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Equal Emissions per Capita over Time – A Proposal to Combine Responsibility and Equity of Rights

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ABSTRACT

After Future climate policy regimes may be based on the Kyoto-Protocol or on other policy instruments such as carbon-taxes. Any effective regime based on the Protocol requires the determination of the concrete contributions by each Party. This involves namely the time of contribution and the quantification of the contribution itself. By now many proposals exist for the two issues, as for example thresholds like GDP per capita for the question of timing or emissions per capita for an allocation of emission rights. Based on the two justice principle *responsibility* and *equity of rights* that form the basis for the so-called *Brazilian Proposal* and *Contraction & Convergence* respectively, a new approach is developed: Future emission rights are allocated on the basis of *equal emissions per capita over time*. By so doing not only are emissions per capita (EPC) taken into account during the allocation but also their evolution over time. I show that nations with high EPC may even be allocated negative quantities of emissions right due to their historical "burden". On the other hand, Parties with low EPC would be allocated large amounts of "fair air" which can increase the incentive to accept absolute emission targets. Even though this approach may currently lack political acceptability, it offers another analytical reference point for the political bargaining process on future allocations.

Keywords: allocation of GHG emission entitlements, Brazilian Proposal, CDM, Contraction & Convergence, equity, post 2012 climate regime

JEL-Classification: Q25, Q28

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1 Introduction

Climate is changing (WMO 2003) and there is more and more evidence that this is due to the human release of greenhouse gases (GHG). This is why the international community adopted the UN Framework Convention on Climate Change (UNFCCC 1992) and its Kyoto Protocol (1997) which sets inter alia the initial step for limiting GHG emissions in the period 2008 to 2012. Even though the Protocol has not entered into force by now, the discussion on future contributions to GHG emission reductions has intensified recently as commitments for subsequent periods shall be initiated at least in 2007 (Art. 3. 9 Kyoto Protocol). The discussion on the allocation of emission entitlements[1] dates back to 1990's and since then many approaches have been and are still presented. Yet, no compromise seems currently reachable as the views between developed and developing countries are rather contrary.[2] On the other hand climate continues to change and thus some action is likely to be agreed upon. Whether it constitutes the deep cut in emissions that is demanded by some stakeholders remains to be seen. The same is true for the Protocol itself: agreements among like-minded countries may also emerge instead of a global consensus (for example Sugiyama (2003)). And the question of sharing the burden of adaptation to the adverse effects of climate change has not even been legitimately addressed in the negotiations, though the discussion at CoP 8 started to look at this issue.

Assuming a future evolution of the Kyoto Protocol, there are two basic options with regard to the determination of future allocations of emission permits. The first option are rolling agreements restricted to the next commitment period, be it five years as the first one or another duration. Secondly, a long-term - if not eternal – approach for allocating emission permits to the Parties of the Convention could be agreed upon (see also Berk et al. (2001) p. 466). An unexpected advocate of the later approach could be industry. In the run-up of the emission trading scheme on the entity level in the European Union (EU (2003)), industry has asked for clear perspectives with regard to the allowance allocation (Anonymous (2003)). Business seeks certainty because of the long life-time of a number of installations as for example coal-fired power plants (see also Aldy et al. (2003) p. 10). Furthermore, by establishing a long-term allocation

[1] The terms emission entitlement, emission right, emission permit and emission allowance are used equivalently in this paper. Note that the term permit is used differently in the EU-directive on emissions trading (EU 2003).

[2] Carraro (1998) shows that an agreement signed by all countries seems quite unlikely from a game theoretic point of view. On the other hand, Ciscar et al. (2002) show for a sequential game framework that both Annex-I as well as non-Annex-I countries reduce their emissions after 2010 as they face climate change.

scheme, there would be no incentive to re-negotiate the target of an upcoming commitment period. This could be of interest in case a Party fears non-compliance in an earlier period (Barret (2002) p. 4, similar Aldy et al. (2003) p. 8).

However, the earlier the targets are set for long-term GHG emissions, the more difficult the negotiations on international level are. Currently, the principle of “common but differentiated responsibility”, as set in the UNFCCC; is widely accepted but in the long-run developing countries will also be asked to contribute to limiting global GHG emissions. And while trying to determine a Party’s contribution each is likely to call for a “fair” allocation. Unfortunately, there is no “one and only” viable justice principle.

Against this background, this paper offers a new approach for the determination of a long-term future allocation. It is based on the so-called Brazilian Proposal (UNFCCC (1997) and the Contraction & Convergence approach (Meyer 2000). Thus, it combines the two justice principles *responsibility* and *equity of rights*. Throughout the paper I assume that the future climate policy regime is based on two principles underlying the Kyoto Protocol. This is namely the quantification of absolute emission budgets for each Party as well as emission trading. I concentrate on the participation method and the determination on the emission targets only. Neither the allocation of burdens from adaptation to climate change nor the distribution of benefits from mitigation are considered.

The paper is structured as follows. The following section summarises the key points of the current international climate policy regime. Section three discusses the key issues for allocation of emission permits in the future climate policy regime assuming that it is based on the Kyoto-principles. In section four, a general version of a new approach for the determination of time of participation as well as the quantification of contributions for further Parties is presented, followed by a numerical example in the subsequent chapter. Section six concludes.

2 Key points of the current regime

In this section core points of the existing international climate policy regime which are relevant in the context of the paper are summarised.

The basic documents of the international regime are as follows: the Framework Convention, the Kyoto-Protocol, the Bonn Agreement and the Marrakech Accords. Depending on the issue under discussion others must be considered as well, as for the example the decisions of the executive board for the CDM or upcoming papers for the treatment of LULUCF projects.

The ultimate objective of the Framework Convention (Art. 2) is the "...stabilization of greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system....". The main principles for the current regime are laid down in Article 3 of the Convention. Among others, a "common but differentiated responsibility" is acknowledged. However, it is not specified how long it should be differentiated. Furthermore, it is stated that *specific needs of developing countries should be considered, lack of full scientific certainty should not be used as a reason for postponing precautionary measures* and that these *measures should be cost-efficient.*

The differentiated responsibility is considered most importantly by the separation of the Parties in so-called Annex-I and non-Annex-I countries in the Convention, and in Annex-B and non-Annex B countries in the Protocol. Annex I countries have more obligations especially with regard to emission reductions, reporting and support of non-Annex I countries.[3] The somewhat vague emission reduction obligations mentioned in Art. 4, 2. of the Convention have been specified in absolute emission targets for the so-called first commitment period, i.e. 2008 to 2012, for the countries listed in the Annex-B of the Kyoto-Protocol. It is worth mentioning that there has been no "principled logic" (Babiker et al. 2002, p. 411) for the determination of the emission targets. They are rather the outcome of a political bargaining process with limited time (Torvanger et al. 1999 p. 13, Grubb et al. 1999 p. 86)[4].

In order to allow a cost-efficient meeting of the absolute emission targets, four flexible mechanisms have been introduced with international emissons trading (IET), joint implementation (JI), and the clean development mechanism (CDM), being the most important options (for more details see for example Grubb et al. 1999, Michaelowa 2001). At this point it is only important to recall that the use of IET and JI between Annex I countries does not affect the total allowed emissions of Annex B countries. The generation of so-called Certified Emission Reductions from CDM-projects in developing countries on the other hand increase the total budget of emission permits as they are not deducted from any national budget as in the case of IET or JI. This is why

[3] Furthermore, a sub-group of Annex I countries defined in Annex II has more obligations especially with regard to financial support.

