Report 728001032/2005

Countries' climate mitigation commitments under the "South–North Dialogue" Proposal

a quantitative analysis using the FAIR 2.1 world model

M.G.J. den Elzen

Contact:
Michel den Elzen
Global Sustainability and Climate (KMD)
Netherlands Environmental Assessment Agency (MNP)
The MNP is associated with RIVM
P.O. Box 1, NL-3720 BA Bilthoven, The Netherlands
Phone: +31 30 274 3584; Fax: +31 30 274 4464
E-mail: Michel.den.Elzen@mnp.nl
Website: http://www.mnp.nl/fair/ , or http://www.mnp.nl/en

This research was conducted at the Dutch Ministry of the Housing, Spatial Planning and the Environment as part of the International Climate Change Policy Project (M/728001 Internationaal Klimaatbeleid)

Netherlands Environmental Assessment Agency (MNP associated with RIVM), P.O.Box 303, 3720 AH Bilthoven, the Netherlands, Tel.: +31-30-2742745; Fax: +31-30-2742971, www.mnp.nl\en

Acknowledgements

This study was performed within the framework of International Climate Change Policy Support project (M/728001 Internationaal Klimaatbeleid). I would like to thank Paul Lucas and Detlef van Vuuren (Netherlands Environmental Assessment Agency) for providing their downscaled information for population, GDP and emissions for the IMAGE 2.2 IPCC SRES scenarios and Malte Meinshausen (Swiss Federal Institute of Technology ETH, Zurich) for his contributions to the multi-gas emission pathways. I am also grateful for their comments and contributions from Marcel Berk (Netherlands Environmental Assessment Agency), Bernd Brouns and Herrmann Ott (Wuppertal Institute for Climate, Environment and Energy, Germany), Niklas Höhne and Simone Ullrich (Ecofys, Germany) and Harald Winkler (Energy Research Centre, University of Cape Town, South Africa).

Abstract

Countries' climate mitigation commitments under the "South–North Dialogue" Proposal – a quantitative analysis using the FAIR 2.1 world model

The "South–North Dialogue Proposal", developed by researchers from both developing and industrialised countries, outlines an approach for an "equitable" differentiation of future climate mitigation commitments among developed and developing countries. This approach is based on the criteria of responsibility, capability and potential to mitigate. The report provides a quantitative analysis of the implications of the proposal in terms of countries' commitments and costs. The analysis focuses on a "political willingness" scenario and on four scenarios leading to the stabilisation of greenhouse gas concentrations at 400, 450, 500 and 550 ppm CO_2-equivalent. The stabilisation scenarios show what emission reductions would be required to stabilise greenhouse gas concentrations in the long-term, whereas the "political willingness" scenario starts from what Parties might be willing to do. Use is made of the new FAIR 2.1 world model, i.e. the FAIR 2.1 model at the level of countries, using as input data for population, GDP and emissions from emission scenarios at the national level. The analysis shows that for the stringent stabilisation targets many developing countries will have to take on quantitative mitigation obligations by 2030, even when the Annex I countries adopt ambitious mitigation commitments far beyond the Kyoto obligations. The political willingness scenario will probably not suffice to limit warming of the earth's atmosphere to a level under 2°C.

Key words: abatement costs, climate policy post 2012, emission allowances, emissions trading, equity, future commitments.

Rapport in het kort

Nationale emissiedoelstellingen onder het "South–North Dialogue" Voorstel – een kwantitatieve analyse met het FAIR 2.1 landen model

Het "South–North Dialogue" voorstel, gezamenlijk ontwikkeld door onderzoekers van ontwikkelingslanden en geïndustrialiseerde landen, bestaat uit een benadering voor een "rechtvaardige" verdeling van de toekomstige internationale lastenverdelingen tussen de ontwikkelingslanden en geïndustrialiseerde landen. Deze benadering is gebaseerd op de criteria van verantwoordelijkheid, capaciteit en de mogelijkheid om emissies te reduceren. Dit rapport presenteert een kwantitatieve analyse van de nationale emissiedoelstellingen en de bestrijdingskosten van het voorstel. De analyse concentreert zich op een "political willingness" scenario en vier scenario's, die leiden tot een lange termijn stabilisatie van de concentraties van de broeikasgassen op 400, 450, 500 en 550 ppm CO_2-equivalent. De stabilisatiescenario's tonen aan wat voor emissiereducties noodzakelijk zijn voor het bereiken van lange termijn concentratiedoelstellingen, terwijl het "political willingness" scenario uitgaat wat de Partijen bereid zijn te doen. Dit is gebaseerd op berekeningen met het nieuwe FAIR 2.1 wereld model (i.e. het FAIR 2.1 model op het niveau van landen), waarbij gebruik is gemaakt van de data voor bevolkingsgroei, GDP en emissies van emissiescenario's op het niveau van landen. De analyse toont aan dat voor de meest stringente stabilisatie scenario's vele ontwikkelingslanden kwantitatieve reductiedoelstellingen op zich moeten nemen, zelfs wanneer de Annex I landen zeer ambitieuze reductiedoelstellingen op zich nemen, die veel verder gaan dan de huidige Kyoto reductiedoelstellingen. Het "political willingness" scenario zal waarschijnlijk niet voldoende zijn om de twee graden doelstelling te halen.

Key words: Mitigatie-kosten, post-2012 klimaatbeleid, emissiehandel, emissiereductie doelstellingen, gelijkheid, toekomstige verplichtingen.

Contents

Samenvatting

Dit rapport presenteert een kwantitatieve analyse van de nationale emissiedoelstellingen en de bestrijdingskosten van een benadering voor internationale lastenverdelingen voor het klimaatbeleid gebaseerd op het “South–North Dialogue” voorstel. Dit voorstel gaat uit van een “rechtvaardige” lastenverdeling, in termen van vergaande emissiereducties van zowel de Annex I en Annex II landen en gedifferentieerde inspanningen voor de ontwikkelingslanden. De laatste groep is verdeeld in vier subgroepen, gebaseerd op een index bestaande uit verantwoordelijkheid, capaciteit en het vermogen om te reduceren. Meer specifiek, de nieuwe geïndustrialiseerde landen en de snel ontwikkelende ontwikkelingslanden, die kwantitatieve verplichtingen (absolute emissieplafonds) op zich zouden moeten nemen, en de andere ontwikkelingslanden en de minst ontwikkelde ontwikkelingslanden, welke alleen meer kwalitatieve verplichtingen (policies and measures) op zich zouden moeten nemen. De analyse presenteert de nationale emissiedoelstellingen onder een “political willingness” scenario en vier scenario’s, die leiden tot een lange termijn stabilisatie van de broeikasgassen op 400, 450, 500 en 550 ppm CO_2-equivalent. De stabilisatiescenario’s tonen aan welke emissiereducties noodzakelijk zijn voor het bereiken van lange termijn concentratiedoelstellingen, en veronderstellen dat Partijen bereid zijn om die noodzakelijke reducties te nemen, terwijl het “political willingness” scenario uitgaat wat de Partijen bereid zijn te doen. Dit is gebaseerd op berekeningen met het nieuwe FAIR 2.1 wereld model, een landen-versie van het FAIR 2.1 model. Dit model maakt gebruik van de een verbeterde methode voor het downscalen van de data voor bevolkingsgroei, GDP en emissies van de IMAGE 2.2 IPCC SRES scenario’s op het niveau van landen. Het “political willingness” scenario leidt tot emissiereducties in de orde van 20% onder het 1990 niveau voor de Annex I landen in 2020, i.e. voor de EU -30% en de VS -15%. Ten einde de 500 ppm CO_2-equivalent doelstelling te halen onder dit scenario, zijn er substantiële emissiereducties noodzakelijk. Het lijkt onwaarschijnlijk dat de twee graden doelstelling onder een dergelijk scenario wordt gerealiseerd. Onder het 400 en 450 ppm CO_2-equivalent scenario, dat meer zekerheid geeft voor het behalen van de twee graden doelstelling, zijn zelfs meer ambitieuze emissiereducties noodzakelijk voor de Annex I landen, i.e. 30% tot 35% beneden de 1990 niveau’s in 2020, en 80-90% in 2050. De emissies voor de nieuwe geïndustrialiseerde landen kunnen tot 2010 blijven groeien, maar zullen daarna aanzienlijk moeten worden gereduceerd. De snel ontwikkelende ontwikkelingslanden zullen hun emissies moeten verminderen ten opzichte van hun baseline in 2020. Voor het behalen van de stringente doelstellingen zal een grote groep van landen behorende tot deze landen, maar ook de rest van de ontwikkelingslanden in 2020, al in 2030-2040 de status krijgen van de nieuwe geïndustrialiseerde landen.

Summary

This report documents a quantitative analysis of the emission and cost implications of the South–North Dialogue Proposal for the differentiation of countries' future mitigation commitments. This is a proposal outlining equitable approaches to mitigation – including deep cuts in emissions of both the Annex I and Annex II countries, and differentiated mitigation commitments for developing countries. These are divided into four country groups on the basis of an index composed of indicators for responsibility, capability and potential to mitigate. These are: 1) the newly industrialised countries (NICs), 2) the rapidly developing countries (RIDCs), which would have to take on quantitative mitigation commitments, 3) the other developing countries (Other DCs) and 4) the least developing countries (LDCs), which only have qualitative mitigation commitments (policies and measures).
The tool used for the analysis of the countries' emission allowances is the FAIR 2.1 world model, the country version of the FAIR 2.1 model, which uses an improved methodology for the downscaling of the population, GDP and emissions data of the IMAGE 2.2 IPCC SRES baseline scenarios to the level of individual countries. The report analyses a "political willingness" scenario and four other scenarios leading to stabilisation of greenhouse gas concentrations at 400, 450, 500 and 550 ppm CO_2-equivalent. The stabilisation scenarios show what the emission reductions are required to reach greenhouse gas concentration in the long-term, and simply assume that Parties will be politically willing to make the necessary effort, whereas the "political willingness" scenario starts from what Parties might be willing to do − or at least one set of assumptions about what "political willingness" might look like. The "political willingness" scenario requires reductions of about 20% below 1990 levels for the Annex I countries in 2020, i.e. the EU-25 (-30%) and the USA (-15%). Under this scenario, stabilisation of CO_2-equivalent concentrations at 500 ppm is kept within reach up to 2020, but substantial reductions have to occur thereafter. It seems unlikely that this scenario will limit global average temperature change to 2 ^{o}Celsius. Even more ambitious reduction targets for the Annex I countries will be necessary under the 400 and 450 ppm CO_2-equivalent scenarios, which provide more certainty about limiting global average temperature change to 2 ^{o}Celsius, i.e. 30% to 35% below 1990 levels in 2020, and about 80 to 90% in 2050. The NIC emission allowances could grow up to 2010, but then would need to be reduced substantially. RIDCs are assumed to reduce emissions slightly below baseline emissions, but to reach the low emission levels in 2050, a large group of countries in the RIDC group, but also Other DCs and LDCs in 2020, would have to move to the NIC country group as early as around 2030-2040.

1 Introduction

The proposal, "South–North Dialogue – Equity in the Greenhouse" (hereafter referred to as the South–North Dialogue Proposal), was designed by researchers from13 industrialised and developing countries. It offers guidance on the content of a future climate agreement and the process of achieving it (Ott et al., 2004). The proposal outlines equitable approaches to mitigation, including both deep cuts in the emissions of the North and differentiated mitigation commitments for developing countries. It further examines adaptation, as no agreement will be equitable or adequate if it fails to incorporate appropriate funding and institutional mechanisms to address the needs of the most vulnerable to the impacts of climate change. Finally, the proposal includes recommendations on the political process of achieving such an agreement by outlining a leadership strategy. The proposal is described in detail in Ott et al. (2004) and Winkler et al. (2005) http://www.south-north-dialogue.net.

This report focuses only on the part of the proposal dealing with mitigation commitments, and tries to assess the implications of the proposal for costs and emission allowances[1] when combined with different long-term greenhouse gas concentration stabilisation levels. This should help both the drafters of the proposal and others to evaluate the appropriateness of the proposal in arriving at an equitable approach for differentiating mitigation commitments. But first of all, let us look at a more detailed description of how the mitigation commitments are defined in the proposal.

Mitigation commitments for the South–North Dialogue Proposal

The focus of the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC) in Article 2, namely "to achieve stabilisation of greenhouse gas concentrations in the atmosphere" under specified constraints, indicates a consensus among Parties to take action on mitigation. The problem the world is facing is not whether mitigation is important, but rather "who" is mitigating and "how much" is being mitigated. According to the UNFCCC the developed countries should take the lead in mitigation. This is reflected in the Kyoto Protocol, where only the industrialised countries (Annex I) have (quantified) mitigation commitments. The fact that the developed countries need to take the lead implies that at some stage developing countries will be expected to follow. What is required in thinking beyond 2012, therefore, is further and more systematic differentiation among countries, also in the South.

Article 3.1 of the UNFCCC states that such a differentiation should be in accordance with Parties "common but differentiated responsibilities and respective capabilities" (…) (UNFCCC, 1992). The South–North dialogue proposal thus proposes that the differentiation should be based on the criteria of *responsibility*, *capability* and *potential to mitigate*. These three characteristics are integrated into a differentiation framework as follows:

- *Responsibility* refers to the Parties' responsibility for the problem. This was defined in an earlier attempt by the "Brazilian Proposal" directly in relation to Parties' overall contribution to temperature increase (UNFCCC, 1997). In the South–North Dialogue proposal, by contrast, cumulative per capita emissions of fossil CO_2 over the 1990 to 2000 period are used as a proxy indicator of responsibility. The relatively recent period avoids 'punishing' countries for historical emissions, since the consequences

[1] In the literature also referred to as assigned amounts, emission permits, or emission endowments; from this point on we will use the term "emission allowances".

were less widely known in the past. Since the IPCC's First Assessment Report in 1990, the implications can, at least, be said to be well-known internationally. [2]

- *Capability* refers here to the country's ability to pay for and implement mitigation efforts; this criterion recognises the fact that a country's capability to reduce emissions might be quite different from its level of responsibility. A country may have great responsibility for contributing GHG emissions, but be too poor to devote resources toward mitigation and/or it might not have access to the necessary technologies. Emissions do not have to be linked to human development, but under given socio-economic and technological conditions, a certain level of emissions will be necessary to guarantee a decent life for poor people (Pan, 2002). Two indicators of capability are considered: the Human Development Index (HDI) and Gross Domestic Product (GDP) per capita. Countries with higher levels of national income and a higher rank on the HDI are expected to carry a higher burden of mitigation.
- *Potential (to mitigate)* refers to a country's opportunities for reducing GHG emissions and can be related to two factors – intensity of the emissions and emissions per capita. A high value for CO_2/GDP would suggest a high potential to mitigate. The more efficient an economy already is (lower CO_2 emissions per unit GDP), the less potential there is (at a given cost) to mitigate further through efficiency. However, the level of emissions per capita needs to be taken into account as well. High per capita emissions suggest unsustainable consumption patterns, which should provide potential to mitigate without endangering a basic level of development, for example, through lifestyle changes. National circumstances such as resource endowments also influence mitigation potential.

Based on these criteria of responsibility, capability and potential, the South–North dialogue proposal concludes that the first level of differentiation in the Convention – i.e. between Annex I and non-Annex I, remains valid. As a consequence, it is obvious that Annex I countries must continue to take the lead in reducing emissions, and their emissions reductions should be strengthened considerably in the period after 2012.
The Proposal defines four groups of non-Annex I countries, each including countries with similar national circumstances. The first two are the newly industrialised countries (NICs) and the rapidly industrialising developing countries (RIDCs). Both groups are considered particularly important in taking the next round of climate negotiations forward. The two other groups are the least-developed countries (LDCs), and "other developing countries" the latter consisting of countries not belonging to any of the previous groups. The last two groups are both excluded from taking on quantitative commitments (Table 1). This *grouping* of the non-Annex I countries is based on an index combining the criteria of *responsibility*, *capability* and *potential* to mitigate. This index is defined by the equal weighting of cumulative fossil CO_2 emissions per capita, the Human Development Index and an indicator of potential (derived from CO_2 emissions/GDP and greenhouse gas emissions/capita).

[2] See also den Elzen et al. (2005d).

Table 1. Regions and their responsibility according to the proposal "South–North Dialogue – Equity in the Greenhouse". Source: Ott et al. (2004).

