhouse gases or substances that influence the global climate. The Kyoto gases are estimated to account for about 92% of the total radiative forcing by substances with a "high" to "medium" level of scientific understanding (IPCC 2001, p. 8)[7]. Tropospheric ozone has a forcing of almost 15%, while stratospheric ozone depletion reduces the forcing by 6%. Inclusion of tropospheric ozone would be a realistic option and politically interesting as it acts as a major local pollutant with negative effects on health and agricultural production. Targets could be expressed in ozone levels but policy measures would have to be aimed at the precursors**.**. Stratospheric ozone depletion will be reversed due to the success of the international ozone regime and thus the reduction of forcing will diminish over time.

Aerosols such as dust and SO_2 lead to regional cooling effects that counteracts the greenhouse gas warming. The order of magnitude of the direct effect is 30% of the Kyoto basket but the indirect effect could be almost as large (IPCC 2001, p. 8). It is likely that the cooling phase from 1940 to 1975 was due to the strong increase in aerosol loads during that period and that measures to reduce SO_2 emissions in industrialised countries have contributed to the strong warming push since the mid-1980s as global sulphate forcing stabilised (IPCC 2001, p. 402). As aerosols are linked to local and regional pollution there is a strong incentive for countries to reduce these emissions; in fact newly industrialised countries are embarking on this path.

Theoretically, countries with a high production of aerosols could receive a "bonus" for their greenhouse gas target. The quantification of this bonus is difficult due to the regional character of the cooling effect and the transboundary pollutant effects.

Many observers from the US have argued for an inclusion of black carbon, the only aerosol with a warming contribution whose radiative forcing is about 8% of the cumulative radiative forcing of the Kyoto basket.

[7] The radiative forcing is proportional to the current concentrations of the respective greenhouse gases and thus not directly linked to current emissions.

A problem with the inclusion of additional gases or substances is that a certain degree of measurement accuracy is necessary to avoid opening of loopholes; the IPCC classifies the level of scientific understanding for all categories besides the Kyoto basket and stratospheric as well as tropospheric ozone as “very low” (sulphate scores a “low”).

7.4 Usage of GWPs for conversion into CO_2 equivalents

The Kyoto Protocol fixed the use of 100 year Global Warming Potentials (GWPs) as specified by the IPCC Second Assessment Report (SAR) for the first commitment period. Accordingly, the 2001 update of GWPs by the Third Assessment Report (TAR) has not been followed by the Kyoto Protocol. A procedure has to be developed how updates are done. Also, the 100 year timeframe may not be seen as adequate. Choosing a different time horizon might lead to significant differences in the GWP of a given greenhouse gas (see table 18).

Moreover, indirect effects (e.g. due to the atmospheric chemistry properties) should be taken into account. In the case of methane they increase the GWP by over 35% (IPCC 2001, p 387).

table 18: GWP changes over time

Gas	Average lifetime (years)	20 years TAR	*Kyoto SAR*	100 years TAR	500 years TAR
CO_2	Variable, about 150	1	1	1	1
CH_4	12	62	21	23	7
N_2O	114	290	310	296	156
HFCs	0.3-260 (majority double-digit)	40-9400	140-11,700	12-12,000	4-10,000
PFCs	2600-50,000	3900-8000	6500-9200	5700-11,900	8900-18,000
SF_6	3200	15,100	23,900	22,200	32,400

Data source: IPCC (2001), p. 388-389

7.5 Length of commitment periods

Currently the climate negotiations develop in “rounds” of about five years. This structure is very similar to the world trade negotiations. Apparently, a five year period to show results is a timeframe that is still attractive for policymakers who have a relatively high chance to survive two policy cycles in power. Obviously, policymakers try to shift burdens to future periods. This may explain why emission target dates have always been set more than a decade in the future.

A decision on a concentration target far in the future could be possible but the short-term initiation of a path that deviates from business as usual is politically difficult. Nevertheless, a long-term perspective through the definition of an emission path would be a clear signal for decision makers to invest in low-emission technologies.

7.6 Coverage of international transport

The Kyoto Protocol exempted international air and sea travel from the emission reductions commitment of Annex B targets.

This exemption should be lifted. Emissions could be allocated to the countries where trips originate and end or the International Maritime Organisation (IMO) and the International Air Transport Association (IATA) would be allocated a distinct target (see Bode et al. 2002). Emissions from air travel should use a special conversion factor that includes the indirect effects due to the specific chemistry of aircraft emissions in the high troposphere. Using IPCC results, this factor amounts to 2 to 4 (IPCC 1999). Contrail effects are not included in this estimate but should enhance this factor further as recent findings have reconfirmed their significance (Travis et al. 2002).