[4] Interestingly, allocations based on the one of the pure fairness principles *Sovereignty, Egalitarian or Ability to Pay* deviate more from Kyoto outcome than several other proposals under discussion prior to CoP 3 (Torvanger et. al. (1999, p. 59)).

special rules for the determination of the reference scenarios, for monitoring, validation and certification for the CDM are necessary.

Preparation to and bearing of costs of adaptation to the adverse affects of climate change is also vaguely dealt with in the different documents. As the paper focuses on mitigation efforts only, adaptation is not discussed any further.

3 Key issues for mitigation efforts in the future climate policy regime

There has been a large discussion on the Kyoto-Protocol itself, its future development as well as on possible alternatives. The probably most famous comment on the Protocol was the withdrawal by the Bush administration. It was judged that the implementation of the Protocol would be too costly to the US economy and that it was lopsided for not imposing obligations on the developing countries. Unfortunately, the US administration did not manage to present an alternative until now - even though it seems to be the only option remaining for the US (Bodansky (2002)). However, this has been done by others, even prior to the US withdrawal. Most importantly emission trading itself has been criticised. Instead, taxes have been favoured (Pizer (1997), Cooper (2000)).

Others do not propose to directly reject Kyoto but, for example, to put the stress on long term issues. For example, Barrett (2002) proposes to focus on collective funding of basic research into development of new, carbon-saving technologies. However, even though the possibility for short term protocols, such as the Kyoto Protocol, is briefly discussed, no reference to the ultimate objective of the framework convention is made - an aspect that should be generally taken into account when discussing future climate policy regimes. Edmonds et. al (1999) provide an analyses of a more specified "technology protocol". Baumert et al. (1999) propose intensity targets as incentives for voluntary participation of developing countries. But they also point out that this would require a re-conceptualisation of the existing framework, in particular with long-term environmental considerations. An overview and evaluation on 13 alternatives to the Kyoto-Protocol is provided by Aldy et al. (2003).

As already mentioned, throughout the paper I assume that the future climate policy regime is based on the Framework Convention and the Kyoto principles. This is namely the objective formulated in Art. 2 of the Convention, the quantification of absolute emission budgets for each nation as well as emission trading.[5] Furthermore, a long-term approach for allocating emission permits is discussed. Shaping this allocation in the future climate policy regime thus requires a discussion of the following:

(a) Global targets (final and interim targets, i.e. path)

(b) Determination of time of participation [6]

(c) Quantification of contributions to limiting GHG emissions by participants

3.1 Global targets and path

Generally, there are several ways to determine a global emission target in terms of net GHG emissions to the atmosphere. One may for example, minimise the sum of total abatement costs plus total damage costs. However, the approach faces some general drawbacks in the context of pollution control (see for example Perman et al. (1999, pp. 290-291)). Another option is to define a *concentration target* as mentioned in Art. 2 of the Framework Convention without directly referring to costs.

Even though the objective of the Convention seems quite precise, a lack of clarity remains. The understanding of a *dangerous interference,* a *threat to food production* or other issues may differ among people and nations. This may complicate the finding of an agreement on the ultimate global emission. Furthermore, the relationship between GHG emissions, atmospheric GHG concentration, radiative forcing and the temperature increase or extreme weather events is not fully understood, as is the role of solar and volcanic forcing or the effects of aerosols (IPCC 2001a). Nevertheless, a general idea of allowable total emissions exists (see Table 1).

Apart from the ultimate emission target there has been an intensive discussion on the interim targets, i.e. the path to take to get there. The most important argument in this discussion has not been the technical feasibility for near term cuts in emissions, but rather the associated costs. Some authors argued that postponing emission reductions would result in lower costs as otherwise existing capital stock would have to be prematurely retired (Wigley et al. (1996)). Others have argued that by postponing

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[5] The latter may well be considered as an integral part of any future regime regardless of how it is design in detail (SEPA 2002 p. 38). The recent activity in Europe with regard to emissions trading on entity level may support this assessment.

[6] It should be noted that the stabilisation target does not inevitably require all countries to limit their emissions. Technically it would be conceivable that some countries continue to emit while others invest in removal from the atmosphere including biological sinks and technical removal as suggested by Lackner et al. (no year).

reductions the benefits from learning-by-doing would be foregone (Vuuren et al. 2001). Other points of discussion have been the way to consider technical change in economic models or the discount rate to be used (SEPA (2002, pp. 22-25)). Until economists come up with a coherent solution, policy makers are likely to set interim targets that are somewhere in between the possible extremes. For the ultimate concentration target, Jacoby et al. (1999, p. 7) state that it seems most likely that an atmospheric concentration of 550 ppmv will be selected as it is "...in the middle of what has become the standard range of numbers, making it a moderate compromise."

Once the total target(s) have been set, a discussion on the contribution of the different Parties in order to reach the goal is necessary.[7] As this burden sharing is a zero sum game, it is all but trivial and Parties are likely to put "good" arguments forward in order to get a sufficiently big piece of the pie.

Table 1: Stabilisation level and related allowable emissions

WRE CO2 Stabilisation Profile (ppm)	Accumulated CO_2 Emissions 2001-2100 (Gt CO_2)	Year in which Global Emissions Peak
450	1314-2646	2005-2015
550	2124-4068	2020-2030
650	2646-4932	2030-2045
750	2952-5400	2040-2060
1000	3258-5832	2065-2090

Source: IPCC (2001b, p.108).

3.2 Excursus: "Good Arguments" or justice priciples

The discussion on justice in the context of climate change started at least at the end of the eighties or early in the nineties of the last century (d'Arge (1989), Rose (1990)). Since then, different sets of relevant principles have been presented and applied, some of them being quite similar, though called by different names. Table 2 gives some examples for principles discussed. The reader is referred to the authors for more details.

[7] A theoretically straightforward way to avoid such discussion implying high transaction costs would be to auction the permits already on the international level.

Table 2: Examples for justice principles discussed

Author:	Rose (1992) [a)]	Blanchard et al. (2001)	Torvanger et al. (2002) [b)]
Principle:	Horizontal (initial) [a)]	Equity of rights	Responsibility
	Vertical (initial)	Utilitarian equality	Need
	Ability to pay (outcome)	Democratic equality	Capacity
	Sovereignty (outcome)	Causal responsibility	
	Egalitarian (outcome)	Merit	
	Market justice (process)	Proportional equality	
	Consensus (initial)		
	Compensation (process)		
	Rawls' Maxim (process)		
	Environmental equity		

[a)] Rose et al. (1998) point out that it is important to distinguish whether a "criterion applies to the process by which a criterion is chosen, the initial allocation of permits, or to be the final outcome of the implementation of the policy instrument..."
[b)] Apart from the three fairness principles, six operational requirements are applied.

Even though we have a more or less clear understanding of these different principles, two major problems are faced when applying them for allocations of emission entitlements[8]: Firstly, the different principles are in most cases equally justified. This is to say that one cannot say which principle is to be preferred in case there are different opinions. To overcome this problem, Müller (2001) proposes the so-called *preference score method* to reach a "compromise-solution" between different principles or approaches, as discussed below. Secondly, apart from the principle, a reference base, e.g. population, as well as an operational rule for applying the principle, e.g. allocate in proportion to population, is required (Rose 1992). However, "there is no one-to-one relation between a fairness principle and a specific formula, meaning that one formula can be supported by more than one principle, and one principle can support more than one formula" (Torvanger et al. (1999 p. 15)). The reference to justice principles may thus guide negotiations, but it is unlikely that any agreement reached will fit into a clear systematic concept. Finally, Rose et al. (1998) showed that a mere philosophical distinction between different criteria may well be mathematically equivalent and thus have the same welfare outcomes.