	Annex II	**Annex I, but not Annex II**	**NICs**	**RIDCs**	**Other DCs**	**LDCs**
Potential to mitigate						
CO_2/GDP, 2000	*Medium*	*Very high*	*High*	*Medium*	*Medium*	*Low*
GHG/capita, 2000	*Very high*	*High*	*High*	*Medium*	*Low*	*Low*
Responsibility to mitigate						
Cumulative CO_2/capita, 1990-2000	*Very high*	*High*	*High*	*Low*	*Low*	*Very low*
Capability to mitigate						
GDP/capita, 2000	*Very high*	*Medium*	*Medium*	*Medium*	*Low*	*Very low*
HDI, 2000	*Very high*	*High*	*High*	*Medium*	*Medium*	*Low*
Mitigation commitments						
Type of quantitative commitment	Binding (strict) absolute reduction targets, domestic reduction	Binding absolute reduction targets, domestic reduction	Absolute limitation or reduction target, domestic mitigation*	Absolute limitation targets, if funding and technology provided by Annex I*	No targets	No targets
Qualitative action			SD-PAMs (obligatory), Sector CDM, Non-binding RE & EE targets	SD-PAMs (obligatory, co-funded), Sector CDM, Non-binding RE & EE targets	SD-PAMs (obligatory, co-funded), Sector CDM, Non-binding RE & EE targets	SD-PAMs (optional, funded), Sector CDM, Non-binding RE & EE targets
Commitments to provide financial and technological resources to support mitigation activities	High direct payments (out) to non-Annex I.	Low / no payments	NIC co-funds mitigation, but some transfers from Annex II.	High direct payments from Annex II.	Direct payments from Annex II.	Direct payments from Annex II.

* Targets only could become binding if all major Annex I countries have binding quantified emission reduction obligations.

It should be noted that LDCs, which by definition have low potential, low capability and low responsibility, form a distinct analytical group. The remaining non-LDC non-Annex I countries are then ranked by this index. NICs are identified as those countries with an index value more than one standard deviation above the mean, i.e. those with the highest aggregate score. The next group of non-Annex I countries with a medium index value (mean plus/minus one standard deviation) are defined as RIDCs. RIDCs are generally characterised by having experienced relatively rapid industrial growth in the last decade and a relatively high income. RIDCs are therefore selected more from the remaining non-Annex I countries, i.e. those with higher per capita GDP-PPP than the non-Annex I average per capita GDP-PPP and a higher than 2% annual GDP growth in 1991-2000. Finally, the remaining 39 non-Annex I countries that are neither NICs/RIDCs nor LDCs are grouped as "other developing countries". These are at a very early stage of industrialisation but are not as poor as those countries defined as "least developed" or just – in short: "regular" developing countries.

Based on the three criteria applied for the differentiation of countries (responsibility, capability and potential to mitigate), a set of decision rules was developed. This resulted in the following *types of commitments* for the six country groups identified (see Table 1, two groups in Annex I, four in non-Annex I):

- Both Annex I groups – Annex II and others – retain Kyoto-style quantitative commitments, i.e. (binding) *quantified (absolute) emissions reduction obligations* with targets for Annex II countries being more demanding than Kyoto levels. The latter will also be committed to financial and technological transfers to those non-Annex I countries with low-to-medium capability to mitigate.

- Countries belonging to the group of NICs and RIDCs will have to take on *quantitative* mitigation commitments as well – although subject to the conditionality that all major Annex I countries (including the USA) take on quantified emission reduction commitments and fulfil their commitments to provide financial and technological resources. Due to their high responsibility and potential to mitigate, NIC countries will have absolute limitation or reduction commitments, but will also have access to financial and technological resources (from Annex II countries) to help them fulfil the commitments. RIDC countries would also take on absolute limitation targets, and would have access to an even greater share of resources than the NICs, consistent with their lower capacities. However, the conditionality concerning Annex I participation in the regime is also valid for RIDCs, as well as the availability of full funding of incremental costs for mitigation activities by Annex II countries. Regardless of whether the terms of conditionality for quantified commitments are fulfilled, NICs and RIDCs will engage in *qualitative* mitigation commitments, such as sustainable development policies and measures (Winkler et al., 2002), sectoral CDM (Samaniego and Figueres, 2002; Sterk and Wittneben, 2005) or voluntary renewable energy or energy efficiency targets (see Table 1).
- *Qualitative mitigation commitments* (policies and measures) will also be obligatory for the group of “other developing countries”, but quantifiable mitigation commitments for these countries and the LDC group are not justifiable – and not in line with the decision rules (until their status changes).

There must be agreed conditions (like “binding obligations for all major industrialised countries”) that will lead to the start of developing-country quantitative emission targets. While these conditions can be quantitatively defined, even more important is getting political agreement on what they should be. They further differ from graduation triggers in that they may include conditions for both developing and industrialised countries.

The approach chosen for differentiation of the (types of) commitments among countries is not static. As national circumstances in countries evolve over time, the composition of the groups will change. If a country exceeds (or falls below) a certain threshold (valid for all of the three criteria – potential, responsibility, capability to mitigate) it will move from one group to another and, as a consequence, will have to take on other types of commitments. Countries “graduate” when their indicators become more representative of the following higher group. Therefore, the composition of the groups may need to be modified after each commitment period.

Differences with an earlier analysis of the proposal

This report uses the methodology of Höhne and Ullrich (2005)[3] for calculating the emission allowances under the South–North Dialogue Proposal, including a method on how to decide which countries belong to which country group over time. This is supplemented with a methodology for calculating the abatement costs and financial flows resulting from emission trading. Only financial flows associated with quantified emissions commitments in the South-North Dialogue Proposal are evaluated. The methodology does not quantify the effect of qualitative commitments, e.g. SD-PAMs (obligatory), sectoral CDM and non-binding targets of the proposal, as this requires more detailed, disaggregated, sectoral energy modelling. For the quantification of the financial funding related to the support of

[3] The methodology here is almost the same, except that in Höhne and Ullrich the definition of RIDCs is without the additional condition on economic growth and income level, which in their analysis leads to a larger group of RIDCs.

(the incremental costs of) mitigation activities in NICs, RIDCs, simple assumptions have been made. The methodology also includes the financial flows resulting from the use of the Kyoto Mechanisms (particularly international emissions trading).
The study of Höhne and Ullrich was the first quantitative analysis of the emission allowances under this Proposal. Note that Höhne & Ullrich and this study use the same definition of the *emission allowances*, i.e. CO_2-equivalent emissions including the anthropogenic emissions of six Kyoto greenhouse gases (fossil CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 (using the 100-year GWPs IPCC, 2001)), but excluding LUCF (land-use and land-use change-related) CO_2 emissions.[4] The analysis presented here differs in five ways from the analysis of Höhne and Ullrich:

1. *Baseline scenarios at the level of individual countries are based on an improved (non-linear) downscaling method that tries to deal with the limits of present downscaling methods*. Both studies make use of the IMAGE implementation of the IPCC SRES emission scenarios (hereafter simply referred to as: IMAGE IPCC SRES scenarios) at the level of 17 world regions[5], but Höhne and Ullrich (2005) use a different methodology for downscaling the regional information of population, GDP and emissions to the level of countries (about 192). Höhne and Ullrich used the regional trend to downscale the information, i.e. applied the regional growth rates for all countries belonging to a region (hereafter also referred to as the linear down-scaling method). This linear downscaling method was also used by Gaffin et al. (2004) for downscaling the population (for 2050–2100)[6] and GDP (2000-2100) data of the original IPCC SRES emission scenarios defined at the level of the four IPCC regions. However, this linear downscaling method has been criticised in the literature (see Pitcher, 2004; van Vuuren et al., 2005), as it leads to unrealistic results.[7] In particular, it falls short in cases where the differences in historical trends and absolute levels between countries in a region are too large. This happens, for example, in the region of East-Asia, including China, North Korea, South Korea, Mongolia and Taiwan, where it can lead to extremely high income levels for countries considerably richer than their neighbouring countries (e.g. especially South Korea compared to the population-dominant region of China).

   The linear downscaling method of Höhne and Ullrich (2005) results in similar problems. On the one hand, the problems are likely to be even more severe than for Gaffin at al., as the method is now applied to a longer time horizon (population projections up to 2050 and emissions up to 2100), while, on the other, they may be less, as they used information at the level of 17 regions instead of the four IPCC regions. This is illustrated in Text box 1 and Appendix A, and in more detail in van Vuuren et al. (2005).[8]

---

[4] Emissions from these sources are highly uncertain and emission estimates from various sources are often not consistent. Therefore it has also been suggested to treat emissions from deforestation with an instrument separate from other emissions (WBGU, 2003).
[5] Canada, USA, OECD-Europe, Eastern Europe, FSU, Oceania and Japan (Annex I regions); Central America, South America, Northern Africa, Western Africa, Eastern Africa, Southern Africa, Middle East & Turkey; South Asia (incl. India), East Asia (incl. China), South-East Asia (non-Annex I regions) (IMAGE-team, 2001).
[6] For the 2000-2050 period Gaffin et al. (2004) used an existing scenario on a country level and the relative positions of countries within the larger unit as the basis for the downscaling. This method was not criticised in Pitcher's review.
[7] Pitcher (2004) concluded that the shortcomings of using the regional trend in Gaffin et al. (2004) were so severe that most of the results do *not* provide a satisfactory basis for doing research.
[8] The country level baseline scenarios of Höhne and Ullrich were also used for the post-2012 regime analyses, as described in Höhne et al. (2004; 2005). An earlier study of Höhne et al. (2003) used this downscaling method for the IPCC SRES emission scenarios (Nakicenovic et al., 2000) at the level of the four IPCC SRES regions, where it fails even more, given the larger differences between countries in each region.

Text box 1. The impact of the linear downscaling method vs. the non-linear downscaling methods on projections of a country's baseline population, per capita income and emissions

Table 2 gives the downscaled information of countries' population, per capita income and emissions in 2050 of the IMAGE 2.2 IPCC SRES scenarios of the linear downscaling method used by Höhne and Ullrich (2005), and of the non-linear downscaling method of van Vuuren et al. (2005) used by this study. The absolute numbers here represent the median over the six IMAGE 2.2 IPCC SRES scenarios. It also presents the relative differences, i.e. comparing the relative growth factors compared to the 2000 levels for both studies, which only reflect the differences due to the downscaling method, and not due to differences in the 2000 estimates. These relative differences correspond with the numbers in the last column in Table A.1, A.2 and A.3 in Appendix A.
The table depicts the first ten countries, with a population of at least 10 million persons, with the highest differences. This is followed by the first five countries, with again the highest differences, for a population of at least 100 million persons. It also gives the global estimates. The last row gives the average of all relative differenced (in absolute terms) for all countries.
The table shows that the average (relative) difference for population projections in 2050 will be as high as about 25%, with a difference of more than 50% for some African and Asian countries, and also for Cuba, South Africa (almost 90%) and Afghanistan (almost 52%). For per capita income, the highest difference (as mentioned before) for some Asian countries is more than 100%, such as Singapore (about 130%) and South Korea (about 120%), with per capita income levels far exceeding the Annex I per capita income levels. The average difference over all the countries is now even almost 27%. For the emissions, we find very high differences for some Asian and African countries. Table 2 also shows that aggregates of the linear-downscaling method used by Höhne and Ullrich (2005) may differ from the global estimate of the original IMAGE 2.2 IPCC scenarios (for example, global 2050 per capita income is about 15% higher), whereas the methodology of van Vuuren et al. (2005) is always consistent with the original source, by ensuring that aggregation retains the original dataset. Finally, the data for both studies at the level of all countries are compared in Appendix A.

Table 2. The countries' population, per capita income and emissions in 2050 of the IMAGE 2.2 IPCC SRES scenarios of the linear downscaling method used by Höhne and Ullrich (2005)[v]*, and of the non-linear downscaling method of van Vuuren et al. (2005) used in this study, and its relative difference. The absolute numbers here represent the median over the six scenarios.*

	Population (millions) – 2050				Per capita income (1000PPP$/capita)				Emissions (in $MtCO_2$) – 2050			
	Country	**Linear downscaling**	**Non-linear downscaling**	**Relative difference* (%)**		**Linear downscaling**	**Non-linear downscaling**	**Relative difference***		**Linear downscaling**	**Non-linear downscaling**	**Relative difference***
1	Kenya	68.1	35.2	92.7	Singapore	128.9	53.8	130.1	Burundi	34.4	12.1	337.0
2	South Africa	96.2	51.5	89.6	Korea (South)	10.6	41.3	120.9	Uganda	523.4	87.1	203.7
3	Zimbabwe	28.0	16.4	71.6	Korea (South)	91.2	48.9	109.3	Kenya	420.4	313.3	173.4
4	Cuba	16.3	9.7	67.9	Taiwan	121.2	102.0	94.9	Senegal	152.2	80.9	131.6
5	Yemen	38.2	94.0	-60.2	United Arab. E	93.1	83.4	94.4	Ethiopia	466.3	231.8	129.4
6	Cameroon	33.0	21.2	58.0	Cyprus	85.4	37.0	93.8	Ghana	151.0	96.8	114.6
7	Angola	29.2	62.4	-55.9	Qatar	124.7	87.5	92.5	Congo	15.9	24.7	91.1
8	Afghanistan	33.6	68.5	-51.7	Gabon	39.9	19.9	85.1	Mali	54.7	80.1	77.5
9	Niger	24.0	49.0	-51.4	Slovenia	86.2	44.2	83.4	Namibia	26.0	27.1	71.4
10	Sri Lanka	29.3	19.1	50.1	Israel	87.3	47.3	76.3	Eritrea	197.4	14.2	67.2
	Countries with more than 100 million persons				Countries with more than 100 million persons				Countries with more than 100 million persons			
	Turkey	138.6	99.8	42.2	Russian Fed.	52.7	32.3	42.0	Dem. Rep. Congo	241	175	59.3
	Pakistan	218.4	332.0	-33.6	India	19.5	15.6	24.6	India	8670	7549	18.2
	Iran	146.2	107.7	28.2	Iran	23.1	30.1	-16.7	Russian Fed.	3348	3805	-17.3
	Dem. Rep. Congo	113.1	135.8	-20.6	Congo	5.9	5.1	16.5	Mexico	1426	1704	-14.6
	Russian Federation	150.8	133.5	13.0	Mexico	41.6	35.7	16.1	Nigeria	1275	857	13.4
	Global	8583	8629	-1.3	**Global**	22.1	22.5	-3.5	**Global**	71782	80174	10.0
	Average difference			**25.5**	**Average difference**			**27.3**	**Average difference**			**26.2**

[v] The baseline scenarios on a country level from Höhne and Ullrich were also used for the post-2012 regime analyses, as described in Höhne et al. (2004; 2005). * Relative differences correspond with the figures in the last column of the tables in Appendix A.

Text box 1. Continued

Concluding, the linear downscaling method used by Höhne and Ullrich (2005) does not provide a satisfactory set of results, and leads to completely different results from the non-linear downscaling method by van Vuuren et al. (2005) used here. It should be noted that as emission allowances calculated are dependent on the baseline scenarios used, these are also highly affected by the use of the downscaling methods. In fact, as illustrated above and in Appendix A, the impact of the downscaling methods may be of more importance than the assumed reductions under a post-2012 regime for differentiation of future commitments for quite a few countries (in particular, the developing countries). This report will not analyse the impact of the downscaling methods used in the emission allowances in much detail as this is not the main focus of this study.

This study uses a set of downscaling algorithms based on recent work of van Vuuren (2005). The recently published long-range population projections on a country level by the UN (UN, 2004b) are used for downscaling population data. For downscaling GDP and emissions, van Vuuren et al. assumed a convergence of countries' per capita income and emissions per GDP to the average regional level. A form of convergence is likely to occur within larger regions – and has also been assumed in the IPCC SRES storylines. In this way, these downscaling algorithms try to deal with the shortcomings of the earlier methods using a regional trend, and thereby provide much more plausible results for population, GDP and emissions projections.

2. *Historical and base-year greenhouse gas emissions are based on the same data as in the original study*, namely the CAIT 2.0 database of the World Resource Institute (WRI) (http://cait.wri.org), whereas Höhne and Ullrich (2005) make use of national emission inventories submitted to the UNFCCC and, where not available, existing emission databases.
3. *More consistent calculations of the multi-gas emission pathways and emission allowances.* Höhne and Ullrich (2005) make use of CO_2-only emission pathways stabilising the CO_2 concentration at 400 and 450 ppm CO_2-only (Höhne et al., 2005). For the calculating the countries' emission allowances, they use the global CO_2-only emission targets (relative to 1990 levels) for the global CO_2-equivalent emission targets (including the six Kyoto greenhouse gases, but excluding LUCF CO_2) by assuming the same trend for the non-CO_2 greenhouse gases as for CO_2. This assumption does not seem realistic given the time-dependent share of non-CO_2 gases in the reductions in multi-gas strategies using Global Warming Potentials (GWPs). In other words, the contribution of the non-CO_2 gases in total reductions is very large early in the scenario period, but the focus in the long-term is still CO_2 (van Vuuren et al., 2003). However, assuming the same trend for the fossil CO_2 emissions and land-use related (LUCF) CO_2 emissions seems unlikely, as the present baseline (non-intervention) scenarios already shows strong decreases in the LUCF CO_2 emissions compared to the present levels (IMAGE-team, 2001).

   This study uses the recently developed set of multi-gas emission pathways for different CO_2-equivalent concentration[9] stabilisation levels, i.e. 400, 450, 500 and 550 ppm CO_2-equivalent (den Elzen and Meinshausen, 2005a; 2005b), compatible with levels of certainty for adequately keeping the global mean surface temperature increase below 2° Celsius above pre-industrial levels (see section 2). The calculations of the countries' emission allowances make use of the global CO_2-equivalent emission targets of the emission pathways, which are both calculated in terms of CO_2-equivalent emissions of

[9] "CO_2 equivalent concentration" summarises the climate effect ("radiative forcing") of all human-induced greenhouse gases, tropospheric ozone and aerosols, following the IPCC definition, as if we only changed the atmospheric concentrations of CO_2 (see Schimel et al., 1997).

the six Kyoto greenhouse gases (excluding LUCF CO_2). This methodology seems more consistent, as it better accounts for the time-dependent share of non-CO_2, LUCF CO_2 and fossil CO_2 emissions in the global CO_2-equivalent emission pathways.