8. The role of policies and measures in the international climate regime

If effective, absolute emissions targets cannot be negotiated on a global scale, a common set of policies would be a possible alternative and might enhance developing country participation. In fact in the early stages of international climate policy the discussion concentrated on policy harmonisation. The EU supported such an approach against US opposition until Kyoto.

In the following, an overview of potential instruments is given. It should be noted, however, that absolute emission targets are to be preferred from the ecological perspective.

8.1 Global greenhouse gas tax with local recycling

Proponents of an efficient climate policy based on a uniform price signal have long favoured a co-ordinated greenhouse gas tax. It was already proposed prior to UNCED and has been revived from time to time. The main problem of a tax is the reluctance of policymakers to introduce pervasive new taxation and the issue of revenue recycling. Proposals that revenue should be administered by a global institutions are not viable. Recycling of revenues collected by each country may be a more acceptable solution. A problem of the co-ordinated tax is how changes in exchange rates and differences in national abilities to pay are addressed because otherwise "tax havens" would come into being. Another basic drawback of taxes is that a defined global emissions targets cannot precisely be met, but that there will be an – eventually complex and time-intensive – trial-and-error process to define an appropriate tax level.

8.2 Co-ordinated efficiency standards

For consumer goods, a co-ordination of efficiency standards could boost efficiency improvements. The U.S. Energy Star programme for computers has been adopted in many countries.

8.3 Technology Marshall Plan to develop backstop technologies

Recently, a global subsidy programme to develop renewable or carbon-free technologies has been suggested (Philibert/Pershing 2002, p. 84-88, Barrett 2001). The problem with such an approach is that governments have a mixed record in picking technological winners. Other observers (Hoffert 2001) argue "the history of the last 50 years shows that all of the important innovations that have spurred the growth in wealth have all come from government sponsored military R&D, first in World War II and then in the Cold War. It is simply not cost effective, because there is no profit for many years, for the private sector to invest in the development of the kinds of transformative technology that will be necessary to solve this problem".

8.4 Co-ordinated regulation

Edmonds and Wise (1999) proposed that all new fossil fuelled power plants should have to sequester the carbon geologically. Their proposal was even discussed as likely to be adopted by the Bush Administration in mid-2001. Such an approach suffers from all the efficiency problems that characterises regulation. Costs may be much higher than under a market-based solution.

8.5 Voluntary commitment to no-regret policies

Countries could give a commitment to implement all macroeconomically sensible policies with greenhouse gas benefits. A narrow approach would be to address all projects that are pure monetary no regrets. Krause (2000, p. 30f) estimates the potential at 1.7 to 6.7 billion t CO_2 for the first commitment period.

A wider perspective would be to take positive local pollution externalities into account ("ancillary benefits", OECD 2000). In severely polluted areas, the externalities can be higher than the costs for greenhouse gas abatement and reach values of above 10 €/t CO_2 eq..

8.6 Subsidisation of mitigation and adaptation action in developing countries

Winkler, Spalding Fecher, Mwakasonda and Davidson (2002) propose that industrialised countries can subsidise mitigation action in developing countries without getting emission credits. As long as the alternative CDM exists, such a proposal is completely unrealistic and unaccountable. Already the Marrakech decision to set up several funds for developing countries raises the question how an effective use of these funds can be assured. Lessons from development co-operation show that disbursement of multilateral funds without a clear vision did not lead to sustained impacts, especially in countries with ineffective institutions and bad policies. For example, in Tanzania, $2 billion were spent on building roads over 20 years. The road network did however not improve due to lack of maintenance as roads deteriorated faster than they could be built (World Bank 1998, p. 1). It should be avoided that the same can be said about mitigation and adaptation fund spending 20 years from now, especially as many countries are vying for a share of the relatively small funds. Instead of spreading it equitably, climate change financing should go only to countries with a strong track record in policy reform and an interest in effective institutions. Mitigation and adaptation targets have to be specified clearly in quantitative terms to allow a check of effectiveness and there has to be an ex-ante defined monitoring strategy. A warning sign is that purely political targets of development spending were often not reached and had to be scaled down or to be referred to a more distant future (Carvalho 2002, p. 5). It is crucial that the rules for disbursement of the Marrakech funds are defined clearly and that incentives are set that provide for long-term continuation of projects. Goals must be country-specific and have a clear timetable. Then it may be possible to match or surpass World Bank performance, where project evaluation finds that about three quarters of projects can be labelled as satisfactory at the end of donor involvement (Carvalho 2002, p. 8).