[8] Furthermore, Pan (2003) states that equity concerns in the context of burden sharing of mitigation efforts are generally restricted to equity among nations and points out that there is also an intra-nation dimension.

3.3 “Formula“ and “reference bases“ for applying equity principles

When referring to justice principles in the context of the allocation of emission rights in the future climate policy regime, they have to be specified in way that allows calculation of an emission target. Theoretically, the number of potential reference bases seems unlimited. Rose (1992 p. 65) proposes the following reference bases:

- Economic welfare
- Population
- Land area
- Energy use
- Energy reserves
- CO_2 emissions

Other bases, as for example GHG emissions, GHG abatement costs could also qualify. For making them an operational reference, other “units” as for example CO_2 emissions per capita or per unit GDP would sometimes be necessary. Referring to the initial part of this section, these reference bases could mostly be used for both the determination of thresholds for participation as well as for the determination of the contribution to mitigation efforts.[9] It goes without saying that the figures can be weighed and combined.

3.4 Proposals for allocations of permits

The first proposals and analyses for allocation of permits date back to the beginning of the 1990’s (for example Barret 1992). Subsequently, a larger number of proposals emerged as a result of the Ad Hoc Group of the Berlin Mandate (AGBM). These proposals differ with regard to their specification as well as to the reference basis chosen (Torvanger et al. (1999)). An overview is given in Table 3.

9 For example, countries could be obliged to limit greenhouse gas emissions when their per capita emissions exceed a certain threshold. Similarly, allowable emission could be calculated based on certain per capita emissions.

Table 3: Type of reference base and frequency in 16 proposals from the AGBM
(based on Torvanger et al. (1999, p. 18))

Operational reference basis	CDE	CDE / Cap.	CDE / GDP	GDP / Cap	Cum CDE	CDE exp / CDE tot	dPop/ dt	EXP/F F	CDE / km^2	Other
Number of times applied	3	9	7	7	5 *)	2 *)	2	2	1	4

CDE = (Level of) $CO2_{-eq}$ emissions, Cap. = Capita, GDP = Gross domestic Product, Cum = cumulative historical, CDE exp / CDE tot = share of emissions resulting from production of goods for export relative to total emissions, dPop/ dt = Population growth, EXP/FF = Fossil fuel intensity of export, CDE / km^2 = emissions per square kilometer of a country's territorial basis

*) one proposal based on projected data

Additionally to the proposals presented during the climate negotiations, various approaches for the allocation of permits – also called burden-sharing – have been proposed in literature. They differ strongly in specification. Some analyse different burden-sharing rules applied to a limited number of countries (for example Winkler et al. (2002), Groenenberg (2001)) whereas others provide an allocation scheme for the whole world (Meyer 2000). It would be out of the scope of this paper to review all proposals currently in circulation. A review of selected literature until 1998 is provided by Torvanger et al. (1999 pp. 31-33). Evans (2002) discusses some other proposals, which have gained particular attention in the past. The implications of these approaches with regard to costs have been studied by others as well (den Elzen (2002), den Elzen (2003)). Below, I only discuss two proposals in more detail as they form the primary basis for the concept presented in the next section.

Apart from the specification, the proposals differ with respect to the degree of differentiation. Based on the experience from the European burden-sharing negotiations, Ringius (1997, p. 5) argues for differentiated agreements, as "the symmetrical approach ... might result in inefficient and unfair agreements and country obligation." On the other hand, Torvanger et al. (1999, p. 28) questions whether the EU case can be transferred to greater number of countries. Furthermore, it may be difficult to define the indicator for differentiation on a global level, especially if differences among countries to be considered are based on differences in preferences. To demonstrate this point, consider Germany that has a problem with nuclear energy and rather prefers electricity from lignite-fired power-plants. Why should other Parties renounce a certain part of "their" allocation only because of this particular German preference? A symmetrical approach may thus be supported by a greater number of countries.

▪ The Brazilian proposal

The Brazilian proposal (UNFCCC 1997) has been prepared for the 7th session of the AGBM. The core element is the allocation of emission permits in proportion to the historical responsibility for global warming in terms of accumulated contribution to radiative forcing or temperature increase of certain Parties.[10] Indeed, an allocation of permits was only suggested for Annex-I countries and an overall budget of 30 % below 1990 emissions by 2020 was proposed. CO_2 emissions from the energy sector and cement production should be considered. Non-Annex-I countries were not to make any binding commitment with regard to emission limitations.

The initial Brazilian proposal has been criticised for several reasons, as for example the restriction to CO_2 emissions from limited sources or the methodology used for calculating the contributions to global warming. The proposal had been revised but still some drawbacks remained. Nevertheless, a group of experts came to the conclusion that "... these deficiencies can in general be readily addressed by improving the model by corrections or by importing techniques and processes already available in other models." (den Elzen et al. (1999). Even though the discussion among experts continued (for an overview see: IIDS (2003)) no final applicable methodology has been found yet. Most important issues are the indicators for climate change, the consideration of non-linearities and feedbacks, as well as the databases. However, they conclude that "... the Brazilian Proposal is probably the best one to deal with the "common but differentiated responsibilities ..."" (IISD 2000).

- Contraction & Convergence

The idea of Contraction & Convergence has been presented by the Global Common Institute (Meyer 2000). The contraction part refers to the cutting back of emissions in order to reach an CO_2 concentration target, which must be fixed on an international level. As already discussed above, once a global target has been defined, an allocation of the resulting emission permits has to be agreed upon. The convergence part reflects the idea that this allocation should be carried out on an equal basis to all of human kind – i.e. an equal per capita allocation of emission rights which can be traded. Apart from the concentration target an agreement on the time of convergence is required. Berk et al. (2001, p. 475) point out that a late date of convergence is disadvantageous for developing countries since it results in less cumulative emission permits.

[10] Another element was the Clean Development Funds that should be financed by the non-compliance penalties of Annex-I countries. The fund later became the Clean Development Mechanism.

Like the Brazilian Proposal, the idea of Contraction & Convergence has also been judged as a very good concept for future allocation of emission permits by several members of governments in both Annex-I and non-Annex-I countries (for a summary see Meyer 2000, pp. 70-75).

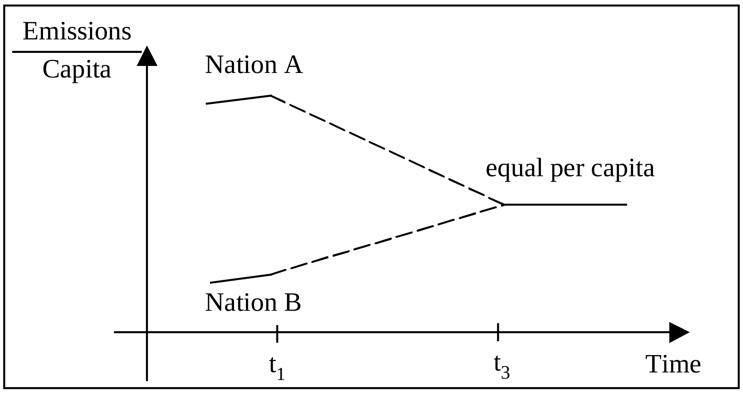
4 Equal Emissions per Capita over Time (EECT)

In the previous section several options for quantifying the Parties' contributions to the reduction of global GHG emissions have been discussed. As mentioned some multi-criteria approaches have also been proposed so far. In this section I present a new approach for the development of the future climate policy regime by combining the equal per capita allocation with the historical responsibility approach.

