A Different Perspective for Global Climate Policy: Combining Burden Sharing and Climate Protection

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Abstract

A method is presented for computing long-term greenhouse gas emission pathways for both industrial ("Annex B") countries and developing ("non-Annex B") countries. This method combines two main factors: (i) climate protection goals, in the form of targets for stabilizing CO_2 in the atmosphere, and (ii) the allocation of global emissions to industrial and developing countries based on a so-called "burden sharing" scheme. In this paper two CO_2 stabilization targets are investigated – stabilization at 450 ppm in 2100 and 550 ppm in 2150. The burden sharing scheme is based on the following rules: A non-Annex B country increases its emissions according to a "baseline" no-policy scenario until its national income reaches a specified "graduation" income level. After reaching this level it freezes its per capita emissions until they are equal to the average per capita emissions in Annex B countries. After this point, the per capita emissions of the non-Annex B country are the same as the average for Annex B countries. For a variety of assumptions about the graduation income level, it was found that the two stabilization targets can be achieved even if total emissions from non-Annex B countries increase until around 2030. However, after this point, emissions from these countries must stabilize or be sharply reduced.

1. Introduction

The climate summits in Kyoto and Buenos Aires achieved some tentative first steps for international climate protection. But an important question that was left open by both summits was the issue of strategies for long-term climate protection and their consequences on emission reduction commitments for both industrialized and developing countries. This question was later given high priority at the 6th International Workshop on "Using Global Models to Support Climate Negotiations", in Kassel, Germany (see Onigkeit et al., 1998) and is addressed by the authors in this paper. The purpose of this paper is to present an approach that combines the question of stabilization targets with the question of allocation of greenhouse gas (GHG) emissions. We use this approach to evaluate the implications of different long-term climate protection targets on the allocation of emission reductions in non-Annex B[1] and Annex B countries. This allocation is based on two indicators that reflect considerations of capability and equity. Why is the allocation of emissions an international issue? First of all, according to the Berlin Mandate and Kyoto Protocol, most industrialized countries are required to begin reducing their greenhouse gas emissions. Some have argued that this is justified because of their high level of per capita emissions and their historical contribution to climate change. On

[1] Annex B countries are those countries that agreed as part of the Kyoto Protocol to control their emissions. These countries are listed in "Annex B" of the Kyoto Protocol, and include all industrialized countries. Countries

the other hand, results of scenario analysis have shown that many climate targets[2] require significant reductions in global emissions that would be virtually impossible for Annex B countries to achieve alone. One reason is that greenhouse gas emissions from developing countries are expected to increase substantially (Alcamo et al., 1995). In response to this situation, we present here an approach that can help identify strategies for both long term climate protection, and for sharing the burden of emission reductions between Annex B and non-Annex B parties. This approach is one of the first attempts to combine climate protection and burden sharing with indicators for equity and capability in a single analysis. In this paper we apply this approach to two CO_2 stabilization targets, taking into account CO_2, CH_4 and N_2O emissions from the energy/industry sector as well as land-use emissions.

2. The Burden Sharing Concept

The main idea behind the proposed burden sharing scheme is that emissions of non-Annex B parties are allowed to increase uncontrolled until they reach a specified income level (the so-called graduation criterion). Above this level, developing countries are expected to participate in international emission regimes. In principle, the graduation income level is set high enough so that developing countries will have a high enough national income to afford controlling their emissions. The first step in participating in international regimes is to freeze emissions, and the second is to reduce emissions (see figure 1a).

In the following paragraphs we specify the rules for allocating global emissions between Annex B and non-Annex B countries. For this allocation, a baseline emissions pathway and an economic growth scenario is needed for each non-Annex B country or group of countries. A population scenario is required for both Annex B and non-Annex B countries.