4. *Multi-gas emission pathways allow for an overshoot in the concentration levels, and the result is less stringent short-term Annex I and Annex II reduction commitments.* For the 400, 450 and 500 ppm CO_2-equivalent concentration targets, this study assumes a certain overshooting (or peaking); i.e. concentrations are allowed to peak before stabilising (going up to 480-500 ppm CO_2-equivalent before going down to levels such as 400 or 450 ppm CO_2-equivalent later on). This overshooting is partially reasoned by the already substantial present concentration levels and the attempt to avoid drastic sudden reductions in the emission pathways presented (den Elzen and Meinshausen, 2005a; 2005b). The CO_2-only emission pathways of Höhne and Ullrich (2005) do not allow for such an overshoot in concentrations, which leads to high, and maybe "unrealistic" fast and deep emission reduction commitment, in particular for the 400 ppm CO_2-only scenario, for the Annex I countries in the short-term (2020-2025).[10] Such deep reductions seem politically, technically and economically unfeasible. The short-term global CO_2-equivalent emission targets are less stringent in this study (section 3). For example, the global emissions target for 2020 for the most stringent concentration target (400 ppm CO_2-equivalent) correspond with Höhne and Ullrich's 450 ppm CO_2-only target (about 500-525 ppm CO_2-equivalent). An overall result of the study are the less stringent short-term reduction commitments for all countries, in particular, the Annex I countries.
5. *Abatement costs and financial flows.* Besides the emission allowances, as presented in the two studies, this report also outlines the abatement costs and financial flows at the level of individual countries.

Build-up of the report

Section 2 starts by providing the set of multi-gas emission pathways, while section 3 describes the tool, the FAIR 2.1 world model, used for the analysis of the emission allowances. This model is essentially a country version of the FAIR 2.1 model, the policy-decision support tool for analysing emission allowances and abatement costs at the level of world regions. The FAIR 2.1 world model makes use of the baseline scenarios at the level of individual countries. Section 4 describes the assumptions made to quantify the emissions allowances under the South–North Dialogue Proposal. The next two sections present the countries' emission allowances for the "political willingness scenario" (Section 5) and for the four scenarios leading to stabilisation of CO_2-equivalent concentration at 400, 450, 500 and 550 ppm, respectively (Section 6). The stabilisation scenarios show what the emission reductions are required to reach greenhouse gas concentration in the long-term, and simply assume that Parties will be politically willing to make the necessary effort, whereas the "political willingness" scenario starts from what Parties might be willing to do − or at least one set of assumptions about what "political willingness" might look like. Section 6 also presents abatement costs and financial flows for the four scenarios. Section 7 summarises the conclusions.

[10] Höhne and Ullrich concluded: "The 400 ppm scenario requires yet more ambitious reduction by all countries, which are at the limit of what some would call realistic. Annex II countries would need to cut emissions in half by 2020 and RIDCs and NICs would follow quickly."

2 Multi-gas emission pathways to stabilise long-term greenhouse gas concentrations

This section presents a set of multi-gas emission pathways for different CO_2-equivalent concentration stabilisation levels, i.e. 400, 450, 500 and 550 ppm CO_2-equivalent, along with an analysis of implied probability of adequately keeping global mean surface temperature increase below 2°C above pre-industrial levels. This work is based on the study of den Elzen and Meinshausen (2005a; 2005b). The applied methodology focuses on a cost-effective division among different greenhouse gas reductions for given emission limitations on GWP-weighted and aggregated emissions. Thus, the model framework reflects the existing policy framework with present caps on GWP-weighted overall emissions under the assumption of cost-minimising national strategies. The emissions that are iteratively adapted to meet the pre-defined stabilisation targets include those of all the major greenhouse gases (fossil CO_2, CH_4, N_2O, HFCs, PFCs and SF_6), ozone precursors (VOC, CO and NO_x) and sulphur aerosols (SO_2).
Den Elzen and Meinshausen (2005a) have developed the emission pathways for three baseline scenarios, the IMAGE IPCC B1 scenario (a low-level emissions scenario) and the Common POLES IMAGE (CPI) baseline (a medium-level emissions scenario) (van Vuuren et al., 2003; 2004b) scenario. This was done with both default Marginal Abatement Costs (MAC) curves, and the CPI+tech scenario, with baseline emissions based on the CPI scenario and fixed LUCF CO_2 emissions of the IMA-B1 scenario (less deforestation) and MAC curves assuming additional technological improvements. Here, we focus on the emission pathways under the CPI+tech scenario, as this is a medium-level emissions scenario, leading to feasible emission pathways for the (low) 400 and 450 ppm CO_2-equivalent concentration targets, whereas for the CPI scenario there were no feasible pathways for these concentration levels.
The emission pathways presented aim at stabilisation of the long-term greenhouse gas concentrations at CO_2-equivalence levels of 550, 500, 450 and 400 ppm. As already mention in section 1, a "peaking strategy" is followed here: i.e. concentrations may first increase to an "overshooting" concentration level up to 480, 500 and 525 ppm then decrease before stabilising at 400, 450 and 500 ppm CO_2-equivalence, respectively. This peaking is partially reasoned by the already substantial present net forcing levels (Hare and Meinshausen, 2004) and the attempt to avoid drastic sudden reductions in the emission pathways presented. shows the probabilistic temperature implications (for 2000-2400) of the emission pathways based on the climate sensitivity Probabilistic Density Function (PDF) of Wigley and Raper (2001).[11] The natural forcings (i.e. solar and volcanic forcings) are included in these transient calculations of den Elzen and Meinshausen (2005a), (see for more details, Hare and Meinshausen (2004).[12]
Figure 1 shows that an emission pathway leading to 550 ppm CO_2-equivalent stabilisation is unlikely to adequately limit global mean temperature increase below 2°C above pre-industrial level (Figure 1). In order to adequately limit global temperature increase below 2°C with a probability of more than 60% (85%) (assuming the probabilistic density function of Wigley and Raper, 2001), greenhouse gas concentrations need to be stabilised to below 450 (400) ppm CO_2-equivalent or lower. If a different climate sensitivity PDF is

[11] The PDF of Wigley and Raper (2001) assumes the conventional 1.5 to 4.5°C climate sensitivity uncertainty range as being a 90% confidence interval of a lognormal PDF.
[12] An exception has been made for the calculations on the risk of overshooting the 2°C limit in equilibrium. There, equilibrium temperatures have been directly derived from anthropogenic radiative forcings (Hare and Meinshausen, 2004). See, for example, Figure 1 - the number on the white arrows.

assumed, for example, the one by Murphy et al. (2004), the probability still sharply increases with lower stabilisation levels, although the risk of overshooting generally increases. Specifically, stabilisation at 450 (400) ppm CO_2-eq. would imply a probability of achieving 2°C of about 22% (66%).
The emissions of the pathways for stabilisation at 550, 500, 450 and 400 ppm CO_2-eq. concentrations (for the 1990-2060) can be summarised in their GWP-weighted sum of emissions of six Kyoto gases, as illustrated in Figure 2. Clearly, there are different pathways that can lead to the ultimate stabilisation level. Den Elzen and Meinshausen (2005a) have assumed that the global emission reduction rates should not exceed an annual reduction of 2.5%/year for all default pathways (at least not over longer time periods). The reason is that a faster reduction might be difficult to achieve given the inertia in the energy production system: electrical power plants, for instance, have a technical lifetime of 30 years or more. Fast reduction rates would require early replacement of existing fossil-fuel-based capital stock, which may be associated with large costs. A maximum rate of 2%/year is hardly ever exceeded for the majority of the post-SRES mitigation scenarios, apart from some lower stabilisation scenarios. As a result of this (the assumed onset of reductions from the baseline emissions), reduction takes place relatively early, and global emissions peak around 2015-2020. For all stabilisation pathways, the global reduction rates remain below 2.5%/year for the whole scenario period, except for the pathways at 400 ppm CO_2-eq., with maximum reduction rates of 2.5-3%/year over 20 years.[13]

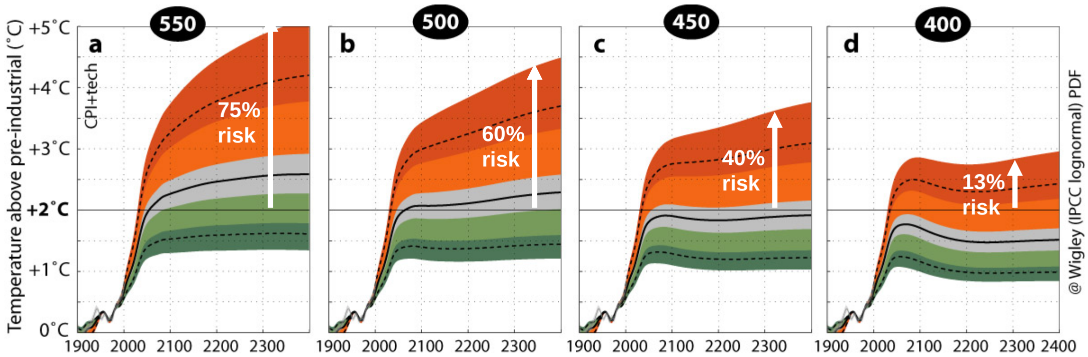


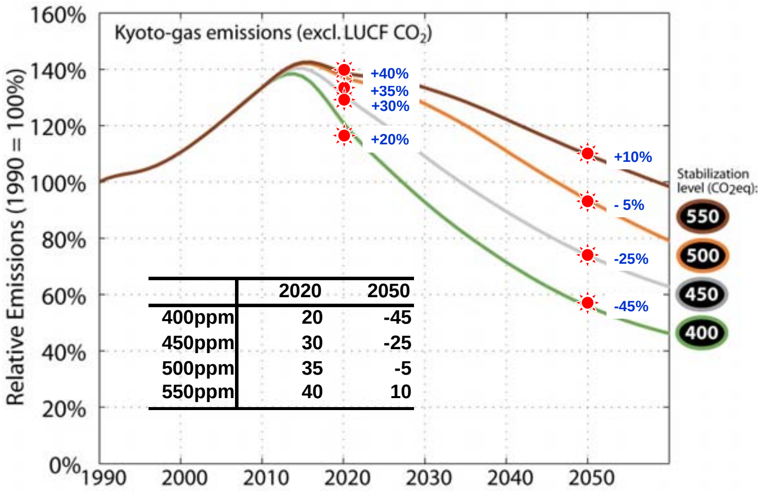
Figure 1. The probabilistic temperature implications for the stabilisation pathways between 1900 and 2400 at (a) 550 ppm, (b) 500 ppm, (c) 450 ppm and (d) 400 ppm CO_2-equivalent concentrations for the CPI+tech baseline scenario based on the climate sensitivity PDF by Wigley and Raper (2001) (IPCC lognormal). The median (solid lines) and 90% confidence interval boundaries (dashed lines) are shown, as well as the 1%, 10%, 33%, 66%, 90%, and 99% percentiles (borders of shaded areas). The historical temperature record and its uncertainty from 1900 to 2001 is shown by the grey shaded band (Folland et al., 2001). Source: den Elzen and Meinshausen (2005a).

By 2050, global greenhouse gas emissions (excl. LUCF CO_2), basically the Kyoto gas emissions, will have to be near 40-45% below 1990 levels for stabilisation at 400 ppm CO_2-eq. For higher stabilisation levels, e.g. 450 ppm CO_2-eq., greenhouse gas emissions (excl. LUCF CO_2) may be higher, namely 15-25% below 1990 levels. The reduction requirements become as high as 50 to 55% (30 to 40%) below 1990 levels for stabilisation

[13] A further delay in the peaking of global emissions in 10 years doubles maximum reduction rates to about 5% per year, and will very likely lead to high costs (den Elzen and Meinshausen, 2005a).

at 400 ppm CO_2-eq (450 ppm CO_2-eq) in 2050 for all greenhouse gas emissions, including LUCF CO_2.

For the analysis of this report, eight reference points of global greenhouse gas emission levels excluding LUCF CO_2 emissions in 2020 and 2050 were selected; these have to be met by all approaches for the following quantification of emission allowances. These are based on the rounded-off percentages (to the nearest multiple of 5%) from the CPI+tech scenario, as the emissions of this scenario are in the middle of the emissions for the six IPCC SRES scenarios, which are used in the calculations in this study.



	2020	2050
400ppm	20	-45
450ppm	30	-25
500ppm	35	-5
550ppm	40	10

Figure 2. Global emissions relative to 1990, excluding LUCF CO_2 emissions between 1990 and 2060, for the stabilisation pathways at 550, 500, 450 and 400 ppm CO_2-equivalent concentrations for the CPI+tech scenario. The global reduction targets used (dots) for the analysis of emission allowances of the South–North Dialogue Proposal are also given here.

3 The FAIR 2.1 world model: a tool to analyse countries' emission allowances and abatement costs

The tool used for the analysis of the emission allowances and abatement costs, the FAIR 2.1 world model, is briefly described here. But first we will briefly review the FAIR 2.0 model, the foundation of the FAIR 2.1 world model.

3.1 The FAIR 2.0 model

The policy decision-support tool, FAIR 2.0 (Framework to Assess International Regimes for the differentiation of commitments) (den Elzen and Lucas, 2003; 2005b) was developed to explore and evaluate the environmental and abatement cost implications of various international regimes for differentiation of future commitments for meeting such long-term climate targets as stabilisation of the atmospheric GHG concentrations. There have been many proposals for differentiating commitments among countries, both from literature and from Parties to the UNFCCC (see Aldy et al., 2003 for an overview; Bodansky, 2004; Kameyama, 2004; Torvanger and Godal, 2004). The FAIR 2.0 model includes about ten approaches, all defining the differentiation of commitments based on criteria and rules for the distribution of emission allowances (i.e. allocation-based approaches, see also section 2). The model does not comprise approaches for differentiating commitments in terms of outcomes, such as equal mitigation costs (Babiker and Eckhaus, 2002), as these are dependent on a macro-economic model (not included in the FAIR model). "Policies and Measures" approaches, such as technology and performance standards including energy-efficiency standards (e.g. Barrett, 2001; Edmonds and Wise, 1999), financial measures (e.g. Schelling, 2002) and carbon taxes (Cooper, 2001) (for an overview, see Bodansky, 2004; den Elzen and Berk, 2004) have not been implemented, as this requires more detailed, aggregated, sectoral energy modelling. The model focuses on multi-lateral regimes based on the UNFCCC and the Kyoto Protocol, and not on regimes based on smaller coalitions between like-minded parties, the most important players or collaboration at the regional level. This approach is often combined with a pledge-based approach with countries' commitments based on their "willingness to pay". While the model allows for simulating such an approach, its focus is on evaluation of rule-based approaches to defining international commitments.
The FAIR 2.0 model can be used for a consistent and quantitative comparison of various allocation-based, multi-lateral regime proposals, as has been done, for example, for the EU DG Environment project, "Greenhouse gas reduction pathways in the UNFCC post-Kyoto process up to 2025" (Criqui et al., 2003; den Elzen et al., 2003; van Vuuren et al., 2003). The model was also used to evaluate the Kyoto Protocol under the Bonn and Marrakesh agreements in terms of environmental effectiveness and costs (den Elzen and de Moor, 2001; 2002a; 2002b; Lucas et al., 2005), the Bush Climate Change Initiative (van Vuuren et al., 2002) and the Brazilian Proposal (den Elzen et al., 2003; 2005b; den Elzen and Schaeffer, 2002; 2005d). Furthermore, the model was used to support dialogues between scientists, NGOs and policy makers (e.g. Berk et al., 2001). To this end the model is set up as an interactive tool with a graphical interface, allowing for interactive changing and viewing model input and output.[14] Other scientific applications of the FAIR 2.0 model are, in combination with the integrated assessment model IMAGE15 and the energy model

[14] A demonstration version of FAIR 2.0 can be downloaded from: http://www.mnp.nl/fair.
[15] The IMAGE 2.2 model is an integrated assessment model, consisting of a set of integrated models that together describe important elements of the long-term dynamics of global environmental change, such as

TIMER16, the analysis of multi-gas mitigation scenarios in the Emission Modelling Forum (EMF 21) (van Vuuren et al., 2004b).