One may generally question whether an allocation based on equal per capita emissions or on historical responsibility is "equitable" (e.g. Beckerman et al. 1995). However, I neglect this theoretical discussion and rather analyse the implications of such an allocation based on these two principles as practical politics may well decide on such a rule regardless of its support by any justice principle. And as mentioned above, the two approaches have been judged to be a good candidate for forming the basis of future burden sharing schemes.

Even though it has not been explicitly said, the path for reaching an allocation based on equal per capita emissions so far has generally been understood as an monotonously decreasing curve from the day a Party participates (t_1 in Fig 1) until equal per capita emissions are reached (t_3 in Fig 1) for those Parties that have emissions above considered equal per capita emissions (for example: Torvanger et al. (1999, pp. 20-22), Groenenberg et al. (2001, p 1018)). On the other hand, those with lower than average emissions would face an allocation based on a monotonously increasing curve until equal per capita emissions are reached as depicted in Figure 1.

Figure 1: General understanding of the path to equal per capita emissions



As can be seen in Figure 1, a simple allocation based on equal EPC would result in a "fair" allocation from the point t_3, but if looking at a nation's average emissions (allocation) per capita over time one can see that there would be a difference between high and low emitting countries, which could still be judged as "unfair". Rose (1992, p. 66) states: "Industrialized countries have developed by abusing the global commons with little or no penalty. Ignoring the past build-up and simply basing reduction requirements on subsequent emissions would be equivalent to penalizing developing countries for the progress, when no such sanction was imposed on industrialized countries." Shukla (1999) argues the same way and suggests a more equitable convergence scheme as depicted in Figure 2. However, the scheme is not further specified.

I build on this idea and propose to allocate emission rights based on a path such that *average* emissions per capita are also equal for a certain period prior to t_3. Denoting the beginning of this period by t_1, this means that the sum of the emissions per capita in the period between t_1 and t_3 has to be equal for all nations.

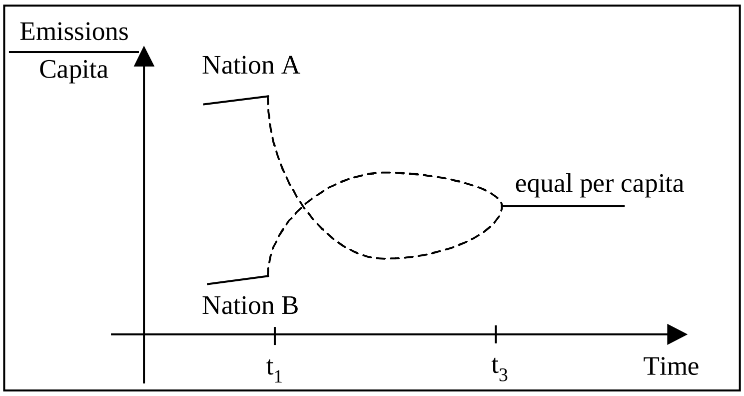
Mathematically, this means that the integral in the limits of t_1 and t_3 of a (piecewise – see below) continuous function $\Phi_i(t)$ which describes the allowed emissions per capita at the time t in country i has to be equal for all nations. Mathematically,

$$\int_{t_1}^{t_3} \Phi_i(t)dt \overset{!}{=} A \qquad \forall i \qquad (1)$$

This condition does not inevitably imply that all Parties are allocated a certain assigned amount from the point t_1. This may happen at a later point t_i^* with $t_1 < t_i^* < t_3$ and would allow for some flexibility with regard to the timing of participation. This is important, as not every Party would even be technically able to take on an absolute emission budget promptly. (This would be the consequence if all countries were to start at the same time, as most Annex B countries are likely to have absolute targets with the Kyoto-Protocol entering into force soon.) Other authors have argued for example for an initial voluntary GHG intensity target to take this aspect into account (Baumert et al. 1999). However, the emissions released between t_1 and t_{i^*} would have an impact on the allocation between t_{i^*} and t_3 as the condition in (1) has to be satisfied. Incentives for early participation are discussed after the presentation of the numerical example.

Keeping in mind that current emissions per capita differ strongly between nations, it becomes obvious that nations with low EPC would receive higher allocations than average emissions in future years (see Figure 2). The opposite would hold true for nations with higher EPC - regardless of whether or not they have an absolute target in the first commitment period. It is important to note, that only the allocation of the permits is based on the curves as shown in Figure 2. As these permits are traded there would be no need for abrupt cuts in emissions.

Figure 2: Schematic depiction of the path for equal emission per capita over time



To determine the concrete allocation in the future for a single nation, it would thus be necessary:

1. to determine the allowed "sum" in the period between t_1 and t_3 for the Parties
2. to gather historical emission data, if t_1 lies in the past
3. to determine the time of participation for nation i (i.e. t_i^*)

4. to determine a rule, e.g. equation, how to distribute the “remaining” budget of permits for the period between t_i^* and t_3.

In this context it is worthwhile to note, that by the allocation of emission entitlements, emission reductions obligations are only allocated implicitly. The reduction obligation is calculated by the subtraction of the entitlements from the real emissions. However, the future development of the latter is highly uncertain, especially when considering long time horizons as in this paper. Thus, the resulting long-term reduction obligations are uncertain, too.

In the next section a concrete option for the determination of the four steps is presented.

4.1 Numerical example

During the discussion of the concrete option in this chapter one should remember that many other options are equally conceivable when specifying the approach. The numerical example is based on CO_2 emission from energy combustion as this data was the most accessible. It goes without saying that the approach can be applied with the whole basket of GHG specified in the Kyoto Protocol.

4.1.1 Determination of the allowed average emissions per capita

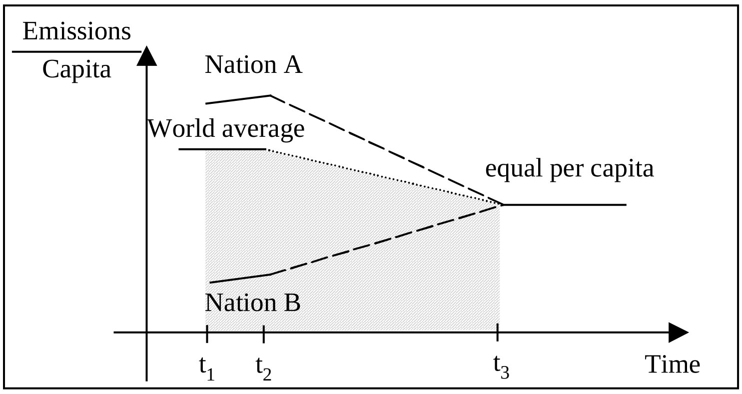
The average emissions per capita are determined as follows: A piecewise continuous curve is constructed consisting of

a) the world average emissions per capita in the interval from t_1 to t_2 (where t_1 = 1992, the year the Framework Convention on Climate Change has been adopted and t_2 = 2013 the beginning of the second commitment period)

b) a straight line connecting world average emissions in t_2 and equal per capita emissions in t_3 (where t_3 = 2092, 100 years after the Framework Convention was adopted). For the determination of the equal per capita emission in 2092 see Annex 1.