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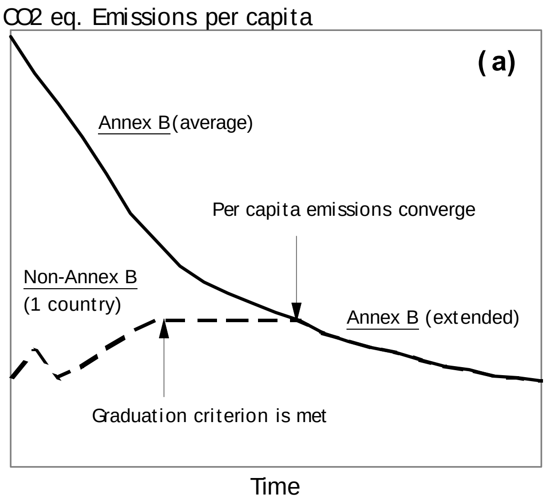
not listed in Appendix B have assumed no official commitments to control their emissions. These include all developing countries.

[2] For example, stabilization of atmospheric CO_2 at 450 ppm, or limiting global temperature increase to 1.5^0C between 1990 and 2100 require global CO_2 emission reductions of at least 50% relative to 1990 by the year 2100.

Procedure for setting climate protection goals and allocating emissions

1. *Pathway of global emissions:* A stabilization target for the atmospheric CO_2 concentration is first specified, and then the global emissions that comply with this stabilization target are computed. If the analysis is based on CO_2 equivalent emissions, additional assumptions must be made for non-CO_2 greenhouse gas emissions.
2. *Non-Annex B emissions up to and after the graduation income level.* Emissions from non-Annex B regions are not controlled until their income reaches the graduation income level. Up to this point they follow their baseline emission pathway. After the graduation level is reached, emissions are frozen until non-Annex B per capita emissions are equal to the average of Annex B emissions.
3. *Non-Annex B emissions equal Annex B emissions*: When the per capita emissions of the non-Annex B region converge with the average per capita emissions of Annex B countries, then they both follow the same per capita emissions pathway (see figure 1a). The non-Annex B party then joins an "Extended Annex B" group.
4. *Annex B total emissions.* The emissions from Annex B are computed to be the global emissions from step 1 minus the total emissions of all non-Annex B emissions. After this step, the total emissions of non-Annex B countries consist partly of baseline emissions (for those non-Annex B countries that did not yet meet the graduation criterion) and partly of controlled non-Annex B emissions.

These calculations are performed iteratively for each of the non-Annex B countries and the average of all Annex B regions for each time step. Since the emissions from all Annex B countries are summed into a single region, their total emissions have to be distributed between the countries of this group in a later step (e.g. all have to carry the same reduction burden or allocate emissions in the most cost effective way by emissions trading). This distribution is not presented in this paper.



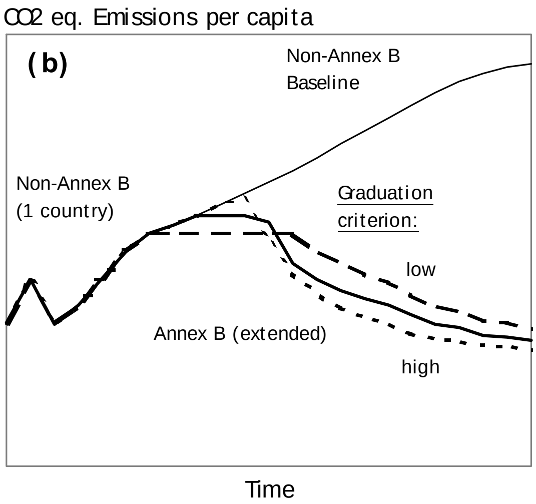


Figure 1: Illustration of the burden sharing concept. a) Per capita emissions pathway of one non-Annex B country and averaged Annex B per capita emissions. b) Illustration of the implications of different graduation criteria. A high graduation criterion stands for a high percentage of Annex B average GDP per capita in 1990 (e.g. 100%) and vice versa.