8.7 Regional/sectoral CDM

A recurrent theme in CDM negotiations has been the question whether CDM only includes concrete projects where a technology is installed or whether it could be interpreted in a broader sense as covering policies. Especially under a unilateral CDM policies would be an attractive option but a tough determination of additionality becomes crucial to avoid “CDMisation” of business-as-usual behaviour and reward of past suboptimal policies. Samaniego and Figueres (2002) suggest even to extend CDM to national policies which exacerbates the additionality problem. However, in the context of a scheme to involve countries with high absolute but with low per capita emissions and low GDP, a national CDM may be able to mobilise a high amount of reductions.

8.8 Biofuel obligation

Read (2002) suggests a mandatory use of biofuel of sinks plantations which would substitute fossil fuels. Such a regulation suffers from the risk that other promising renewable options are not taken up. Read argues that biofuel provision supports developing countries and avoids the permanence problem of sinks.

8.9 Targets for trans-national companies

Trans-national companies (TNCs) under the current conditions will be subject to different domestic policy instruments, depending on the respective country of their operation, which complicates environmental documentation and controlling. Many TNCs have implemented strict standards all over their operations, trying to bring costs down. On the other hand, TNCs have the opportunity and will always be suspected by NGOs to transfer emission-intensive parts of their production to Non-Annex-B countries. Companies like BP Amoco and Shell have been gathering experiences with in-house trading systems in order to detect the lowest cost GHG reduction opportunities. Taking their world-wide activities together, some TNCs cause emissions of an order of magnitude of whole nations. It could thus be an option for further commitment periods to offer TNCs of a certain size an opt-in to Annex B Party status, under the condition that they are willing to accept binding targets that are more stringent than their commitments broken down over the Annex B country Parties they are active in. This would however not include any voting rights in the UNFCCC process. TNCs may be willing to accept these for several reasons:

- They may chose for themselves the globally lowest-cost in-house reductions.
- They will value reduction potentials as an additional asset when planning mergers and acquisitions.
- They will be exempted from national climate mitigation instruments, as long as they are in compliance with their company target.
- They can drastically reduce compliance costs while avoiding CDM or JI transaction costs.

In case of mergers with and acquisitions of other companies, they will need to report to the UNFCCC Secretariat a correction of their target. This correction needs to be simple to calculate. There are several options:

a) Both merged companies have emission targets. The new target will be an addition of both.

b) The acquiring company A has a target, the company B taken over has not.

  i) Until the next commitment period, A will report only the emissions occurred within its former boundary.

  ii) The former company B is attached a proper emissions target on the basis of the average emissions intensity of company A, and the allowances are added up, like in case a).

c) The acquiring company A has no target, while company B taken over has.

  i) Until the next commitment period, A will take over the commitment for the constituencies of the former company B.

  ii The former company A constituencies are attached a proper emissions target on the basis of the average emissions intensity of the former company B, and the allowances are added up, like in case a).

  iii) Company A, retroactively for the ongoing commitment period, takes over any domestic commitments for the foregone operations of company B and opts out from Annex B.

In order to provide for non-compliance or for case c) iii, an annual payment to an escrow account proportional to the companies' total GHG emissions could be requested from TNCs by the COP.

9. Summary and conclusions

As it appears today, the future climate regime has to contain three major elements:

- Adaptation to negative impacts of climate change
- A – hopefully significant - reduction of global GHG-emissions
- Sequestration of CO_2 and eventually other GHGs from the atmosphere

Recent agreements of Bonn and Marrakech already established funds to support developing countries in their adaptation efforts. Although those funds quantitatively are close to negligible compared to the amounts that will be needed on the global level, they can be considered a politically important signal to developing countries – also with a view to potential future commitments of the latter.