A (see equation (1)) is set equal to the area under this curve (see hatched area in Figure 3). For determining the actual allowed emissions, one has to multiply the allowed per capita emissions with the corresponding population of the year analysed.

Figure 3: Quantification of allowable average emissions per capita over time



4.1.2 Determination of time of participation

As mentioned above no specific time for participation is set - except for those Annex B countries having ratified the Protocol. This allows for some flexibility. The only rule assumed is that once a country takes on an absolute allocation of permits, it cannot leave the system anymore. As we discuss later, incentives for early participation depend on the level of current emissions per capita, the treatment of CDM, expectations on future permit prices, etc.

4.1.3 Determination of a function for future allocation

As emissions per capita generally differ among countries, a function for each single Party is needed. I propose to use the same quadratic function of the form

$$\Phi_i = a_i t^2 + b_i t + c_i \qquad (2)$$

for all Parties with only the coefficients *a*, *b* and *c* changing.

Keeping in mind the historical emissions per capita of nation i since t_1, equation (1) is specified as:

$$\int_{t_i^*}^{t_3} (a_i t^2 + b_i t + c_i)dt = A - D_{i,t_i^*} \qquad (3)$$

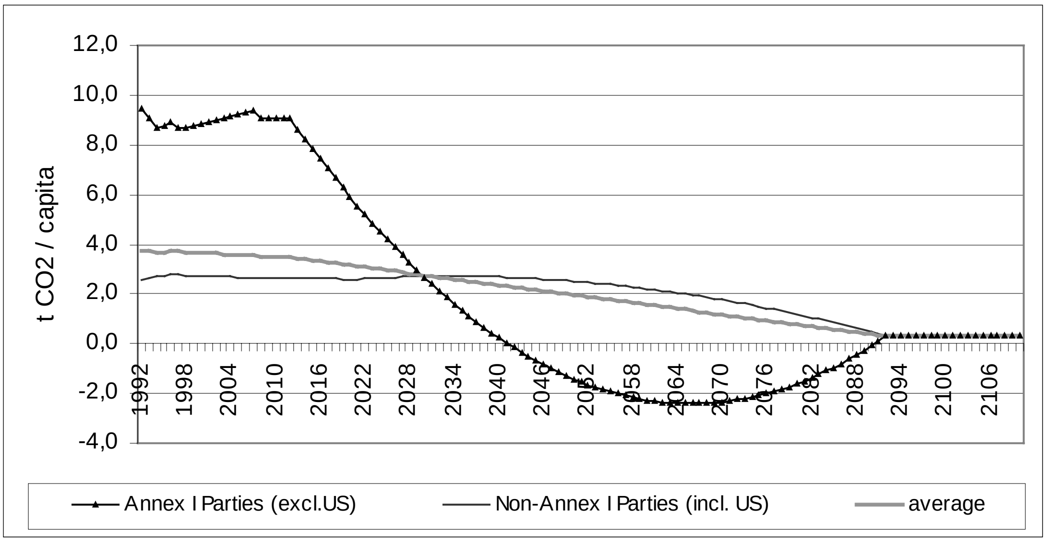
where D_i describes the cumulative emissions per capita between 1992 and the point when nation i starts contributing to the global mitigation efforts.

For the determination of the coefficients a_i, b_i and c_i see Annex 2.

For the finalisation of the numerical example the start of participation of the single countries (t_i^*) has to be determined. This is done for a selection of countries below. Note that, as future commitment periods after 2012 are studied, all calculations are based on prognoses only (see Annex 1). Later allocations could be based on, at that time historical, data from "recent" years as also suggested by GCI (2003).

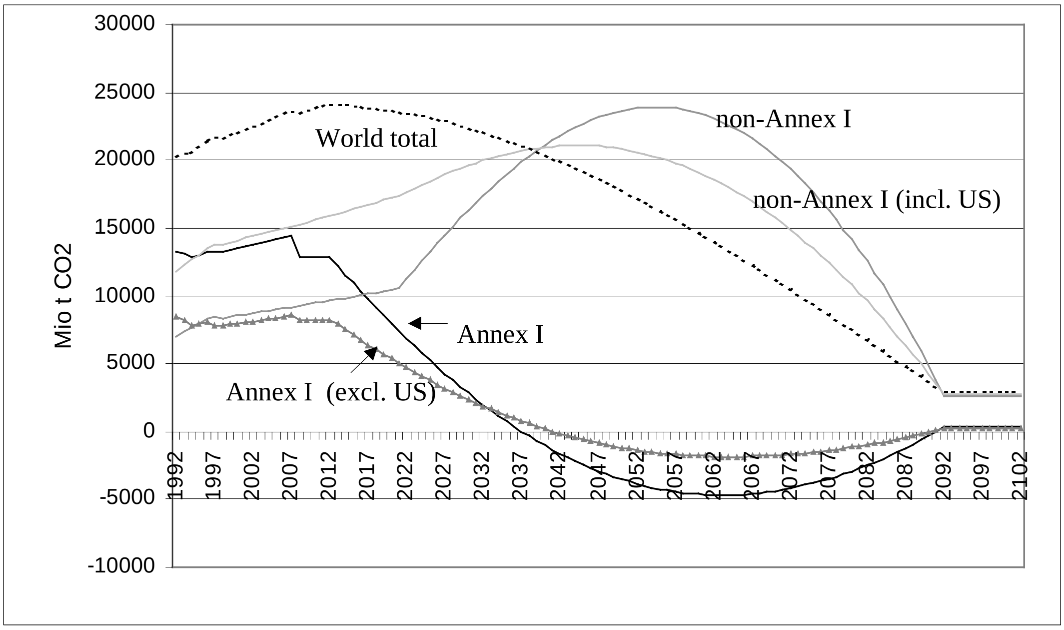
Figure 4 shows the path for allowed emissions per capita assuming that the non-Annex-I countries (including the US)[11] take on an absolute emission budget in 2022. All other Annex I countries, other than the US, are assumed to accept and continue with an absolute budget in 2013. By multiplying per capita emissions by the corresponding population, one gets the total emissions and assigned amount respectively (Figure 5). Data is given for both cases, where the US ratifies the Kyoto-Protocol and where it starts to limit GHG emissions in 2022 as the other non-Annex I countries.

Figure 4: (Assigned) Emissions per capita (CO_2 from fuel combustion) with non-Annex-I incl. US taking on an absolute emission budget in 2022



[11] Australia has been assumed to ratify the Protocol in order to simplify calculations. Given the minor share of global GHG emissions (esp. compared to the US) this seems acceptable.

Figure 5: Emissions and assigned amount (CO_2 from fuel combustion) with non-Annex-I incl. US taking on an absolute emission budget in 2022[12]



It goes without saying the individual allocation can strongly differ from the highly aggregated schedule presented in Figure 5. Table 4 provides less aggregated data for some countries for the allocation in the next commitment periods. Remember that the figures given dependent on the simplified prognoses for population and emissions.