Main findings:

1. Allowable emissions of Annex B depend on the total amount of non-Annex B emissions. Therefore it is advantageous to Annex B countries for non-Annex B countries with a large and fast growing population to join the Annex B group as early as possible.
2. If a high graduation criterion is chosen (e.g. the income (GDP/cap) of a non-Annex B region has to equal 100% of the average Annex B 1990 income before taking action) a non-Annex B party is likely to follow the baseline emissions pathway for a longer time compared to the case of a lower graduation criterion. The price this region has to pay is the need for more rapid reductions of per capita emissions after convergence (see figure 1b). The decision for a low criterion leads to earlier participation in emissions controls but to less stringent annual reduction rates.
3. A stricter stabilization target results in a lower global emissions pathway. In this case stricter emission reductions are required for Annex B countries, since baseline emission profiles of non-Annex B parties remain the same. The consequence for non-Annex B parties is that their per capita emissions sometimes converge with the per capita emissions of Annex B countries before they (the non-Annex B parties) reach the graduation income level.

3. Application of the burden sharing concept

The implications of two stabilization targets on burden sharing were evaluated: (1) Stabilization of the atmospheric CO_2 concentration at 550 ppm, a target which is under discussion in the European Union and (2) a stricter target of 450 ppm. The following are assumptions of this analysis:

1. The analysis was performed for the six non-Annex B regions of the IMAGE 2.1 model (see Alcamo et al., 1998a). The seven Annex B regions of the IMAGE 2.1 model were aggregated to one region.
2. Population for both Annex B and non-Annex B regions increase according to the IPCC medium scenario IS92a (Alcamo et al., 1998b).
3. Economic growth of the non-Annex B regions was based on IPCC scenario IS92a assumptions.
4. The baseline emissions of the non-Annex B regions originated from the Baseline A scenario of the IMAGE model. In this scenario population growth and economic growth assumptions of IS92a have been implemented (Alcamo et al., 1998b). We included CO_2, CH_4 and N_2O emissions from both energy/industry and land use.

3.1 Stabilization targets and global emissions

For this analysis both a long-term concentration target, and the pathway to reach this target, had to be specified. For both targets we used the pathways of the Intergovernmental Panel on Climate Change (IPCC) described in Enting et al. (1994). The targets will be reached in 2100 and 2150 for a CO_2 concentration of 450 ppm and 550 ppm, respectively. The IMAGE model was used to back-calculate allowable global CO_2 emissions. Non-CO_2 emissions (CH_4 and N_2O) from the energy/industry sector were assumed to be reduced proportionally to CO_2 emissions whereas future non-CO_2 emissions from land-use were allowed to increase according to IMAGE 2.1 Baseline A scenario. The resulting CO_2 equivalent concentrations and global emissions are shown in Figures 2a and 2b, respectively. To illustrate the necessary global emission reductions we also present the so-called ”Kyoto” Scenario as a reference scenario. For this scenario we assumed that Annex B regions fulfill the Kyoto commitments until year 2010 and then freeze their total emissions up to 2100. Non-Annex B emissions follow the IMAGE Baseline A emissions pathway without further restrictions.