The most essential but also politically most critical of the above mentioned elements is an *effective reduction* of global GHG-emissions. In order to upgrade the Kyoto Protocol to an effective climate regime in the long term, several steps must be undertaken:

- First, the circle of countries with binding, absolute emission targets must be expanded as far as possible. This is due to two facts: CO_2-emissions of current Annex-B-countries only account for 55% of global CO_2-emissions (1999) which means that 45% of global CO_2-emissions currently are non-capped. Second, whereas emissions of the Annex-B group have remained more or less constant in the past decade (decrease of 0.8% from 1991 to 1999), total emissions of non-OECD countries have increased by 9.3% during the same period of time. Emissions forecasts show a further increasing trend. However, the question is which countries are candidates to take the "burden of entering Annex-B"? Threshold options are listed below.
- Second, substantial GHG-reduction targets need to be defined on the global level. The best option from the ecological point of view would be to do so by defining a global concentration path.
- Third, national emissions targets need to be derived from the global emissions budget defined for a given year/period. Quantification can be based on several criteria (see below).

<u>Possible thresholds to take emissions targets:</u>

Several criteria that trigger joining Annex B have been developed, as:

- GDP (or purchasing power parities) per capita
- CO_2-emissions per capita
- Combined financial indicators and emissions: graduation index
- Absolute emissions thresholds
- Institutional indicators

Variants of those approaches can be thought of concerning the reference year or period. In our analysis of 13 threshold options, the following countries have passed the threshold most often: Singapore, Qatar, Brunei, Saudi Arabia, Oman, Bahrain, Cyprus, Malta, Korea, Trinidad and Tobago, South Africa, Argentina, Kazakhstan, Turkmenistan, Azerbaijan, Barbados, Bahamas, Mexico, Iran, Turkey, North Korea, Venezuela, Malaysia, Chile and Brazil. Some of the most important developing countries in terms of absolute emissions as China, India or Indonesia are characterised by low per capita and low historical emissions as well as low GDP and thus do not surpass many of the defined thresholds. Nevertheless, future commitments of those nations will be of crucial importance to establish an effective climate regime.

<u>Possible criteria to quantify national emission targets:</u>

The criteria listed below differ concerning data demand and the underlying approach to allocate emission rights in a “fair” way and thus favour different country groups. For those reasons, one can hardly expect that the international community can agree on one methodology that is to be applied to all countries.

- Grandfathering (historical emissions in an agreed reference year)
- Per capita allocation
- Contraction and convergence (appears the most elaborate and easy-to-understand option)
- Cumulative emissions
- Preference score
- Triptych
- Multi-sector convergence
- 2 – group approach (developed - non-developed countries)

Developing countries that evaluate if they want to join Annex-B or not will find that there are important differences concerning the institutional requirements and monitoring and reporting requirements between Annex-B status and Non-Annex-B status. Transaction costs that currently apply for the CDM - e.g. establishment of baselines - can be reduced if a country participates in IET. On the other hand, there are additional reporting requirements, e.g. concerning the establishment of national inventories. Probably, the most crucial issue for many developing countries is that they are afraid of adopting stringent targets that reduce their chances of economic development.

Finally, there are some technical issues concerning the evolution of the Kyoto regime. The most relevant points are:

- Establishment of a consistent reporting system which allows the creation of capacity in developing countries
- Future coverage of gases
- Coverage of international transport
- Length of commitment periods

10. Policy recommendations

Relevant issues concerning the evolution of the Kyoto Protocol are:

- The need to define *effective* targets. No new hot or tropical air must be created for the period after 2012. Absolute emissions targets are the best choice from the ecological perspective.
- The CDM must be accompanied by strong rules, especially on investment additionality and baseline determination.
- Emissions resulting from international transport (aviation, shipping) must be included.

The inclusion of developing countries in Annex-B is a very sensitive issue in political terms but also a crucial element of the future climate regime. Recent statements of representatives from DCs have shown that strong opposition of many developing countries against targets and target negotiations can be expected. A two-fold strategy might therefore be the best choice.

This implies the need to create incentives for DCs to join Annex B on the one hand and to allow flexibility concerning emissions targets on the other hand. Also, potential institutional and/or administrative barriers to join Annex-B should be identified and eliminated.

Concerning the selection of "Annex-B accession candidates", the best strategy might be to start from objective, uniform rules/thresholds as discussed in chapter 4, but simultaneously allow to consider for special national circumstances and the need for sustainable development. The consideration of the latter factors might also take place when defining and quantifying the (type of) emissions target. As an example, for some developing countries a mixed target - e.g. combination of relative and absolute targets - might open the door to take any commitment at all. Also, the definition of initially lax absolute targets for joining countries might be a political compromise in the short to medium term. A minimum condition should however be that any target is stricter than a sensible estimate for the business-as-usual emissions path.

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