Furthermore, one has to note that for non-Annex-I countries the starting point of participation is of crucial importance with regard to a country's allocation at a certain time. Figure 6 and 7 visualise this aspect for two countries: Qatar representing countries with currently above average emissions per capita and India for below average countries. As we can see in the case of Qatar, postponing the start of contributing to the global mitigation efforts allows for an business-as-usual, and therefore increasing emissions path. However, the increasing emissions are taken into account later and result in a (more) negative allocation in the last third of the century. The situation for India is similar. Due to its very low emissions per capita, it will be allocated many permits after taking on an absolute emission budget. The later the participation, the

[12] World total emissions indeed slightly differ depending on whether or not the US participates early. This decision influences average per capita emission in 2013, that form the starting point for the reduction path until 2092. Cumulative emission from 1992 to 2100 are about 1,700 b t CO_2 .

bigger the allocation at the end of the century. Incentives for a certain decision with regard to the participation are discussed in the next chapter.

Table 4: Emissions (italic figures) and assigned amount for selected countries*

		2nd CP		3rd CP		4th CP		5th CP		6th CP		7th CP		8th CP		9th CP	
	Start	2013-17	%90*)	2018-22	% 90 *)	2023-27	%90 *)	2028-32	% 90*)	2033-20	%90 *)	2038-42	% 90 *)	2043-47	%90 *)	2048-52	%90 *)
Australia	2013	1193	0,92	845	0,65	513	0,40	207	0,16	-65	-0,05	-380	-0,29	-484	-0,37	-626	-0,48
Canada	2013	1733	0,81	1231	0,57	751	0,35	304	0,14	-98	-0,05	-568	-0,26	-728	-0,34	-945	-0,44
Germany	2013	3223	0,67	2337	0,49	1549	0,32	863	0,18	284	0,06	-275	-0,06	-558	-0,12	-827	-0,17
Japan	2013	4099	0,80	3043	0,60	2112	0,41	1318	0,26	660	0,13	109	0,02	-269	-0,05	-560	-0,11
Spain	2013	1056	1,02	847	0,82	658	0,64	491	0,48	346	0,34	255	0,25	122	0,12	41	0,04
Argentina	2022	*1323*	2,71	*1376*	2,81	1185	2,42	928	1,90	688	1,41	541	1,11	280	0,57	119	0,24
Brazil	2022	*2890*	3,00	*3034*	3,15	3140	3,26	3201	3,32	3207	3,32	3777	3,92	3053	3,16	2912	3,02
China	2022	*29033*	2,55	*30282*	2,66	27877	2,45	24375	2,14	20959	1,84	20915	1,84	14760	1,30	12100	1,06
India	2022	*8913*	3,15	*9367*	3,31	9845	3,48	10347	3,65	10875	3,84	13785	4,87	12013	4,24	13085	4,62
Nigeria	2022	*441*	3,01	*505*	3,44	1299	8,85	2343	15,96	3374	22,99	5348	36,43	5274	35,93	6026	41,05
Saudi Arabia	2022	*2623*	2,98	*2737*	3,11	2280	2,59	1461	1,66	522	0,59	-736	-0,84	-1578	-1,79	-2600	-2,96
United States	2022	*32177*	1,33	*33254*	1,38	24605	1,02	13321	0,55	2831	0,12	-9050	-0,37	-14992	-0,62	-21827	-0,90
Uzbekistan	2022	*1099*	1,96	*1145*	2,04	998	1,78	777	1,38	556	0,99	385	0,69	140	0,25	-39	-0,07

		10th CP		11th CP		12th CP		13th CP		14th CP		15th CP		16th CP		17th CP	
	Start	2053-57	% 92 *)	2058-62	%90 *)	2063-67	%90 *)	2068-72	%90 *)	2073-77	%90 *)	2078-82	%90 *)	2083-87	%90 *)	2088-92	%90 *)
Australia	2013	-724	-0,56	-773	-0,60	-774	-0,60	-727	-0,56	-634	-0,49	-494	-0,38	-305	-0,24	-69	-0,05
Canada	2013	-1089	-0,51	-1160	-0,54	-1157	-0,54	-1080	-0,50	-933	-0,43	-717	-0,33	-436	-0,20	-92	-0,04
Germany	2013	-1003	-0,21	-1089	-0,23	-1093	-0,23	-1019	-0,21	-874	-0,18	-663	-0,14	-388	-0,08	-54	-0,01
Japan	2013	-753	-0,15	-856	-0,17	-880	-0,17	-833	-0,16	-721	-0,14	-547	-0,11	-310	-0,06	-8	0,00
Spain	2013	-18	-0,02	-59	-0,06	-82	-0,08	-89	-0,09	-81	-0,08	-59	-0,06	-24	-0,02	22	0,02
Argentina	2022	-10	-0,02	-107	-0,22	-171	-0,35	-201	-0,41	-197	-0,40	-158	-0,32	-84	-0,17	25	0,05
Brazil	2022	2751	2,85	2538	2,63	2288	2,37	2005	2,08	1688	1,75	1338	1,39	954	0,99	534	0,55
China	2022	9795	0,86	7762	0,68	6050	0,53	4654	0,41	3564	0,31	2766	0,24	2249	0,20	2002	0,18
India	2022	21825	7,71	30575	10,80	35960	12,70	37814	13,36	36035	12,73	30573	10,80	21422	7,57	8610	3,04
Nigeria	2022	6523	44,44	6812	46,41	6812	46,40	6485	44,18	5802	39,52	4741	32,30	3295	22,44	1461	9,95
Saudi Arabia	2022	-3440	-3,91	-4099	-4,66	-4475	-5,09	-4507	-5,12	-4148	-4,72	-3372	-3,83	-2169	-2,47	-549	-0,62
United States	2022	-26831	-1,11	-30024	-1,24	-31159	-1,29	-30120	-1,25	-26843	-1,11	-21316	-0,88	-13582	-0,56	-3737	-0,15
Uzbekistan	2022	-187	-0,33	-297	-0,53	-364	-0,65	-385	-0,69	-359	-0,64	-284	-0,51	-163	-0,29	2	0,00

*) equal per capita emission in 2092, Global assigned amount in 2092: 3 b t CO_2

Figure 6: Emissions (prognosis) and assigned amount as a function of beginning of contributing to mitigation efforts in the case of Qatar