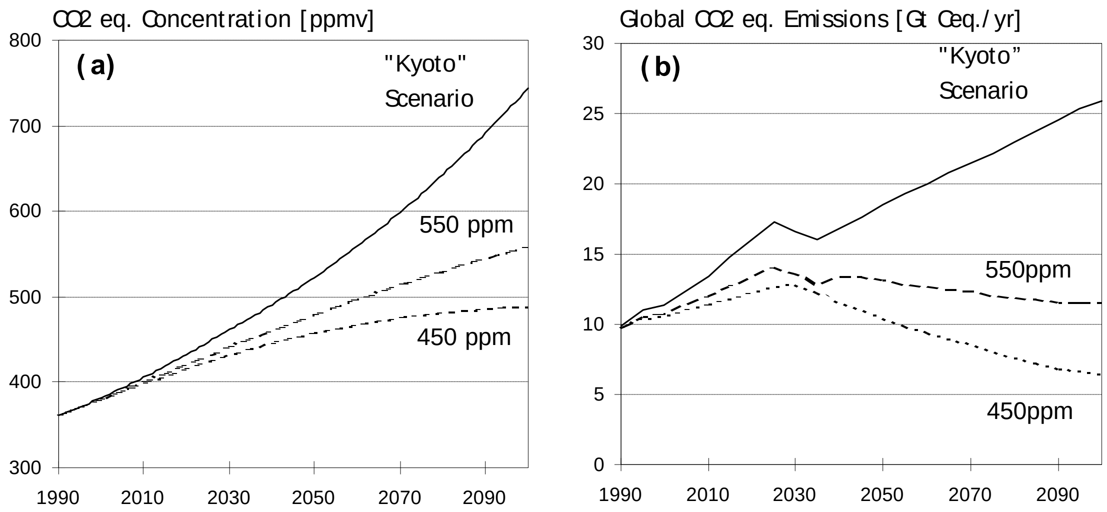


Figure 2: a) Atmospheric CO_2 equivalent concentration of the 450 ppm, 550 ppm and ”Kyoto” reference scenario. b) Global CO_2 equivalent emission pathways complying with the stabilization targets of 450 and 550 ppm. As a reference case global emissions of Baseline A including the Kyoto commitments for the Annex B regions are depicted (for the description of the ”Kyoto” Scenario see text).

Main findings

1. Under the specified assumptions for non-CO_2 greenhouse gases, the 550 ppm and 450 ppm CO_2 stabilization scenarios result in an atmospheric CO_2 equivalent concentration of 560 ppm and 490 ppm, respectively. For the ”Kyoto” Scenario the CO_2 equivalent concentration increases to 744 ppm in 2100.
2. Global CO_2 equivalent emissions for both stabilization scenarios may increase until 2030, then emissions have to decrease to a level slightly above the 1990 level for the 550 ppm scenario and to about half the 1990 emissions for the 450 ppm scenario.

3.2 Per capita emissions resulting from the burden sharing concept

The calculated allowable global emissions were distributed year by year on a per capita basis between Annex B and non-Annex B regions following the specified rules (see figure 3). We present the implications of two different graduation income level criteria for non-Annex B regions: They must freeze their emissions when their income per capita equals (1) 10% and (2) 100% of the Annex B average income per capita in 1990.

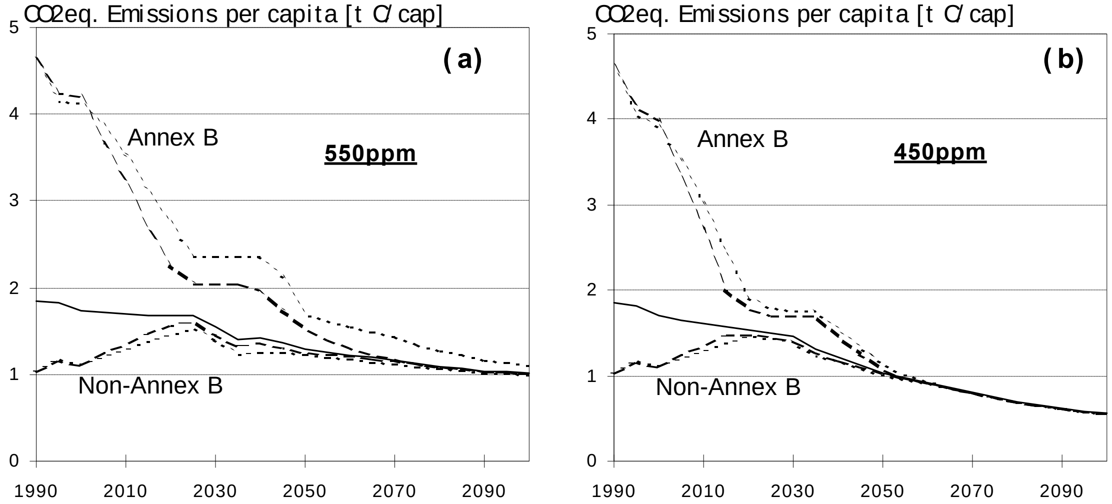


Figure 3: Application of the burden sharing concept to two CO_2 stabilization targets: a) 550 ppm and b) 450 ppm. Depicted are the pathways of average per capita emissions (CO_2 equivalent) of Annex B and non-Annex B countries. The short-dashed line shows results for the specified graduation criterion of 10% of Annex B average GDP/cap. The long-dashed line shows results for the higher criterion – 100% of Annex B average GDP/cap. The solid line gives the global average per capita emissions.