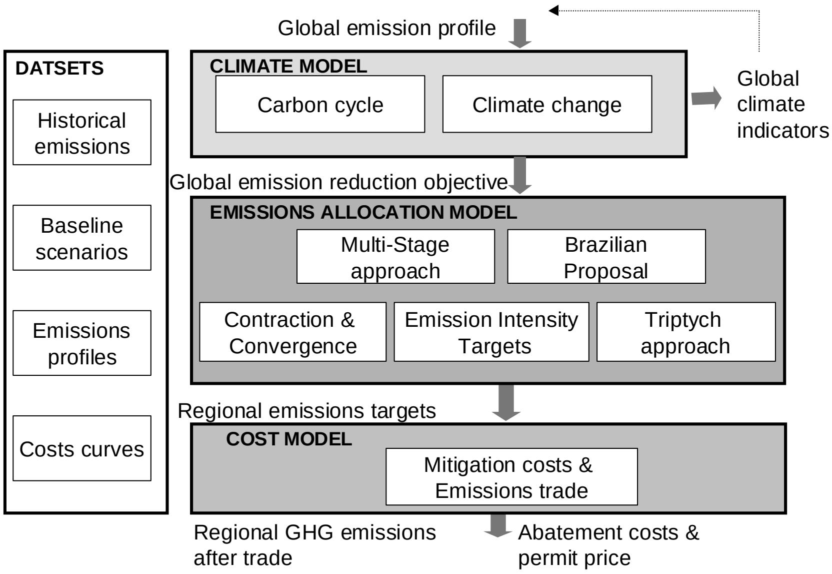


Figure 3. Schematic diagram of the FAIR model showing its framework and linkages (den Elzen and Lucas, 2003; 2005b).

The FAIR model consists of three linked models (Figure 3): 1. A *climate model* to calculate the climate impacts of global emission profiles and emission scenarios, and to determine the global emission reduction objective – based on the difference between the global emissions scenario (without climate policy) and a global emission profile (den Elzen and Schaeffer, 2002; den Elzen et al., 2002; 2005d); 2. An *emission allocation model* to calculate the regional emission allowances for different regimes for the differentiation of future commitments within the context of this global reduction objective (from climate model) (den Elzen, 2002; den Elzen and Berk, 2003; den Elzen et al., 2005a; den Elzen et al., 2003; 2005c); 3. A *costs model* to calculate the emission targets after emissions trading and regional abatement costs on the basis of the emission allowances (from the emission allocation model) follows a least-cost approach, making full use of the flexible Kyoto mechanisms like emissions trading and substitution of reductions between the different gases and sources (den Elzen and de Moor, 2002a; den Elzen et al., 2005c; Lucas et al., 2005). Furthermore, various data sets of historical emissions, baseline scenarios, multi-gas emission pathways and costs curves are included in the model framework to assess the sensitivity of the outcomes towards these key inputs. Calculations were done for 17 regions, i.e. Canada, USA, OECD-Europe, Eastern Europe, FSU, Oceania and Japan (Annex I regions); Central America, South America, the Middle East and Turkey (middle- and high-income non-Annex I regions); Northern Africa, Southern Africa, East Asia (incl. China) and South-East Asia (low-middle income non-Annex I regions) and Western Africa, Eastern Africa and South Asia (incl. India) (low-income non-Annex I regions) (IMAGE-team, 2001).

---

agriculture and energy use, atmospheric emissions of greenhouse gases and air pollutants, climate change, land-use change and environmental impacts (IMAGE-team, 2001).

[16] The global energy model, TIMER 1.0 (as part IMAGE), describes the primary and secondary demand and production of energy and the related emissions of greenhouse gasses and regional air pollutants (de Vries et al., 2002).

3.2 The FAIR 2.1 world model

A logical next step after the realisation of the FAIR 2.0 model (2003) was to extend the calculations of the emission allowances and abatement costs to the level of countries, as individual countries are the actors in the international negotiations and countries' emission profiles may be very different even within one geographic region, e.g. South Korea and China. Hence, individual countries are interested in the implications of various approaches for their emission levels.
However, to date (2005) good reliable data of baseline emission scenarios at the level of all world countries have not been available. The existing downscaling methods to downscale the information on population, GDP and emissions of the IPCC SRES scenarios the level of regions to the level of countries, were strongly criticised in literature (see Pitcher, 2004; van Vuuren et al., 2005), as leading to unrealistic results (in particular the one using the regional trend, as used by Gaffin et al., 2004; Höhne et al., 2003; Höhne et al., 2005). A recently developed new downscaling method by van Vuuren et al. (2005) has changed this situation. This method is used for downscaling the information of the same indicators of the IMAGE IPCC SRES scenarios of the IMAGE-team (2001) at the level of the 17 IMAGE world regions to countries and deals with the limits of the existing downscaling methods. For downscaling the population data, the long-range population projections on a country level recently published by the UN (2004b) are used. For downscaling GDP and emissions, van Vuuren et al. assumed a convergence of countries' per capita income (in US$ or PPP$) and emissions per GDP to the average regional number. This downscaling method assumes (partial) convergence of the units to the average regional number, making sure that the total of the elements complies with the pathway of the larger unit. For several parameters, there are good reasons to assume that some form of convergence *within* larger global regions is likely to occur – certainly in some of the SRES storylines. This is a very logical assumption in the case of large differences between units in a region result in unlikely outcomes in cases of linear downscaling. It is also a very logical assumption if (partial) convergence also occurs between regions. The rate of convergence can be influenced by choosing a convergence year. A detailed description of the methodology can be found in van Vuuren et al. (2005).
The FAIR 2.1 world model (still under development) makes use of this downscaled information of the IMAGE IPCC SRES scenarios at the level of the 192 UN countries (e.g., den Elzen and Lucas, 2005a). This FAIR 2.1 world model can be used for doing quantitative analyses of emission allowances and abatement costs for post-2012 climate regimes for commitments at the level of individual countries, using a set of baseline scenarios at the level of countries, as has been done in this study.[17]
The basis of the FAIR 2.1 world model is formed by the FAIR 2.1 model (under development), which is an update of the FAIR 2.0 model with its calculations still at the level of 17 world regions (completely in line with the IMAGE IPCC SRES scenarios); this includes updated multi-gas emission pathways (see section 2 and den Elzen and Meinshausen, 2005a; 2005b); historical data using as base year 2000 (instead of 1995) (see this report), updated climate attribution calculations (den Elzen et al., 2005b; den Elzen et al., 2005d); an updated Triptych approach (based on the work of Phylipsen et al., 2005), and

[17] Höhne et al. (2003) were the first to present countries' emission allowances for post-2012 climate regimes, but they used a set of baseline scenarios for population, GDP and emissions at the level of countries, based on applying the regional downscaling method for the IPCC SRES emission scenarios (Nakicenovic et al., 2000) from the four IPCC SRES regions to 192 countries, that was criticised in the literature as being unrealistic. In their follow-up studies (Höhne et al., 2005; Höhne and Ullrich, 2005) they applied the growth rates of the IPCC SRES implementation of the 17 IMAGE regions at the level of countries.

two additional post-2012 regimes for post-2012 commitments (i.e. Common-but-differentiated convergence (Höhne et al., 2004) and the South–North Dialogue Proposal (this report). See also den Elzen and Lucas (2005a) and improved costs calculations with the most recent EMF costs curves (den Elzen and Meinshausen, 2005a; den Elzen et al., 2005c; van Vuuren et al., 2004b).

The FAIR 2.1 world model is essentially the same as the FAIR 2.1 model, but now the calculations of emission allowances at the level of 192 UN countries and of abatement costs at the level of 51 countries and/or groups of aggregated countries instead of the 17 regions (see Appendix B). The main specific components of the FAIR 2.1 world model, which differ from the FAIR 2.1 region model, are described below:

- *Historical data* – The base-year (2000) population data is provided by the UN World Population Prospects (UN, 2004a). The national per capita income levels in the base-year (in US$ or PPP$)[18] are based on the 2004 database World Development Indicators (WorldBank, 2004). For the missing countries in this database, the set is supplemented with the series "GDP, at constant 1990 prices – US dollars" from the UN Statistics Database (2005), using a conversion from 1990 to 1995 prices. The historical (1990-2000) countries' GHG emissions are based on the CAIT 2.0 database (http://cait.wri.org). More specifically, the CO_2 emissions from fossil fuel combustion and cement production (1765-2000) are based on the CDIAC database (Marland et al., 2003) and IEA data (IEA, 2002).The CO_2 emissions from land-use changes (1950-2000) are based on Houghton (2003). The non-CO_2 Kyoto GHG emissions (CH_4, N_2O the HCFCs, HFCs, PFCs and SF_6) (1990-2000) are based on the EPA (2004) and EDGAR 3.2 (Olivier and Berdowski, 2001), and where data for 2000 data were missing, these were estimated by WRI. For alternative calculations, the FAIR 2.1 world model also includes the national inventories submitted to the UNFCCC for the base-year emissions and, where these inventories are not available, other sources (based on the same databases as mentioned above) are used. This database is the same as the one used by Höhne et al. (2005).
- *Countries' baseline scenarios* – Baseline scenarios are used for future (2000-2100) projections of the countries' population and GDP (in US$ or PPP$), along with the anthropogenic baseline emissions of the Kyoto greenhouse gases. The different baseline scenarios included are the six IMAGE implementation of the six IPCC SRES scenarios (IMAGE-team, 2001; Nakicenovic et al., 2000) and the Common POLES-IMAGE baseline emission scenario (van Vuuren et al., 2003; van Vuuren et al., 2004b). These scenarios all occur at the level of the 17 IMAGE world regions. Here, a set of algorithms is used for the downscaling of this information from the 17 world regions to the 192 countries (van Vuuren et al., 2005), as described earlier in this section.
- *2012 emission targets* – Up to 2012, implementation of the Annex I Kyoto Protocol targets is assumed for all Annex I countries (for the EU countries these are the internal EU burden-sharing targets) excluding Australia and the USA.[19] Although the USA aims at the proposed greenhouse-gas intensity target (White-House, 2002), this does not lead

[18] The Purchase Power Parity (PPP) is an alternative indicator for GDP per capita, based on relative purchasing power of individuals in various regions, i.e. the value of a dollar in any country, or, in other words, the dollars needed to buy a set of goods compared to the dollars needed to buy the same set of goods in the USA.

[19] Although included in the model, the default calculations here do not analyse the impact of other implementations of the Kyoto Protocol: i.e. (1) a "strong" Kyoto implementation, in which the USA and Australia also implement their Kyoto targets and the emissions of economies in transition (Russia and Eastern European countries) follow the lower of their Kyoto targets and their baseline emissions, and their 'hot air' will not be sold. Neither do the default calculations analyse (2) a "failure" of the Kyoto Protocol, in which all countries implement their baseline emissions, since implementation of both, the "strong" Kyoto implementation and the "failure" of the Kyoto Protocol cases does not seem very politically realistic.

to emissions that are significantly different from their baseline emissions (van Vuuren et al., 2002). Note that the economies in transition (Russia and Eastern European countries) follow their Kyoto targets, leading to some excess emission allowances in 2012, and these Kyoto targets will also be used as the starting point for calculating their post-2012 emission allowances.[20] The non-Annex I regions follow their assumed baseline emissions up to 2012.

The calculations of the abatement costs are valid for 51 countries (including groups of aggregated countries, as listed in Appendix B), and make use of the baseline emission scenarios for 192 countries and the Marginal Abatement Cost (MAC) curves[21] for 17 regions for CO_2 and 19 regions or countries for non-CO_2 greenhouse gases.

- *Marginal Abatement Cost (MAC) curves* are used for the 17 regions, six Kyoto greenhouse gases and different numbers of sources (for example, for CO_2 (12), CH_4(9), N_2O (7). Technological developments, learning effects and system inertia are schematically taken into account by using time-dependent MAC curves (described in den Elzen and Lucas, 2005b; van Vuuren et al., 2004a; 2004b). For more details about the costs calculations we refer to Section 6.2.

[20] The assumptions on the targets for the USA and economies in transition are different from those assumed in Höhne and Ullrich (2005), in which a "strong" Kyoto implementation was assumed (see previous footnote).

[21] MAC curves reflect the costs of abating the last ton of CO_2-equivalent emissions and, in this way, describe the potential and costs of the different abatement options considered.

4 Model implementation of the South–North Dialogue Proposal

4.1 A method for countries to move into a different country group

The South–North Dialogue Proposal suggested a division of countries into the six country groups (section 1). In the original proposal four indicators were aggregated to make the division. For the model implementation of the proposal the division as provided in the proposal up to 2020 is used. After 2020 this study uses the division based on the calculations as provided below. Note that the methodology presented here is based on Höhne and Ullrich (2005).

The following indicators are used in the calculation of an aggregated index where equally weighting potential (energy GHG/GDP and GHG/cap), responsibility (cumulative CO_2 emissions /capita in last decade) and capability (HDI) are incorporated:

1) Energy GHG emissions per GDP (includes all GHG emissions but excludes the sectors, waste and agriculture) – weighting of 1/6
2) All GHG emissions per capita – weighting of 1/6
3) Cumulative energy CO_2 emissions from 1990 per capita divided by the number of years summed (includes all GHG emissions but excludes the waste and agriculture sectors) – weighting of 1/3
4) GDP in purchase power parities per capita – weighting of 1/3

Each indicator for the year 2000 is first translated into an index, where the maximum of all values is 100 and the minimum of all value is 0, as in equation:

Index value = 100 x [(actual value – minimum value) / (maximum value – minimum value)]

According to the methodology of the original proposal, the thresholds for defining the country groups are based on values for 2000:

- NIC: above mean (here: 21.5) plus one standard deviation (here: 15.0), which comes to about 36.5.
- RIDC: between mean plus one standard deviation and mean minus one standard deviation, which comes to between about 6.5 and 36.5.
- Other DC and LDC: below mean minus one standard deviation (here: 6.5).

As already described in section 1, RIDCs also have an additional condition related to economic growth and income level.[22]

Indexing is performed only with regard to non-Annex I countries, excluding the LDCs. This exclusion was one of the key decisions within the South–North Dialogue group. The calculations of the index show very high values for some countries. These outliers define the index value 100 using this methodology. As a result, the mean is very low and the mean minus one standard deviation even becomes negative. Therefore, according to Höhne and Ullrich (2005), nine outlier countries besides the LDCs (indicated in bold in Table 3) are excluded from the indexing (indicated in italics in Table 3).[23] Furthermore, just as in the original report, a number of countries are excluded from the indexing due to a lack of data, e.g. Cook Islands, Iraq, Korea (North), Marshall Islands, Micronesia, Nauru, Niue, Palau,

[22] In the original proposal, RIDCs were selected from those countries with medium index values (mean plus/minus one standard deviation) that have a higher per capita GDP-PPP than non-Annex I countries average and a higher annual growth in 1991-2000 than 2%.

[23] These countries are the same ones as those excluded by Höhne and Ullrich, except for Israel and Saudi Arabia, countries that according to our data were not outliers; Turkmenistan, as outlier due to its high emissions per capita income, is also excluded here.

Serbia and Montenegro, San Marino and Tonga (indicated in bold italics in Table 3). Several LDCs are also excluded, as there was no data for all indicators (according to Table 3, indicated in italics); therefore their index value does not really reflect national circumstances if only one or two indicator values are accounted.[24]
The results of the indexing for 2020 (compare Figure 4a and Figure 4b, and Table 3) are slightly different from those presented in the original report for two reasons: (i) here a different methodology is used (the index account for GDP-PPP per capita vs. the human development index, as future projections of this index are highly uncertain and estimates from various sources are often not consistent); (ii) the use of PPP$ data from other sources.[25] [26]
As mentioned in the beginning of this section, the original division of countries into the six country groups is used for the further calculations of the emission allowances. The following equation is used for the years after 2000:

$$\text{Index value } (t) = 100 \text{ x } [(\text{actual value}(t) - \text{minimum value}_{2000}) / (\text{maximum value}_{2000} - \text{minimum value}_{2000})]$$

Here, the country grouping for a certain year is always based on data from 10 years earlier, as (reliable) information on the threshold indicators is only available after some time, implying that the 2020 country grouping is based on data for 2010.
If desirable, a decline in threshold levels per decade after 2020 can also be specified. The idea behind a declining threshold level is that the “followers” have to start earlier with their reductions, as they benefit from the technology developments induced by the industrialised countries who have started to reduce their emissions. Furthermore, the methodology also assumes that a country can only be graded upwards.

---

[24] These countries are Georgia, Antigua and Barbuda and East Timor.
[25] Our match with the original grouping seems better when compared to the one presented by Höhne and Ullrich (2005).
[26] Table C.1 (Appendix C) gives the results of the indexing for countries arranged alphabetically.

Table 3. Results of indexing for the year 2000 (default calculations).