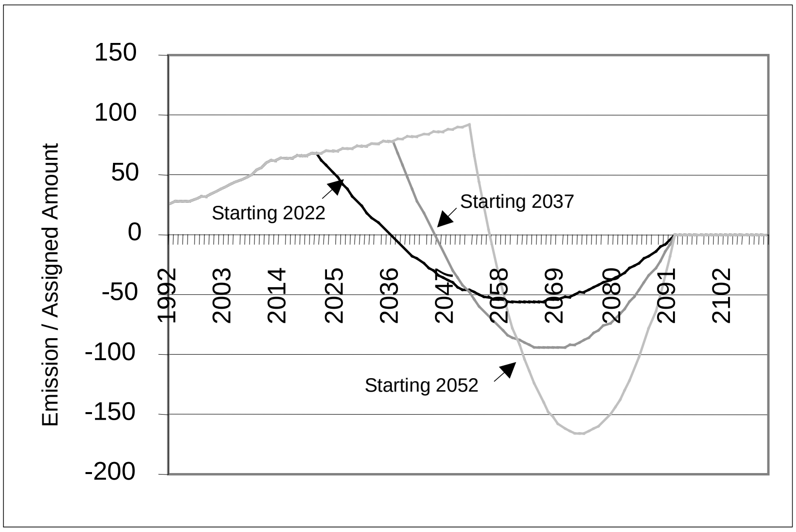
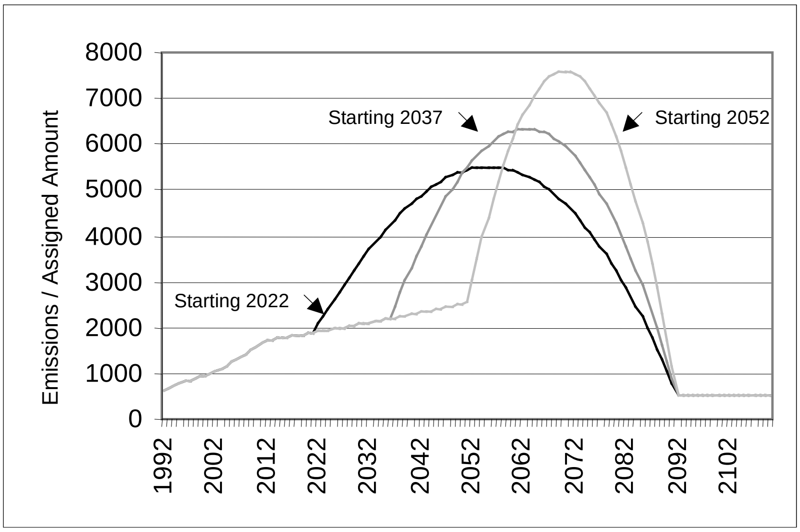


Figure 7: Emission (prognosis) and assigned amount as a function of beginning of contributing to mitigation efforts in the case of India



4.2 Discussion

The numerical example presented above revealed two important implications of the approach presented in the previous section. Firstly, an allocation based on equal per capita emissions considering the historical load can result in a negative allocation in some future commitment periods for countries with emission per capita above average – regardless of whether or not they are already Annex-I countries. The negative allocation on its own, however, is no reason to reject this proposal for theoretical reasons. Indeed, a negative allocation conflicts with the need principle (CICERO p. 20), but on the other hand it takes into account the historical burden concept. Nevertheless, the approach may be politically unattractive right now. A political economy analysis, taking into account the negotiation power of the countries with higher and lower emission per capita respectively, would be an interesting next step. Regardless, the approach provides another analytical input for the political discussion.

The potential financial transfer implied could also be considered as “fair air”, given the historical burden of the Annex-I countries, and the need for the eradication of poverty is mentioned several times in the Convention.[13] On the other hand one has to keep in mind that there are also many non-Annex-I countries with per capita emissions above average. They would not benefit from such fair air.

However, regarding the costs implications of the allocation scheme presented, one must remember that the long-term reduction obligation resulting from the allocation of CO_2 entitlements is highly uncertain, as it depends on the future business as usual emission path. The same uncertainty is faced with regard to the abatement costs, especially when considering a time frame of about one hundred years as proposed in this paper. This is why I refrained from presenting any quantitative data on this issue.

Secondly, the incentives for non-Annex-I countries to join early depend on several factors. First of all, one has to remember that the overall allocation of permits is dependent on the population. This can provide certain incentives. For example, a country with higher than average emissions per capita and decreasing population may opt for a late entry when calculating the overall allocation: The low or even negative computed emissions per capita after entry would be multiplied by a small number of people. The opposite is true for Parties with lower than average emissions per capita and decreasing population. They could enter early in order to get a larger allocation in the

[13] In case one fears that the revenue from the sale of surplus AAUs could be misused for whatever purposes, one could dedicate the financial means for climate protecation fund that helps to promote GHG emission reductions. Whether they should be used for adaption is discussible.

first half of the century. Whether the aforementioned fact could give rise to a change in population policy is discussible, even though I do not think it is likely: An increase of population growth would only be reasonable for countries with per capita emissions lower than the calculated value for the allocation. The number of these countries is likely to reduce over time, especially with allowable per capita emissions decreasing. When per capita emissions are higher than the calculated allocation value, a reduction of population would be reasonable, however not realistic from the author's point of view. Other models also considered population growth as an exogeneously driven factor (Byrne et al. (1998, p. 339)).

Apart from changes in population other factors would also play an important role for the decision to join. As mentioned above, not all non-Annex I countries may even be technically capable to take on an absolute emission budget due to a lack of human capacity. So far national communications have been submitted much later than envisioned in the 1990's.

A country's market position with regard to both surplus permits and marginal abatement costs would also be important in this context. Furthermore, a country's expectation on technical change and thus future carbon prices is also to be considered.[14]

Finally, it is worth mentioning that the approach offers no long-term incentive for carbon leakage. It has been argued in the past that industry may move from countries with emission targets, and thus resulting stronger environmental regulations, to non-capped countries in which GHG emission would be free of charge. In the short run this would still be possible. But the higher early emissions in the un-capped country would be taken into account and result in reduced allocations in the subsequent periods. Thus, the overall emissions over time would be unaffected.

4.3 The role of CDM in the future climate policy regime

The CDM is the product of a political discussion that resulted in a second-best solution. Generally, absolute emission targets for all countries would have been desirable. As the developing countries were vehemently against stringent emissions budgets, the CDM was introduced to involve them all the same. And indeed, the CDM offers the opportunity to realise low cost emission reductions in non-Annex-I countries.

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[14] The flexibility with regard to the time of accepting an emission target indeed allows borrowing for countries, especially when their cumulative emissions per capita exceed their budget.

Even though some approaches for future distribution of emission permits are quite far developed, the authors generally do not explicitly discuss the role of the CDM in their scenarios.

In the approach presented above the CDM would increase the overall emissions. This is due to the fact that the countries' overall assigned amount is independent of the emissions in a certain period (see equation (1)). If a Party, which has not accepted an absolute emission budget yet, hosts a CDM project, its emissions are reduced compared to the non-CDM case. Thus, its emission budget after entry into the scheme would increase. This alone would postpone emissions to a later time and would even be desirable. However, this affect would be compensated as the issuance of CERs allows the buying country to increase its current emissions. Against this background, a continuation of the CDM under the scheme presented above is not reasonable for environmental reasons.

Apart from that, the CDM has other conceptual drawbacks. First of all, it provides incentives for governments in developing countries to refrain from stringent environmental legislation, as only additional projects are eligible for the CDM.[15] With an increasing number of existing projects, the number of opponents to changes in legislation actually increases as projects would get less CERs after a baseline revision due to the higher standard. The number of opponents to any phase out of the CDM is also likely to increase the longer it exists, as project developers, validaters and certifiers, who have all invested in human capital to satisfy the requirements, would oppose it.

Whether the CDM is cost-efficient can also be disputed especially due to the additional transaction costs for the baseline determination, monitoring and certification (for a discussion see Fichtner et al. (2003)). Apart from that, millions of Euro are currently and will be spent for capacity building programmes in developing countries to make people able to develop project design documents and to set-up designated national authorities. Finally, Bode et al. (2003) also showed how a strict investment additionality test, which is required to prevent illegitimate reduction permits from entering the scheme - can result in inefficient investments. Recent decisions by the CDM-Executive Board suggest a rather strong additionality test.

Nevertheless, participating countries could still implement JI projects to benefit from low cost reduction options instead of only selling surplus allowances. As for the participation in the CDM, this decision would be up to individual Parties of course.