Main Findings

1. Annex B per capita emissions have to be reduced by 78% and 88% between 1990 and 2100 for the 550 ppm and 450 ppm stabilization scenarios, respectively (Figure 3). A reduction rate of about 2 to 3% per year is needed between 1990 and 2030 for the 550 and 450 ppm target, respectively. After 2030 reduction rates decline to about 0.75 and 1% per year, but reductions must continue. The stringent reductions required for Annex B per capita emission is caused by three factors: (1) the concentration targets, (2) the growing population and per capita emissions in non-Annex B countries, and (3) the growing population in Annex B regions.
2. Average non-Annex B per capita emissions may increase by 50% up to 2030, but must decline afterwards (Figure 3). For the 550 ppm case, non-Annex B per capita emissions must decline to their 1990 levels by 2100. For the 450 ppm case, per capita emissions must sink substantially below this level by 2100.
3. Varying the graduation criterion has a bigger impact on Annex B per capita emission reductions under the 550 ppm stabilization scenario than under the 450 ppm scenario. This is due to the slower reduction of Annex B emissions between 1990 and 2020 in the 550 ppm scenario. In the 450 ppm scenario it makes no difference for many of the non-Annex B regions whether the graduation criterion is high or low. In any case, their emissions equal Annex B emissions before they meet the graduation criterion, i.e. they are not allowed to

go through a stage of stabilized emissions but have to reduce emissions as their first action. It should be noted that for graduation criteria between 10% and 100%, emission pathways do not necessarily lie between the two presented profiles. Instead, these pathways will be equally influenced by the assumed GDP/cap growth rate for non-Annex B countries; these growth rates will determine when the different non-Annex B countries reach the graduation income level, and when they will freeze their emissions

3.3 Total emissions of Annex B and non-Annex B

Total CO_2 equivalent emissions of Annex B and non-Annex B resulting from the application of the burden sharing concept are depicted in figure 4.

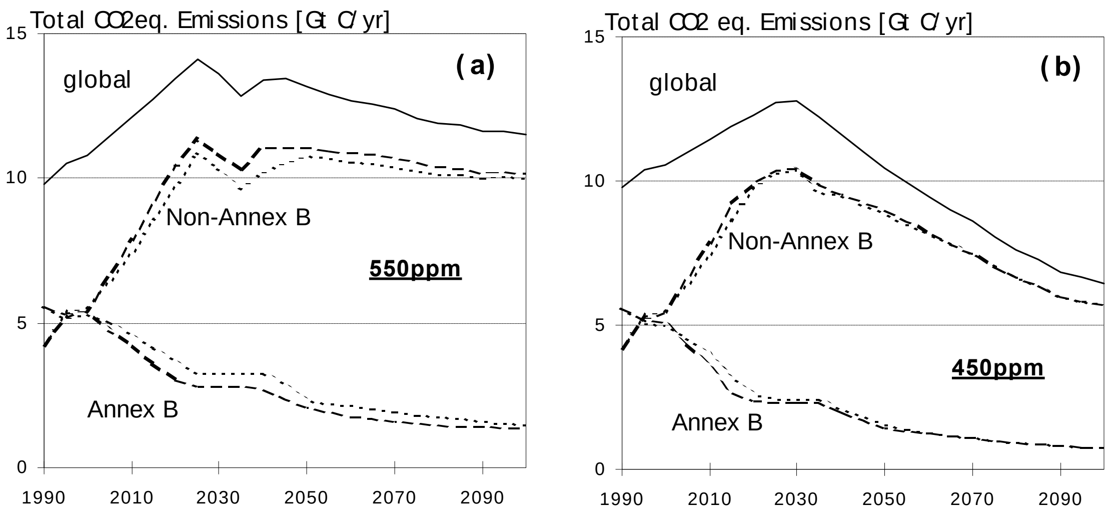


Figure 4: Total CO_2 equivalent emissions of Annex B and non-Annex B compared to allowable global emissions for the two stabilization targets of a) 550 ppm and b) 450 ppm CO_2. The short-dashed line represents a graduation criterion of 10% of Annex B average GDP/cap, and the long-dashed line a higher criterion of 100%.