Country	**Income (in PPP$)**	**Population**	**Potential to mitigate – Energy CO_2 per GDP weight: 1/6)**	**Potential to mitigate – All GHG per capita (weight: 1/6)**	**Responsibility – Cumulative average energy CO_2 per capita from 1990 (weight: 1/3)**	**Capability – Income (in PPP$)/cap (weight 1/3)**	**Aggregated index weighted**	**Resulting stage[27]**	**Original SN proposal**
Units	**Billion US$**	**Million**	**Index**	**Index**	**Index**	**Index**	**Index**	**-**	**-**
Qatar	21.5	0.6	41	*459*	424	113	262	4	4
United Arab Emirates	100.0	2.8	24	*257*	268	109	172	4	4
Kuwait	32.5	2.2	47	*206*	168	44	113	4	4
Brunei	8.2	0.3	19	*145*	162	75	107	4	4
Bahrain	9.7	0.7	38	*165*	172	44	106	4	4
Korea (North)	31.7	22.3	122	63	140	4	79	4	4
Singapore	87.7	4.0	16	107	101	67	77	4	4
Trinidad & Tobago	10.6	1.3	44	112	101	25	68	4	4
Turkmenistan	15.0	4.6	87	90	104	10	68	4	4
Taiwan	724.5	22.2	7	70	64	100	67	4	2
Nauru	0.03	0.0	115	83	91	7	66	2	2
Saudi Arabia	255.6	22.1	28	100	96	35	65	4	4
Palau	0.1	0.0	50	85	101	18	62	4	2
Israel	114.2	6.0	13	86	70	58	59	4	4
Kazakhstan	65.9	15.6	47	68	100	13	57	4	4
Libya	61.2	5.2	19	70	73	36	51	4	2
Cyprus	12.3	0.8	13	68	60	48	50	4	3
Oman	30.0	2.6	21	77	63	35	49	4	3
South Africa	381.3	44.0	22	63	65	27	44	4	3
Seychelles	2.6	0.1	2	23	18	100	43	3	2
Uzbekistan	35.1	24.9	100	49	49	4	43	3	4
Korea (South)	653.7	46.8	17	75	34	43	41	4	2
Bahamas	4.6	0.3	8	44	48	47	40	4	3
Malta	6.4	0.4	8	40	45	50	40	4	3
Venezuela	125.6	24.3	32	67	54	16	40	4	2
Suriname	1.2	0.4	44	55	41	8	33	3	4
Barbados	3.8	0.3	8	39	31	43	33	3	3
Malaysia	189.0	23.0	16	49	37	25	32	3	3
Argentina	412.7	37.1	8	52	29	34	31	3	3
Mongolia	3.7	2.5	44	74	27	5	30	3	2
Azerbaijan	19.2	8.2	43	35	43	7	30	3	2
Iran	362.8	66.4	22	44	38	17	29	3	3
FYR Macedonia	12.2	2.0	17	37	38	18	28	3	2
Serbia & Montenegro	32.8	10.6	32	39	39	10	28	3	2
San Marino	0.7	0.0	0	0	0	80	27	3	2
Iraq	28.7	23.2	65	29	27	4	26	**2**	**2**
Mexico	809.5	98.9	11	35	30	25	26	3	3
Botswana	11.9	1.7	9	62	18	21	25	3	3
Lebanon	13.4	3.5	26	35	30	12	24	3	3
Chile	128.1	15.2	10	34	23	26	24	3	3
Jamaica	8.7	2.6	27	34	28	10	23	**2**	**2**
Gabon	7.1	1.3	12	38	24	17	22	3	2
Uruguay	27.2	3.3	5	51	13	25	22	3	3
Equatorial Guinea	7.1	0.5	2	19	5	48	21	3	1
Bosnia & Herzegovina	15.4	4.0	22	28	24	12	20	3	3
Saint Kitts & Nevis	0.4	0.0	5	16	17	32	20	3	3
Jordan	18.1	5.0	20	32	23	11	20	3	3
Syria	50.8	16.6	25	29	22	9	19	**2**	**2**
Algeria	150.6	30.2	14	25	23	15	19	3	3
Thailand	356.2	60.9	11	29	20	18	19	3	3
Cuba	31.0	11.2	24	30	22	8	19	3	4

[27] The bold typeface in this column indicates the additional economic and income condition of RIDCs valid here.

Country	**Income (in PPP$)**	**Population**	**Potential to mitigate – Energy CO_2 per GDP (weight: 1/6)**	**Potential to mitigate – All GHG per capita (weight: 1/6)**	**Responsibility – Cumulative average energy CO_2 per capita from 1990 (weight: 1/3)**	**Capability – Income (in PPP$)/cap (weight 1/3)**	**Aggregated index weighted**	**Resulting stage[27]**	**Original SN proposal**
Units	**Billion US$**	**Million**	**Index**	**Index**	**Index**	**Index**	**Index**	**-**	**-**
Belize	1.2	0.2	15	36	16	16	19	3	3
Mauritius	10.5	1.2	7	22	15	27	19	3	3
China	4523.7	1275.2	19	26	21	11	18	3	3
Moldova	5.1	4.3	34	17	25	4	18	**2**	**2**
Brazil	1164.9	171.8	7	33	13	21	18	3	3
Saint Lucia	0.7	0.1	14	26	17	16	18	3	3
Guyana	2.8	0.8	13	34	15	11	17	3	3
Maldives	2.9	0.3	5	16	9	30	17	1	1
Tunisia	54.8	9.5	9	21	16	18	16	3	3
Dominican Republic	47.1	8.4	10	24	14	17	16	3	3
Costa Rica	32.1	3.9	4	21	10	25	16	3	3
Panama	17.0	2.9	8	27	12	18	16	3	3
Colombia	236.6	42.1	7	26	13	17	16	3	3
Namibia	10.1	1.9	4	38	6	16	15	3	2
Georgia	0.0	1.0	0	0	42	0	14	**2**	**2**
Grenada	0.6	0.1	3	10	14	21	14	3	3
Mauritania	4.5	2.6	16	35	9	5	13	**1**	**1**
Bolivia	18.2	8.3	16	31	9	7	13	**2**	**2**
Egypt	220.5	67.8	14	18	13	10	13	**2**	**2**
Ecuador	38.3	12.4	13	22	12	9	13	**2**	**2**
Tonga	0.6	0.1	5	17	9	18	13	3	2
Niue	0.0	0.0	17	12	15	7	12	2	2
Paraguay	23.0	5.5	4	32	5	13	12	3	2
Armenia	6.9	3.1	15	14	14	7	12	**2**	**2**
Fiji	3.6	0.8	4	23	8	14	12	3	3
Cook Islands	0.1	0.0	12	12	11	11	11	**2**	**2**
Indonesia	593.9	211.6	13	16	11	9	11	**2**	**2**
Zimbabwe	30.0	12.6	13	18	11	7	11	**2**	**2**
Dominica	0.4	0.1	4	15	8	17	11	3	2
Saint Vincent & Grenadines	0.6	0.1	7	14	9	15	11	3	3
Peru	113.0	26.0	6	18	8	13	11	3	3
El Salvador	26.7	6.2	6	13	7	13	10	3	3
Vanuatu	0.6	0.2	4	30	3	9	10	**1**	**1**
Morocco	93.0	29.1	8	14	8	10	10	**2**	**2**
Tajikistan	4.5	6.1	23	9	10	2	9	**2**	**2**
Kyrgyzstan	7.0	4.9	16	10	11	4	9	**2**	**2**
Albania	11.6	3.1	6	8	9	11	9	**2**	**2**
Philippines	277.7	75.7	6	12	7	11	9	3	3
Swaziland	4.2	1.0	3	17	4	12	9	3	2
Samoa	0.8	0.2	4	6	6	14	9	3	1
Guatemala	41.5	11.4	6	13	5	11	8	**2**	**2**
India	2257.9	1016.9	11	12	7	7	8	**2**	**2**
Nicaragua	11.6	5.1	7	17	5	7	8	2	2
Yemen	13.7	18.0	22	9	5	2	8	**1**	**1**
Cambodia	22.1	13.1	1	35	0	5	8	**1**	**1**
Honduras	14.9	6.5	8	14	5	7	8	**2**	**2**
Djibouti	1.2	0.7	7	18	5	5	8	**1**	**1**
Pakistan	249.7	142.7	10	13	5	5	8	**2**	**2**
Congo	3.0	3.4	18	10	6	3	7	**2**	**2**
Nigeria	92.8	114.7	17	10	5	2	7	**2**	**2**
Angola	22.2	12.4	7	15	4	5	7	**1**	**1**
Sri Lanka	59.2	18.6	4	10	3	10	7	**2**	**2**
Papua New Guinea	11.7	5.3	5	11	4	7	6	2	2
Cape Verde	1.9	0.4	3	3	2	13	6	1	1
Vietnam	144.9	78.1	8	11	3	6	6	2	2
Sudan	47.5	31.4	3	21	1	5	6	1	1

Country	**Income (in PPP$)**	**Population**	**Potential to mitigate – Energy CO_2 per GDP (weight: 1/6)**	**Potential to mitigate – All GHG per capita (weight: 1/6)**	**Responsibility – Cumulative average energy CO_2 per capita from 1990 (weight: 1/3)**	**Capability – Income (in PPP$)/cap (weight 1/3)**	**Aggregated index weighted**	**Resulting stage[27]**	**Original SN proposal**
Units	**Billion US$**	**Million**	**Index**	**Index**	**Index**	**Index**	**Index**	-	-
Senegal	12.8	9.4	8	14	3	4	6	1	1
Sao Tome & Principe	0.2	0.1	15	5	4	3	6	1	1
Cameroon	26.0	15.1	4	12	2	5	5	2	2
Central African Republic	4.0	3.7	2	22	1	3	5	1	1
Kenya	28.2	30.5	8	12	2	3	5	2	2
Solomon Islands	0.8	0.4	5	7	3	5	5	1	1
Côte d'Ivoire	23.0	15.8	7	7	2	4	5	2	2
Togo	6.0	4.6	6	9	2	4	4	1	1
Lesotho	3.6	1.8	1	11	1	6	4	1	1
Zambia	7.5	10.4	6	12	2	2	4	1	1
Myanmar	65.7	47.5	3	12	1	4	4	1	1
Ghana	35.3	19.6	4	7	2	6	4	2	2
Madagascar	12.1	16.0	5	14	1	2	4	1	1
Kiribati	0.1	0.1	11	4	2	2	4	1	1
Bhutan	5.0	2.1	2	6	1	7	4	1	1
Guinea-Bissau	1.0	1.4	7	10	1	2	4	1	1
Guinea	14.7	8.1	2	8	1	6	4	1	1
Benin	5.6	6.2	7	8	1	3	4	1	1
Gambia	2.0	1.3	3	7	1	5	4	1	1
Burkina Faso	11.1	11.9	2	12	1	3	4	1	1
Chad	6.3	7.9	0	16	0	2	4	1	1
Mali	8.1	11.9	2	15	0	2	4	1	1
Bangladesh	196.8	138.0	4	6	1	4	4	1	1
Haiti	12.1	8.0	3	6	1	5	3	1	1
Nepal	28.6	23.5	3	9	1	4	3	1	1
Tanzania	16.6	34.8	4	12	1	1	3	1	1
Laos	7.5	5.3	1	8	0	4	3	1	1
Niger	7.4	10.7	4	8	1	2	3	1	1
Sierra Leone	1.9	4.4	7	6	1	1	3	1	1
Liberia	1.7	2.9	6	6	1	2	3	1	1
Uganda	27.3	23.5	1	8	0	4	3	1	1
Comoros	1.1	0.7	2	4	1	5	3	1	1
Tuvalu	0.0	0.0	0	0	0	7	2	1	1
Dem. Republic Congo	31.0	48.6	2	7	1	2	2	1	1
Mozambique	14.4	17.9	2	6	1	2	2	1	1
Ethiopia	42.5	65.6	2	6	0	2	2	1	1
Eritrea	2.8	3.7	5	1	1	2	2	1	1
Afghanistan	9.3	21.4	2	7	1	1	2	1	1
Rwanda	7.9	7.7	2	3	1	3	2	1	1
Malawi	6.3	11.4	3	4	1	2	2	1	1
Federated States of Micronesia	0.2	0.1	0	0	0	5	2	2	2
Marshall Islands	0.1	0.1	0	0	0	5	2	2	2
Burundi	3.5	6.3	2	3	0	2	1	1	1
Antigua & Barbuda	0.0	1.0	0	0	3	0	1	3	3
Timor-Leste (East Timor)	0.3	0.7	0	0	0	1	0	2	2

Note: the shading of the cells corresponds with the colour of the country groupings based on the calculations in Figure 4 and Figure 5. LDCs (in bold) and some developing countries (in italics) are excluded from the indexing, as we do not have data for all indicators.

Data sources: GDP: base year data from the Word Bank (2004) and UNSTAT (2005); population (UN, 2004a) and GHG emissions (CAIT: http://cait.wri.org)

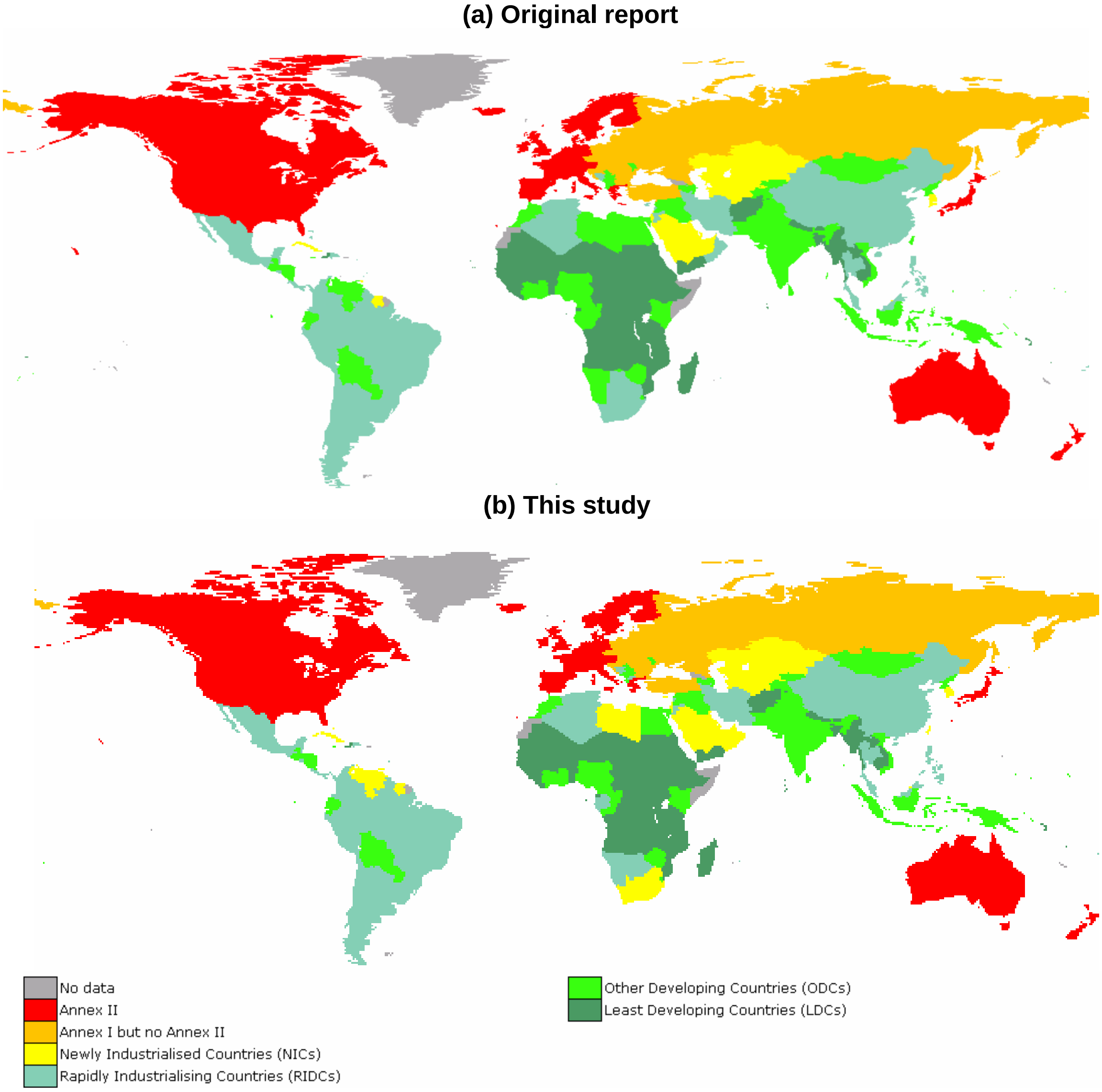


Figure 4. Membership of countries in groups (Annex II, Annex II but no Annex I, NICs, RIDCs, other DCs and LDCs) for the (a) original report, and (b) this study.

Table 4 shows how the membership of countries to the six country groups changes over time based on the average results over the six IMAGE IPCC SRES emission scenarios, assuming that the thresholds decline with 5% decline per decade. It clearly shows a gradual shift from LDCs and Other DCs to RIDCs, and finally to NICs.