[15] In this context the term legal additionality is often used to be more specific.

5 Conclusions

A first step to limiting human greenhouse gas emissions into the atmosphere has been taken by adopting the Kyoto-Protocol in 1997. However, as emission targets have only been agreed upon for a limited number of countries for the so-called first commitment period from 2008 to 2012, some challenging tasks are waiting for the climate negotiators when discussing future contributions to further limit GHG emissions.

A major source of conflict is the different notion of what an equitable contribution is. Literature provides many justice principles. However, none of these principles is per se more just than the others. Some kind of compromise will have to be found. And apart from these theoretical considerations, it is not easy to institutionalise principles with regard to the allocation of emission rights either. Nevertheless, a number of proposals have now been suggested. They differ with regard to their specification and to the justice principles they refer to. Thus, they are supported differently by developing and industrialised countries as the burden implied changes considerably.

In this framework, a new proposal for the long-term allocation of emissions rights based on the so-called Brazilian Proposal and the Contraction & Convergence approach was presented. It is thus based on the two principles *responsibility* and *equity of rights*. The main feature of the proposal is that the average emission per capita in a period to be defined has to be the same for all countries. By determining this allowable average value, the question of the exact starting point of contributing to limitation of global GHG emissions becomes less important. With an overall fixed budget set, higher emissions in the near future result in a smaller allocation of emission permits after a Party decides to join the scheme. This allows for a lot of flexibility for the countries that do not want to accept an emission target right now, be it because they are technically unable to do so or for other reasons. Flexibility in timing can also be one aspect of "differentiated responsibility" (Matsui (2002)).

As the overall allocation is calculated on the basis of a per capita value, the total population is a dominating factor in this calculation. Whether this gives incentives to change population policy is discussible. A numerical example that considered emission since 1992 showed that the allocation may well be negative in some periods for certain countries. In this context, one should note that for the latter issue it is not important whether it is a developing or industrialised country, but rather whether it has considerably higher per capita emissions than average.

The numerical example was restricted on CO_2 emissions from energy combustion. The number of sources could be extended. Future work could also analyse the resulting costs which have not been studied for certain reasons so far. The same goes for the impact on atmospheric GHG concentrations. All errors are mine.

6 Annexes

Annex 1:

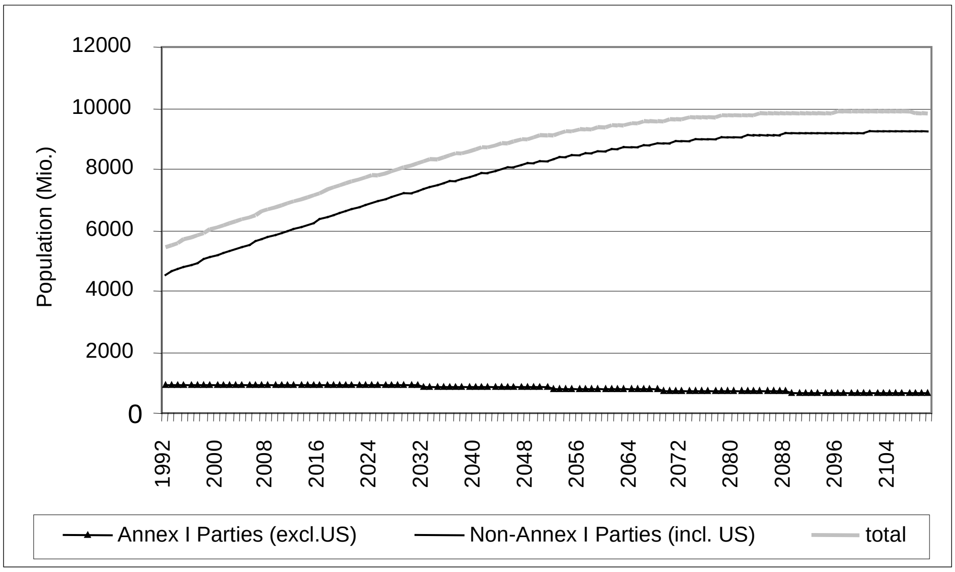
Data used for the numerical example.

<u>Population:</u>

Population data and prognoses until 2050 on country level have been taken from UN (2002). For the prognoses, the medium variant was used.

Further projections are only given for the year 2150 on continental level(UN (1999)). The continental trend between the period 2050 and 2150 has been used on the country level as well. For the time in between, a regression curve of the type $f(x)=ax^6+bx^5+cx^4+dx^3+ex^2+fx+g$ has been used. Population was assumed to be constant from 2150 onwards. Figure A 1 shows the population development for selected regions.

Figure A 1: Population development as assumed for the numerical example



Emissions:

For the future development of GHG emissions, a great number of scenarios is available (see IPCC (2000) that provide a wide range of potential GHG emissions in 2100. In this report, it is stated that "no judgement is offered in this report as to the preference for any of the scenarios and they are not assigned probabilities of occurrence...".

This is why a rather straightforward approach has been used to calculate future emission on country level for the numerical example. Historical emissions for the years 1992 to 1998 have been taken. Emissions have been restricted to CO_2 emissions from energy combustion. Data was taken from OECD/IEA (2000). After 1998 emission were assumed to grow annually by 1%. Note that emissions in the numerical example are only shown as long as a Party has not accepted an absolute emission target. Once it participates, the assigned amount is presented. The difference between emissions and assigned amount is not analysed further.

The global budget for CO_2 from energy combustion in 2092 has been set somewhat arbitrarily to 3000 Mio. t CO_2.

Annex 2:

Three equations are available for the determination of the allocation function $\Phi_i(t)$:

$$\int_{t_i^*}^{t_3} (a_i t^2 + b_i t + c_i)dt = A - D_{i,t_i^*} \qquad \text{(A1)}$$

$$\Phi_i(t_3) = eepc \qquad \text{(A2)}$$

$$\Phi_i(t_i^*) = epc_{i,t} \qquad \text{(A3)}$$

(A1) specifies the remaining budget on per capita basis, when Party i accepts an emission target in t_i^*.

(A2) describes the *equal emissions per capita* to be reached in t_3. The same value applies for all countries.

(A3) are the emissions per capita for Party i when it starts to join the system.

The system of the three equations solves as follows:

$$a_i = \frac{t_i^* y_1 + t_i^* y_2 + 2A - t_3 y_2 - t_3 y_1}{t_i^{*3} - 3t_3 t_i^{*2} + 3t_i^* t_3^{\ 2} - t_3^{\ 3}}$$

$$b_i = \frac{-2(t_i^{*2} y_1 + 2t_i^{*2} y_2 + 3At_i^* - t_3 y_2 t_i^* + t_i^* t_3 y_1 - 2t_3^{\ 2} y_1 + 3At_3 - t_3^{\ 2} y_2)}{(t_i^* - t_3)(t_i^{*2} + t_3^{\ 2} - 2t_i^* t_3)}$$

$$c_i = \frac{t_i^{*3} y_2 + 2y_1 t_3 t_i^{*2} + t_i^{*2} t_3 y_2 - 2y_2 t_i^* t_3^{\ 2} - y_1 t_i^* t_3^{\ 2} + 6At_i^* t_3 - y_1 t_3^{\ 3}}{(t_i^* - t_3)(t_i^{*2} + t_3^{\ 2} - 2t_i^* t_3)}$$

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