Main findings

1. Annex B total CO_2 equivalent emissions have to be reduced by 76% and 86% up to 2100 for the 550 ppm and 450 ppm scenario, respectively (Figure 4).
2. Non-Annex B total CO_2 equivalent emissions are allowed to more than double up to 2030 for both stabilization scenarios (Figure 4). Afterwards, emissions slowly decrease under the 550 ppm scenario, and sharply decrease under the 450 ppm.
3. Varying the graduation criterion makes a difference of about 0.1 Gt C and 0.4 Gt C equivalent total emissions per year for the 450 ppm and 550 ppm scenario, respectively.

The reason for the difference between the two stabilization scenarios has already been described in section 3.2.

4. Concluding Remarks

As follow-up to the work presented in this paper, it would be valuable to carry out further sensitivity analyses using the described approach. In particular, the effects of assumptions about population and economic growth on emission pathways should be identified. In addition, the sensitivity of results to different graduation criteria should be investigated.

The question arises, can the burden sharing approach presented in this paper be used in climate policymaking? In answering this, an important consideration is that this approach requires the specification of only two factors: a graduation criterion and a climate target and pathway. It also uses a widely accepted parameter as a graduation criterion (GDP/cap). This simplicity and transparency could be a valuable asset in its use for climate policymaking. On the other hand, the simplicity of the method can also be viewed as a drawback, because policymakers might prefer to specify a wider set of goals and policy options than are included in this approach. Nevertheless, it is not intended to cover all options for assessing and developing climate policies. Instead this approach is only one among many tools that can provide information useful for climate policymaking.

Despite its simplicity the approach presented in this paper takes into account both concrete climate goals, as well as important equity and capability considerations in determining future emission pathways. As such it can provide useful input to the climate policymaking process.

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5. References

Alcamo, J., Bouwman, A., Edmonds, J. Grübler, A., Morita, T., Sugandhy, A. (1995): *An evaluation of the IPCC IS92 emission scenarios.* In: Houghton, J.T., Meira Filho, L.G., Bruce, J., Lewe, H., Callander, B.A., Haites, E., Harris, N., Maskell, K. (eds): Climate change 1994: Radiative forcing of climate change and an evaluation of the IPCC IS92 emission scenarios, Cambridge University Press, Cambridge, pp 247-304.

Alcamo, J., Kreileman, G.J.J., Krol, M., Leemans, R., Bollen, J., Van Minnen, J.G., Schaefer, F., Toet, S. and De Vries, B. (1998a): *Global Modelling of environmental change: An overview of IMAGE 2.1*. In: J. Alcamo, R. Leemans and G.J.J. Kreileman (Eds), Global change scenarios of the 21st century. Results from the IMAGE 2.1 model. Pergamon/Elsevier Sci., Oxford, UK, pp 3-94.

Alcamo, J., Kreileman, G.J.J., Bollen, J., Van den Born, G.J., Gerlagh, R., Krol, M.; Toet, T., and De Vries, B.: *Baseline scenarios of global environmental change.*(1998b). In: Alcamo, J., Leemans, R., Kreileman, G.J.J. (Eds.): Global change scenarios of the 21st century. Results from the IMAGE 2.1 model, Pergamon/Elsevier Sci.,Oxford, UK, pp 97-139.

Enting, I.G., Wigley, T.M.L. and Heiman, M. (1994): *Future emissions and concentrations of carbon dioxide*. Research technical paper no. 31, CSIRO Division of Atmospheric Research, Australia.

Onigkeit, J., Berk, M., and Alcamo, J. (1998): *Report on the Sixth International Workshop on Using Global Models to Support Climate Negotiations* . Center for Environmental Systems Research, University of Kassel, Germany. The report is available as a pdf file at http://www.usf.uni-kassel.de/service/bibliothek/kassel-1-report.pdf.