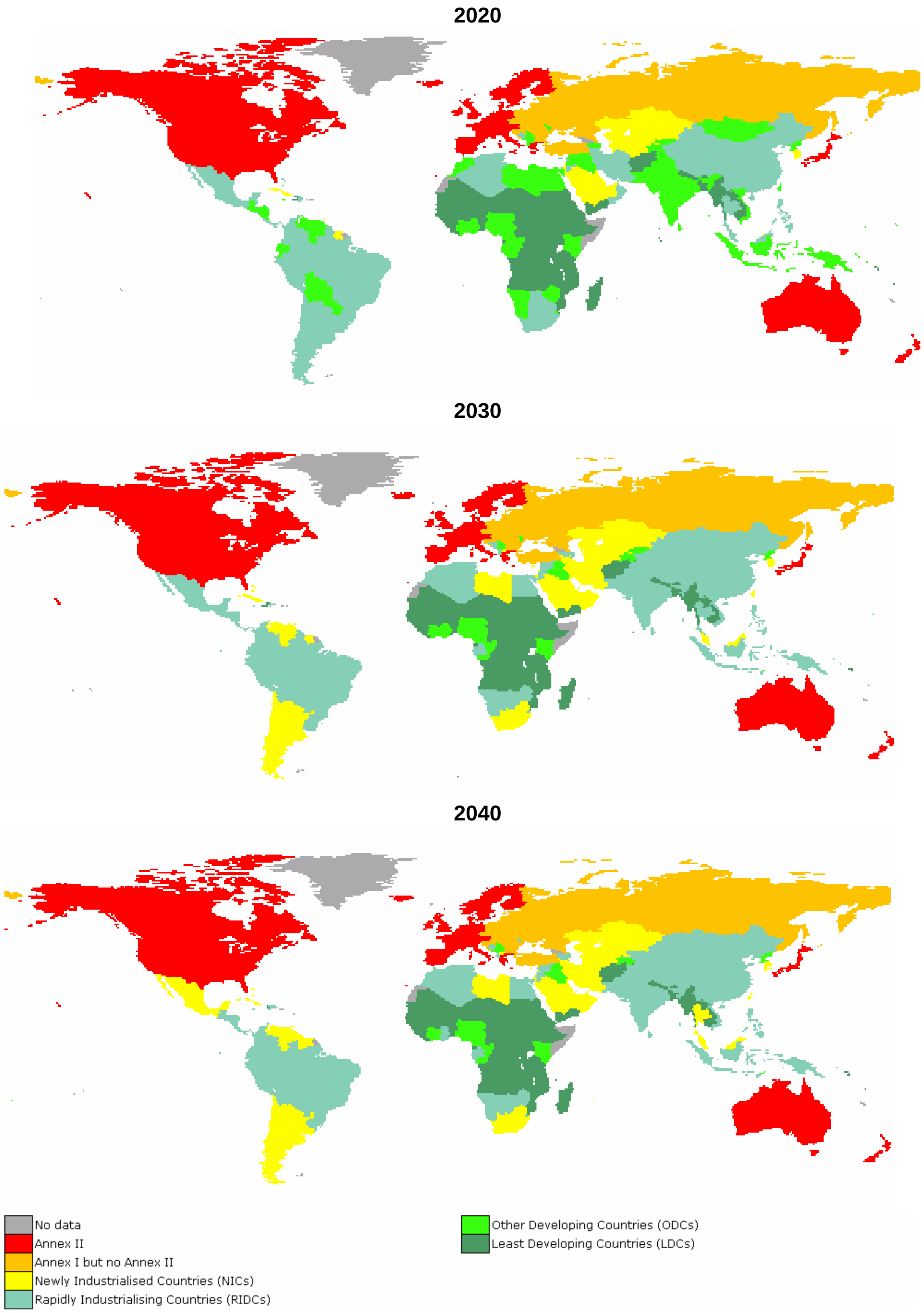


Figure 5. Membership of countries in the groups (Annex II, Annex II but no Annex I), NICs, RIDCs, other DCs and LDCs from 2020 to 2100 for the IMAGE IPCC SRES B2 scenario. After 2020, the participation threshold decreases by 5% per decade.

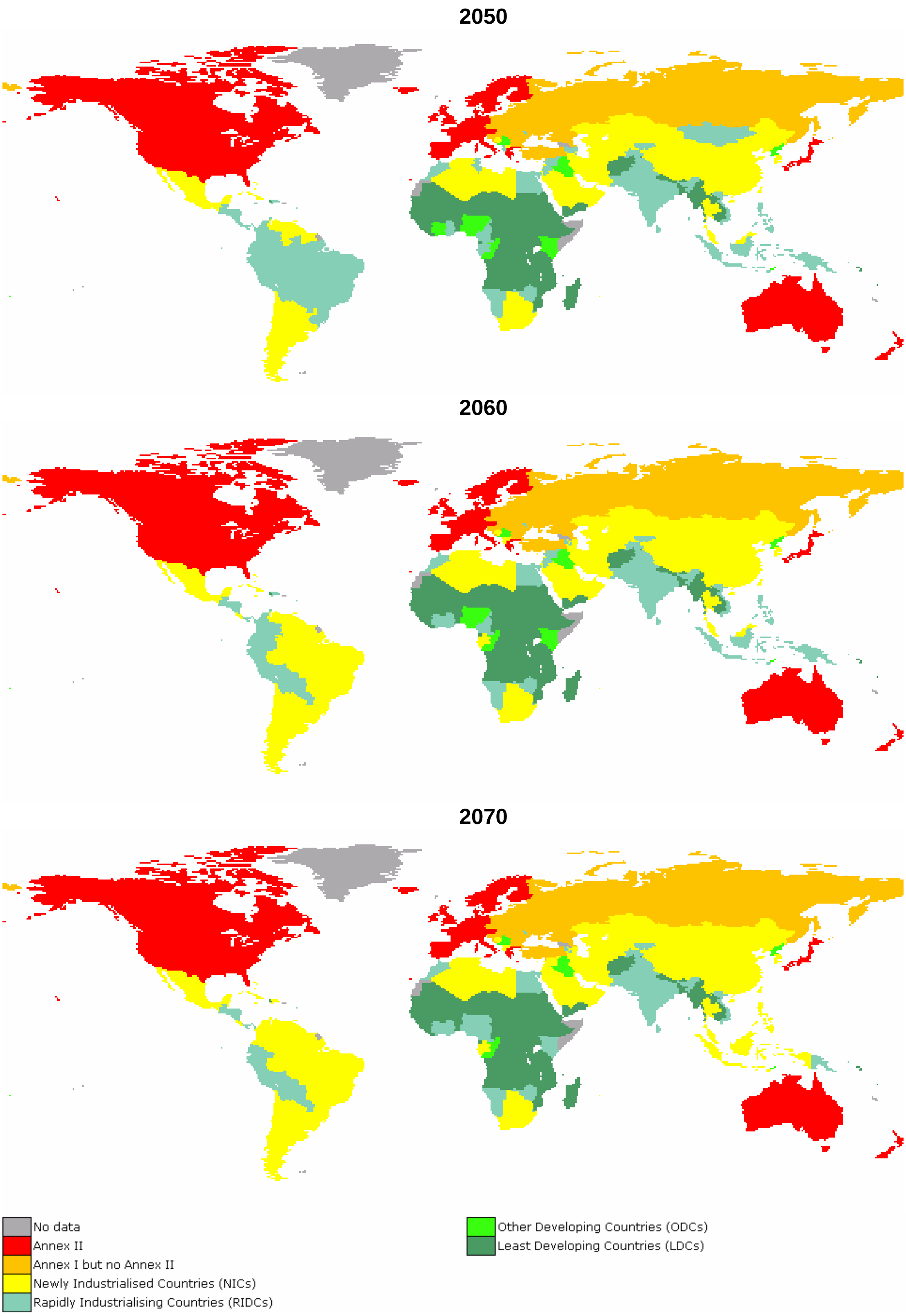


Figure 5. Continued

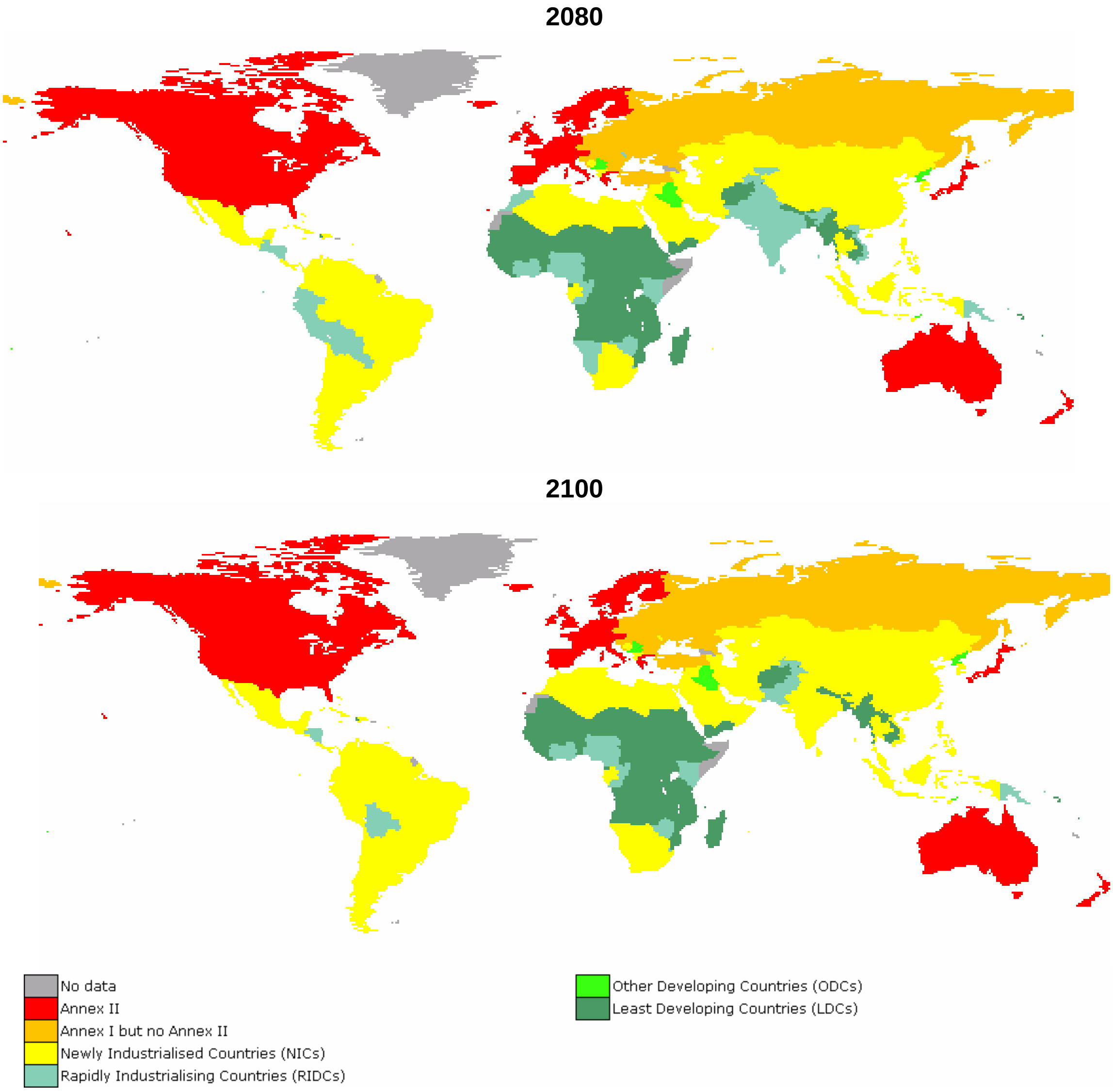


Figure 5. Continued

Table 4. Membership of countries in groups LDCs (1), other DCs (2), RIDCs (3) and NICs (4), while after 2020 the participation threshold decreases by 5% per decade.

Country	This study 2020	Original proposal 2020	2030	2040	2050	2060	2070	2080	2090	2100
Afghanistan	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Albania	2.0	2.0	2.8	3.0	3.5	3.7	3.8	3.8	3.8	3.8
Algeria	3.0	3.0	3.0	3.7	3.8	4.0	4.0	4.0	4.0	4.0
Angola	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Antigua & Barbuda	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Argentina	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Armenia	2.0	2.0	2.8	3.0	3.0	3.5	3.7	3.8	3.8	3.8
Azerbaijan	2.0	2.0	3.0	3.3	3.5	3.8	3.8	3.8	3.8	3.8
Bahamas	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Bahrain	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Bangladesh	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Barbados	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Belize	3.0	3.0	3.0	3.7	3.7	3.8	3.8	4.0	4.0	4.0
Benin	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Bhutan	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Bolivia	2.0	2.0	2.8	3.0	3.0	3.5	3.7	3.7	3.7	3.7
Bosnia & Herzegovina	3.0	3.0	3.2	3.7	4.0	4.0	4.0	4.0	4.0	4.0
Botswana	3.0	3.0	3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Brazil	3.0	3.0	3.0	3.7	3.8	4.0	4.0	4.0	4.0	4.0
Brunei	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Burkina Faso	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Burundi	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cambodia	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cameroon	2.0	2.0	2.0	2.5	2.7	3.0	3.0	3.5	3.7	3.7
Cape Verde	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Central African Republic	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Chad	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Chile	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
China	3.0	3.0	3.0	3.5	3.8	3.8	3.8	3.8	3.8	3.8
Colombia	3.0	3.0	3.0	3.3	3.7	3.7	3.8	3.8	3.8	4.0
Comoros	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Congo	2.0	2.0	2.0	2.0	2.5	2.7	2.7	2.8	2.8	3.3
Cook Islands	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Costa Rica	3.0	3.0	3.0	3.2	3.7	3.8	3.8	3.8	3.8	4.0
Côte d'Ivoire	2.0	2.0	2.0	2.5	2.7	2.8	3.2	3.5	3.7	3.7
Cuba	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Cyprus	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Dem. Republic Congo	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Djibouti	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Dominica	2.0	2.0	3.0	3.0	3.3	3.7	3.7	3.8	4.0	4.0
Dominican Republic	3.0	3.0	3.0	3.5	3.7	3.8	3.8	3.8	4.0	4.0
Ecuador	2.0	2.0	3.0	3.0	3.5	3.7	3.7	3.7	3.8	3.8
Egypt	2.0	2.0	3.0	3.0	3.3	3.7	3.7	3.8	3.8	3.8
El Salvador	3.0	3.0	3.0	3.0	3.0	3.7	3.7	3.7	3.8	3.8
Equatorial Guinea	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Eritrea	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Ethiopia	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Federated States of Micronesia	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Fiji	3.0	3.0	3.0	3.0	3.0	3.0	3.5	3.7	3.8	3.8
FYR Macedonia	2.0	2.0	3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Gabon	2.0	2.0	3.5	3.7	3.8	4.0	4.0	4.0	4.0	4.0
Gambia	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Country	This study 2020	Original proposal 2020	2030	2040	2050	2060	2070	2080	2090	2100
Georgia	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Ghana	2.0	2.0	2.0	2.0	2.7	3.0	3.0	3.5	3.7	3.7
Grenada	3.0	3.0	3.0	3.0	3.5	3.7	3.8	4.0	4.0	4.0
Guatemala	2.0	2.0	2.7	2.8	3.0	3.5	3.7	3.7	3.7	3.8
Guinea	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Guinea-Bissau	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Guyana	3.0	3.0	3.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Haiti	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Honduras	2.0	2.0	2.0	2.7	2.8	3.0	3.5	3.7	3.7	3.7
India	2.0	2.0	2.8	3.0	3.3	3.5	3.7	3.7	3.8	3.8
Indonesia	2.0	2.0	3.0	3.0	3.5	3.5	3.8	3.8	3.8	3.8
Iran	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Iraq	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Israel	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Jamaica	2.0	2.0	3.5	3.7	3.8	4.0	4.0	4.0	4.0	4.0
Jordan	3.0	3.0	3.0	3.0	3.7	3.8	3.8	3.8	3.8	3.8
Kazakhstan	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Kenya	2.0	2.0	2.0	2.0	2.7	3.0	3.5	3.5	3.8	3.8
Kiribati	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Korea (North)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Korea (South)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Kuwait	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Kyrgyzstan	2.0	2.0	2.0	2.5	2.8	2.8	3.3	3.5	3.8	3.8
Laos	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lebanon	3.0	3.0	3.3	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Lesotho	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Liberia	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Libya	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Madagascar	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Malawi	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Malaysia	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Maldives	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mali	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Malta	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Marshall Islands	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Mauritania	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mauritius	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Mexico	3.0	3.0	3.8	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Moldova	2.0	2.0	2.5	2.8	2.8	3.3	3.5	3.7	3.8	3.8
Mongolia	2.0	2.0	2.8	3.3	3.3	3.8	3.8	3.8	3.8	3.8
Morocco	2.0	2.0	2.8	3.0	3.0	3.5	3.7	3.7	3.8	3.8
Mozambique	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Myanmar	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Namibia	2.0	2.0	3.0	3.0	3.5	3.7	3.7	3.7	3.8	4.0
Nauru	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Nepal	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nicaragua	2.0	2.0	2.0	2.7	2.8	3.0	3.7	3.7	3.7	3.7
Niger	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Nigeria	2.0	2.0	2.0	2.0	2.7	2.7	2.8	3.2	3.5	3.7
Niue	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Oman	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Pakistan	2.0	2.0	2.0	2.8	2.8	3.0	3.5	3.5	3.7	3.7
Palau	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Panama	3.0	3.0	3.0	3.0	3.7	3.7	3.8	3.8	3.8	3.8
Papua New Guinea	2.0	2.0	2.0	2.0	2.7	2.8	2.8	3.0	3.5	3.5
Paraguay	2.0	2.0	3.0	3.0	3.0	3.7	3.7	3.7	3.8	3.8
Peru	3.0	3.0	3.0	3.0	3.2	3.7	3.7	3.7	3.8	3.8
Philippines	3.0	3.0	3.0	3.0	3.0	3.5	3.8	3.8	3.8	3.8
Qatar	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Rwanda	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Saint Kitts & Nevis	3.0	3.0	3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0

Country	This study 2020	Original proposal 2020	2030	2040	2050	2060	2070	2080	2090	2100
Saint Lucia	3.0	3.0	3.0	3.7	3.8	4.0	4.0	4.0	4.0	4.0
Saint Vincent & Grenadines	3.0	3.0	3.0	3.0	3.5	3.7	3.7	3.8	3.8	3.8
Samoa	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
San Marino	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Sao Tome & Principe	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Saudi Arabia	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Senegal	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Serbia & Montenegro	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Seychelles	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Sierra Leone	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Singapore	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Solomon Islands	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
South Africa	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Sri Lanka	2.0	2.0	2.7	2.8	3.0	3.5	3.7	3.7	3.8	3.8
Sudan	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Suriname	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Swaziland	2.0	2.0	2.7	3.0	3.0	3.5	3.7	3.7	3.7	3.7
Syria	2.0	2.0	3.0	3.0	3.7	3.7	3.8	3.8	3.8	3.8
Taiwan	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Tajikistan	2.0	2.0	2.0	2.0	2.5	2.8	2.8	3.3	3.5	3.8
Tanzania	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Thailand	3.0	3.0	3.3	3.8	3.8	3.8	4.0	4.0	4.0	4.0
Timor-Leste (East Timor)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Togo	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Tonga	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Trinidad & Tobago	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Tunisia	3.0	3.0	3.0	3.5	3.8	3.8	4.0	4.0	4.0	4.0
Turkmenistan	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Tuvalu	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Uganda	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
United Arab Emirates	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Uruguay	3.0	3.0	3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Uzbekistan	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Vanuatu	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Venezuela	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Vietnam	2.0	2.0	2.0	2.8	2.8	3.0	3.5	3.5	3.8	3.8
Yemen	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Zambia	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Zimbabwe	2.0	2.0	2.7	3.0	3.0	3.5	3.7	3.7	3.7	3.8

Note: numbers show the median over the six IPCC SRES scenarios.

Figure 6 shows the impact of assuming that the participation threshold declines by 20% per decade (instead of 5%) after 2020 in the membership of countries in the six country groups in 2050. This leads to a more rapid shift from LDCs and Other DCs to RIDCS, and finally to NICs (compare Figure 6a with Figure 6b). This shift is even more accelerated when assuming a baseline scenario with higher economic and emissions growth, such as the IMAGE IPCC SRES A1b scenario vs. the IMAGE IPCC SRES B2 scenario (compare Figure 6b with Figure 6c).

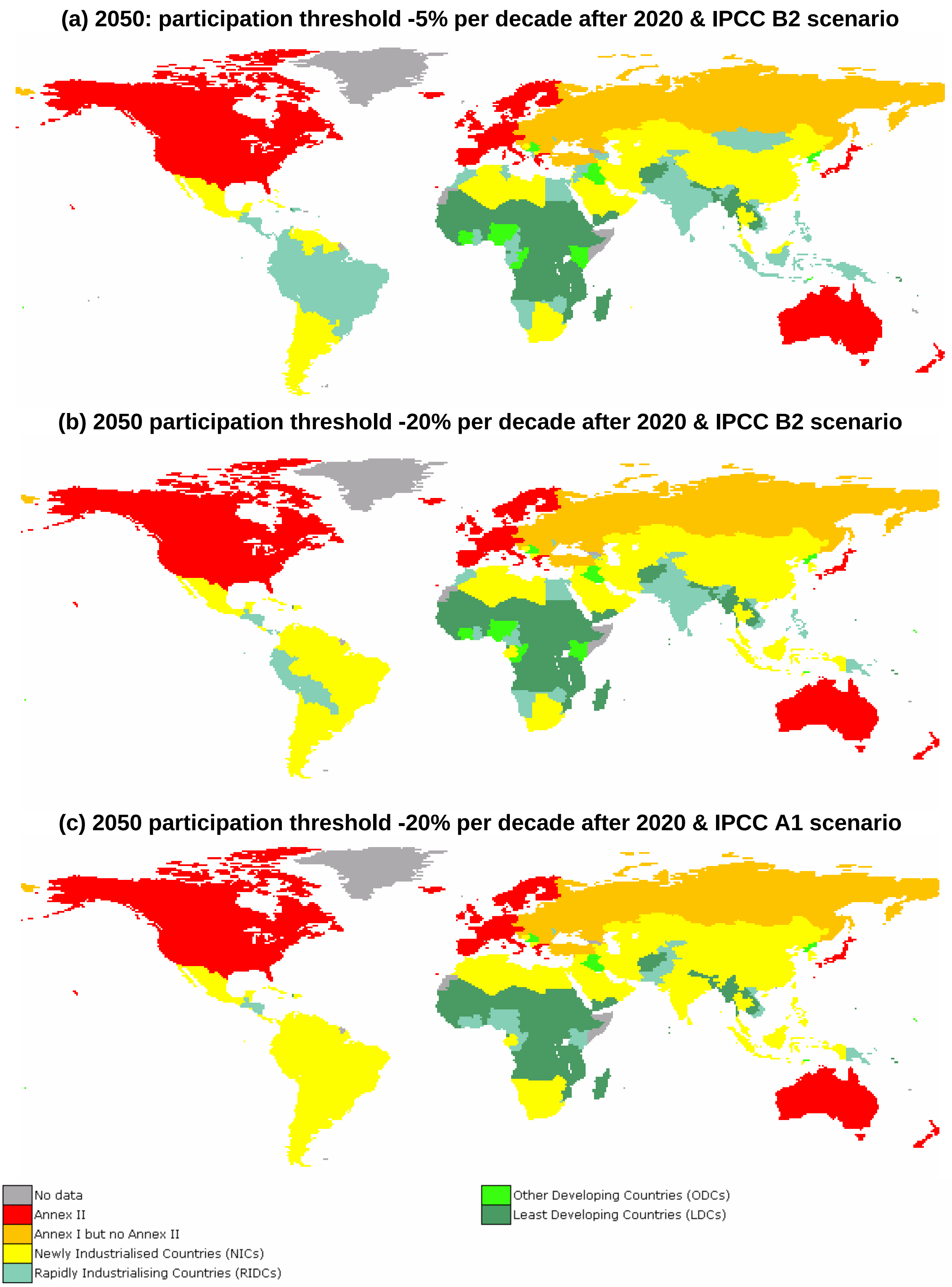


Figure 6. Impact of the reduction rate of the participation threshold and emissions scenario in membership of countries in groups in 2050: (a) -5% per decade and the IMAGE IPCC SRES B2 scenario, (b) -20% per decade and the IMAGE IPCC SRES B2 scenario and (c) -20% per decade and the IMAGE IPCC SRES A1b scenario.

4.2 Assumed reductions per country group

Similar to the study by Höhne and Ullrich (2005), this study also assumes that the different country groups, as defined by the South–North Dialogue Proposal, reduce emissions as follows:

- Annex II: first emissions decrease linearly from 2010-levels to *a*% below 1990 level in 2020, then *b*% per decade (e.g. in 2030 *b*% below 2020 level)
- Annex I but not Annex II: first emissions decrease linearly from 2010-levels to *c*% below 1990 level in 2020, then *d*% per decade
- NIC: Option 1: Reduce *e*% below baseline scenario in 2020; Option 2: Increase emissions *f*% above 2000 levels by 2020, then reduce *g*% per decade for both options
- RIDC: Reduce *h*% below baseline scenario in 2020, then stay *i*% below baseline emissions

The values for parameters *a* to *j* are reported for the political willingness scenario (section 5: Table 5) for the 400 and 450 ppm CO_2-only scenario of Höhne and Ullrich (2005) (Appendix D: Table D.1) and for four scenarios leading to stabilisation of CO_2-equivalent concentration at 400, 450, 500 and 550 ppm (section 6: Table 7). The "political willingness" scenario represents an assessment made by a number of the research institutes involved in the South–North Dialogue proposal on the emissions constraints that might be considered politically acceptable (see Chapter 5). A set of the reduction parameters (*a* to *i)* are selected for each scenario. Here, the parameters of the reference cases are chosen in such a way that the Annex I countries take the lead in the reduction efforts (defined in terms of reductions compared to the baselines), followed by Annex I but not Annex II, NICs and, finally, RIDCs. Therefore, the selected value of parameter *a* is greater than the value of *c*. Likewise, the value of parameter *b* is greater than the value of parameter *d*, which is again greater than value of parameter *g*. To cover for the uncertainty of future emissions, the calculations are based on six cases for each parameter setting, one for each IMAGE IPCC SRES scenario.

5 The political willingness scenario for 2020

Here we present the emission allowances of the "political willingness" scenario, as described in Höhne and Ullrich (2005). Assumptions on reductions for 2020 were chosen for this scenario in such a way (Table 5) as to be politically acceptable for all Parties if possible. This scenario does not make any assumption about what future emission or concentration levels should be reached, but we compare the resulting emissions levels and costs to those under long-term concentration stabilisation scenarios, which give some indication of the gap between what is required and what Parties might be willing to do. The scenario was developed by researchers from the Wuppertal Institute and Ecofys (Germany), the Energy Research Centre/University of Cape Town (South Africa) and the Netherlands Environmental Assessment Agency (The Netherlands).

Table 5. Configuration for the "political willingness" scenario (Höhne and Ullrich, 2005)

Region	Configuration	% in 2020
Annex II	EU-25[28]: reduce below 1990 level	30%
	Others: reduce below 1990 level	15%
Annex I but not Annex II	Reduce below 1990 level	20%
Newly industrialised countries (NIC)	Reduce below baseline emissions	30%
Rapidly industrialising countries RIDC)	Reduce below baseline emissions	10%
Other developing countries (Other DCs)	Follow baseline emissions	
Least developed countries (LDCs)	Follow baseline emissions	

The emission allowances for the political willingness scenario are calculated using these assumptions. In the calculations, the USA is assumed to implement its intensity targets (White-House, 2002). Annex I, but not Annex II countries, start initially with the lower edge of their Kyoto target and their reference scenario. Figure 7 shows the development of the emission allowances (before international emissions trading) of the country groups (including the USA and EU-25) compared to their 1990 levels. For Annex II countries, the basic assumption is that their overall emission targets would be 20% below 1990 levels in 2020, which is halfway between the 15-30% range for focusing the Annex I reduction target to below 1990 levels, as formulated by the European Council (2005). As the EU-25 would be able to accept a –30% target, the rest of Annex II would only have to decrease to –15% so that the Annex I as a whole would reach –20%. The USA is assumed to reach its national emission intensity target in 2010 and would have to reduce emissions drastically afterwards in order to attain the Annex II target of -20% (Figure 7a). After reaching its Kyoto target, the EU-25 would also have to accelerate its rate of reductions to attain the –30% target, which is at the lower end of the 15-30% reduction target range suggested for the industrialised countries in 2020 by the European Council in its March 2005 conclusions (European-Council, 2005).

[28] The countries belonging to both the EU-25 and Annex I, but not Annex II, aim for achievement of the EU-25 target.

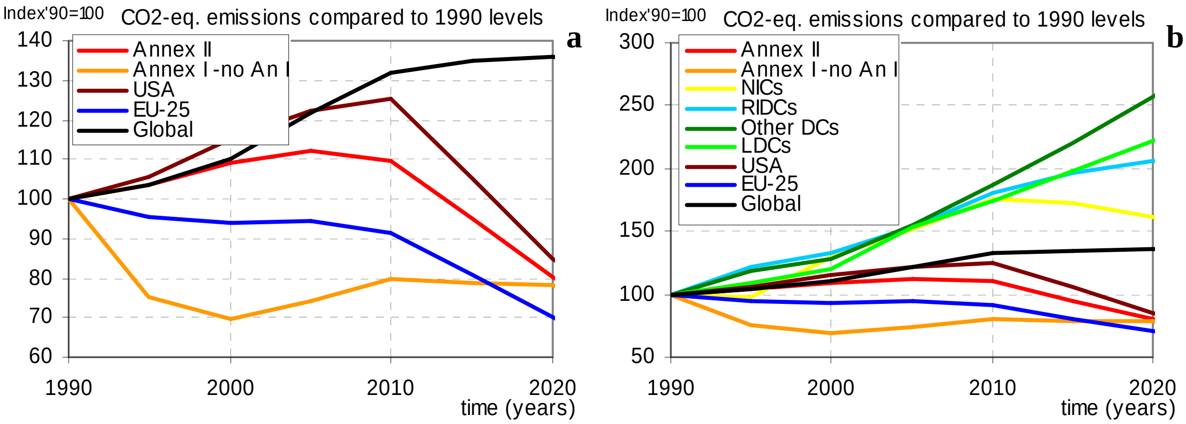


Figure 7. Change in emission allowances compared to 1990 levels under the "political willingness" scenario for the Annex II and Annex I regions (a) and the six country groups (b) for the median over the six IMAGE IPCC SRES scenarios. The results for the USA and EU-25 are also included here. The results for the Annex II and Annex I regions (a) are scenario-independent, since the Annex I, but not Annex II, countries are assumed to start with their Kyoto targets in 2010. ***Note****: the country groups is equal to the static 2020 country groups in the original proposal.*

The use of different SRES scenarios has no impact on the emission levels of the Annex II countries, since the emissions for all Annex II countries up to 2000 are based on historical emissions, while the emissions up to 2010 are prescribed by the reduction pathways according to the Kyoto targets.
The emissions of the country group "Annex I but not Annex II" dropped to about 32% below its 1990 levels in 2000 and is expected to remain 10 to 25% below its 1990 levels in 2010 (not shown here). This implies that the country group has surplus emission allowances ("hot air"), with a median value of about 20% of their baseline emission levels. After 2010 they, like Annex II countries, will have to reduce their emissions to below their baseline emissions by about 20% in 2020, but such a reduction target may be quite feasible for them to achieve, given their financial revenues coming from the surplus emission allowances (although uncertain) and Joint Implementation (JI) and International Emission Trading (IET) from the first commitment period.
RIDCs are assumed to reduce their emissions slightly below their baseline emissions and would still be allowed to increase their emissions substantially (Figure 7b). The emissions of the NICs could grow until 2010 but then would have to be reduced by 30% below baseline levels. This implies in fact a stabilisation of their emissions (Figure 8). Figure 8b shows the resulting per capita emissions for the different country groups to start to converge after 2010.

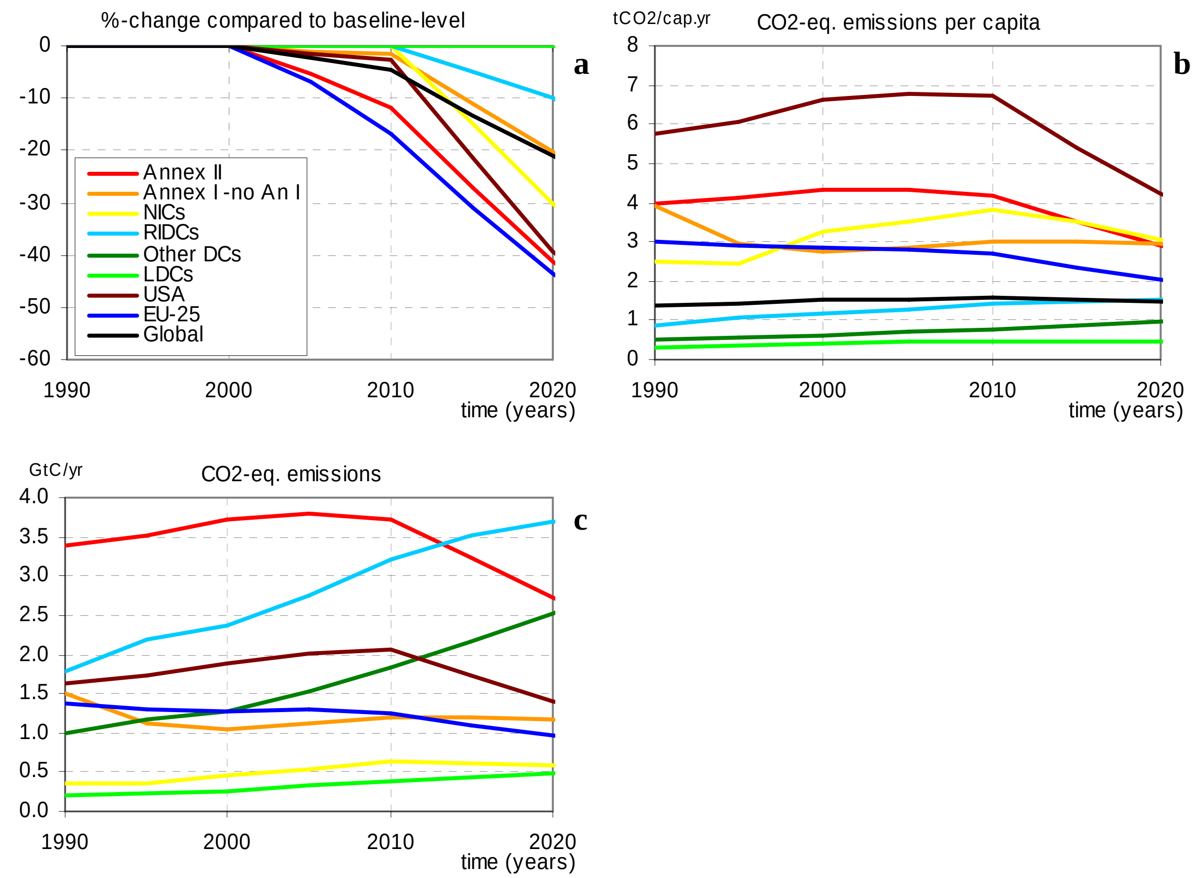


Figure 8. Change in emission allowances compared to the baseline emissions (a), per capita emissions (b) and total emissions (c) under the "political willingness" scenario for the country groups (including the USA and EU-25) for the median covering the six IMAGE IPCC SRES scenarios.

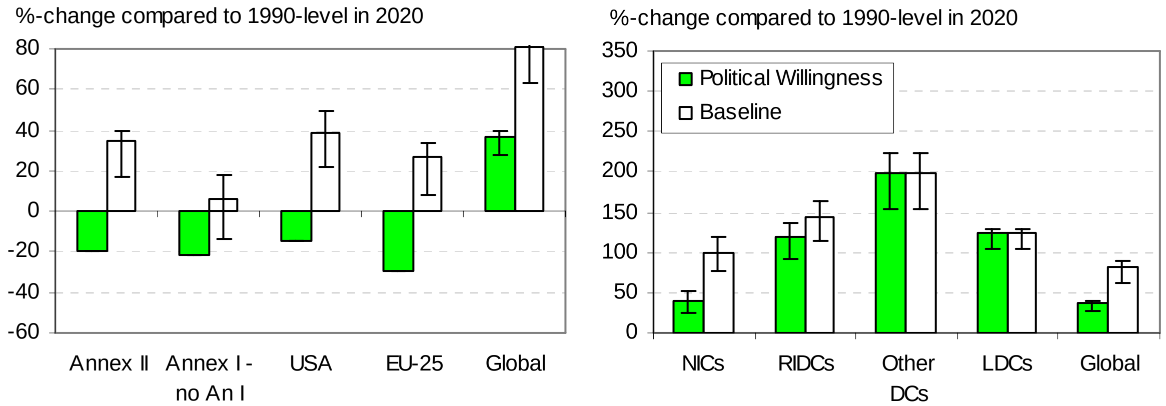


Figure 9. Change in emission allowances in 2002compared to 1990 levels under the "political willingness" scenario for the country groups (including the USA and EU-25). The bars represent the median over the six IMAGE IPCC SRES scenarios; the error bars, the full range of the different SRES scenario.

Figure 9 shows the change in both the emission allowances for the six country groups compared to the 1990 levels in 2020 and in the regional emission allowances compared to the baseline levels for regions. These also provide more information on the magnitude of effort required from the different regions (This illustrates that the Annex I countries and NICs will have to reduce emissions well below their baseline emission levels. RIDCs will only have to reduce their emissions slightly, while Other DCs and LDCs do not have to reduce emissions as they (still) do not participate.

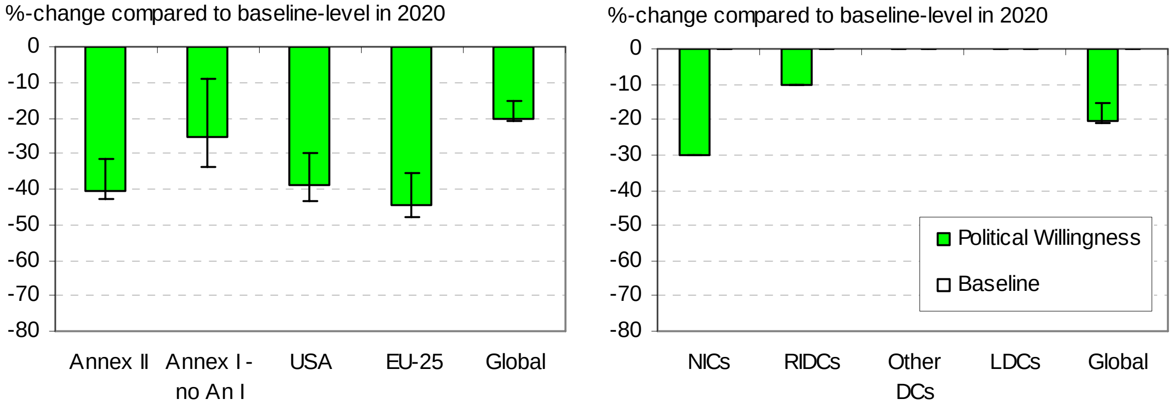


Figure 10. Same as Figure 9 but now compared to the baseline emissions.

Comparing the global emissions resulting from the "political willingness" scenario with the global emissions of the multi-gas emission pathways towards concentration stabilisation, as presented in section 2 (Figure 2), shows the emission level of the political willingness scenario in 2020 at the top of the range of the multi-gas emission pathways. In other words, the resulting level approaches near stabilisation of the CO_2-equivalent concentration at 500 ppm. However, to reach this ultimate long-term concentration stabilisation at 500 ppm, substantial reductions after 2020 are needed, as will be shown in the next section. For stabilising the CO_2-equivalent concentration at lower levels, such as 400 and 450 ppm CO_2-equivalent, global emissions already need to be lower than found in the political willingness scenario.

These higher near-term emission levels will have to be compensated for by lower future emission levels, which may require a doubling of the maximum global emission reduction rates to about 5%/year (e.g., den Elzen and Meinshausen, 2005a). Such high reduction rates will be difficult to achieve given the inertia in the energy production system and will probably lead to high costs. Therefore, it may be concluded that the political willingness scenario is likely to put stabilisation at 400 and 450 ppm CO_2-equivalent concentration levels out of reach, and therefore also unlikely to limit global mean temperature increase to 2^oC above the pre-industrial level (see section 2).

Finally, Figure 11 shows the countries' emission reduction compared to their baseline emissions (in this case, the IMAGE SRES B2 scenario) and Figure 12 the countries' per capita emissions in 2020.

%-change compared to baseline emissions in 2020

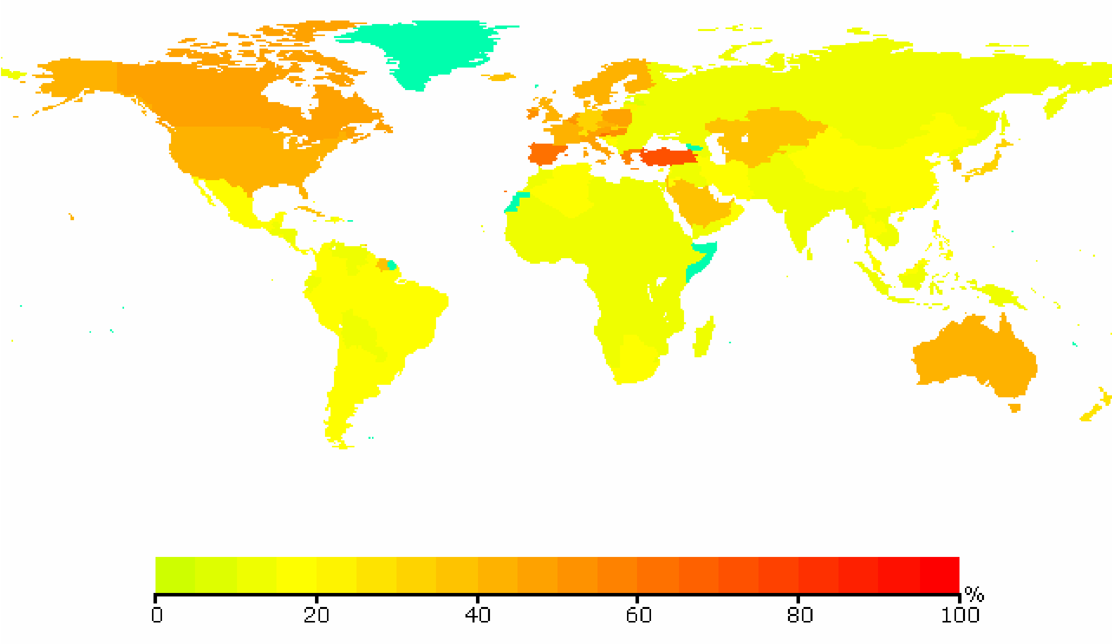


Figure 11. Countries' change in emission allowances compared to the baseline emissions under the "political willingness" scenario for the IMAGE B2 IPCC SRES scenario.

Per capita emissions in 2020

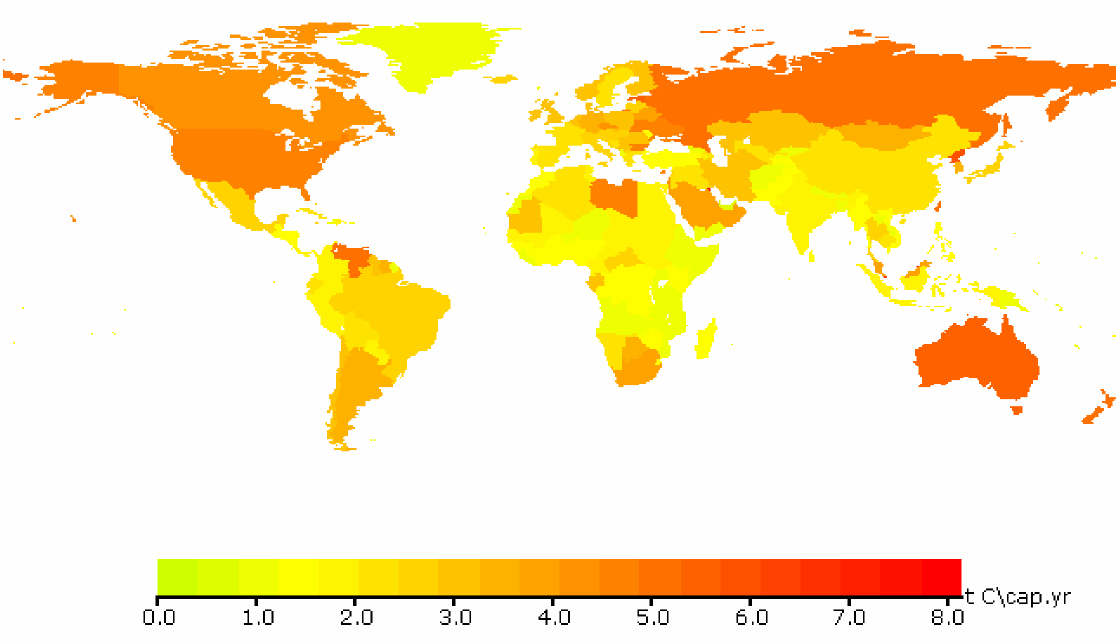


Figure 12. Countries' per capita emission allowances under the "political willingness" scenario for the IMAGE B2 IPCC SRES scenario.

Table 6. The emission allowances of countries or aggregated groups of countries[29] under the "political willingness" scenario

	1990	*2020*			
"Political willingness" scenario	1990	Baseline	Target	Relative to 1990	Relative baseline
	MtCO2eq	MtCO2eq	MtCO2eq	%	%
Annex I	17146	21186	13605	-20.7	-35.8
Non -annex I	13127	32639	29238	122.7	-10.6
World	30273	53046	42843	41.5	-20.6
01 USA	6024	8344	5121	-15.0	-38.6
02 EU15	4115	5172	2881	-30.0	-44.3
03 EU+10	908	1186	649	-28.6	-44.6
04 RWEU	103	137	88	-15.0	-35.9
05 Russian Federation	2929	2683	2344	-20.0	-12.3
06 REEU in Annex I	1415	1247	1132	-20.0	-8.7
07 Japan	1180	1499	1003	-15.0	-33.1
08 Rest of Annex I	1046	1545	889	-15.0	-42.5
09 Turkey	277	743	222	-20.0	-70.1
10 REEEU	1017	973	780	-23.3	-19.8
11 Argentina	244	638	575	135.1	-10.0
12 Brazil	682	1700	1530	124.5	-10.0
13 Mexico	432	1122	1010	133.9	-10.0
14 Venezuela	197	658	658	233.6	0.0
15 Rest of Latin America	515	1369	1235	139.9	-9.8
16 Egypt	126	436	436	245.7	0.0
17 South Africa	357	871	784	119.6	-10.0
18 Nigeria	126	405	405	221.0	0.0
19 Rest of North Africa	197	618	583	195.4	-5.7
20 Rest of Africa	661	1557	1553	135.2	-0.3
21 Saudi Arabia	194	729	510	163.3	-30.0
22 United Arab Emirates	65	236	165	156.5	-30.0
23 Rest of Middle East	571	1948	1706	198.5	-12.5
24 China	3707	8442	7598	105.0	-10.0
25 India	1316	4312	4312	227.5	0.0
26 Indonesia	330	1147	1147	247.8	0.0
27 Korea (South)	252	981	686	172.7	-30.0
28 Malaysia	89	391	352	294.8	-10.0
29 Philippines	90	292	263	191.4	-10.0
30 Singapore	31	148	104	231.0	-30.0
31 Thailand	174	560	504	189.4	-10.0
32 Rest of Asia	1037	2360	2355	127.1	-0.2

Note: numbers show the median over the six IPCC SRES scenarios.
Source: FAIR 2.1 world model

[29] **02 EU15, Old EU Member states:** Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom; **03 EU+10, New EU Member states:** Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia; **04 RWEU (Rest of Western Europe):** Iceland, Liechtenstein, Monaco, Norway, San Marino, Switzerland; **06 REEU (Rest of Eastern Europe in Annex I):** Belarus, Bulgaria, Croatia, Romania, Ukraine; **08 Rest of Annex I:** Australia, Canada, New Zealand; **10 REEU (Rest of former soviet states):** Albania, Armenia, Azerbaijan, Belarus, Bosnia & Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, FYR Macedonia, Moldova, Serbia & Montenegro, Tajikistan, Turkmenistan, Uzbekistan; **15 Rest of Latin America:** Bahamas, Barbados, Belize, Bolivia, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Saint Kitts & Nevis, Saint Lucia, Saint Vincent & Grenadines, Suriname, Trinidad & Tobago, Uruguay; **19 Rest of North Africa:** Algeria, Libya, Morocco, Tunisia; **20 Rest of Africa:** Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Dem. Republic Congo, Côte d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Rwanda, Sao Tome & Principe, Senegal, Seychelles, Sierra Leone, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe; **23 Rest of Middle East:** Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Syria, Yemen; **24 Rest of Asia:** Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia, Cook Islands, Fiji, Kiribati, Korea (North), Laos, Maldives, Marshall Islands, Federated States of Micronesia, Mongolia, Myanmar, Nauru, Nepal, Niue, Pakistan, Palau, Papua New Guinea, Samoa, Solomon Islands, Sri Lanka, Taiwan, Timor-Leste (East Timor), Tonga, Tuvalu, Vanuatu, Vietnam.

Main findings

- The political willingness scenario assumes that the overall Annex I emissions drop 20% below the 1990 level in 2020. Under the condition that the EU-25 emissions drops 30% below the 1990 level in 2020, the USA will need to drop its emissions 15% below the 1990 level in 2020 to achieve the overall Annex I target. Its national target in 2010 could take US emissions to about 20% above 1990 levels in 2010.
- After reaching its Kyoto reduction target, the EU-25 will have to accelerate its rate of reduction to reach the –30% reduction compared to their 1990 levels in 2020.
- The country group of "Annex I but not Annex II" may benefit from their surplus emission allowances (about 20% of their baseline emissions) up to 2010, but after 2010 they will also have to reduce their emissions compared to their baseline emissions by about 20% in 2020.
- The emissions of the NICs could grow until 2010 but then would have to drop by 30% below baseline emission levels, which in fact would mean a stabilisation from 2010 to 2020.
- RIDCs are assumed to reduce emissions slightly below baseline emissions and would still allow emissions to grow substantially (Figure 9).

With the "political willingness" scenario, stabilisation of CO_2-equivalent concentration at 500 ppm (about 425-450 ppm CO_2 only) is possible if followed by substantial reductions after 2020. However, for this scenario, the option of continuing to stabilise the CO_2-equivalent concentration at 400 and 450 ppm CO_2-equivalent becomes very difficult, as this would require a doubling of the maximum reduction rates to about 5% per year, and very likely lead to high costs. Therefore, it seems unlikely that the "political willingness" scenario would adequately limit the global mean temperature increase to 2^{o}C above the pre-industrial level.

6 The implications of the South–North dialogue proposal for long-term concentration stabilisation scenarios

This section analyses the implications of the South–North Dialogue proposal for differentiating future (post-2012) commitments for four scenarios leading to stabilisation of CO_2-equivalent concentration at 400, 450, 500 and 550 ppm. First, the implications for the allocation of emission allowances is explored, followed by an (preliminary) analysis of the distribution of costs among the various country groups of the proposal.

6.1 Emission allowances

Here the FAIR 2.1 world model is used to tune the reduction parameters in such a way that the reductions required of different country groups meet the global emissions ceiling of the pathways for the various CO_2-equivalent concentration stabilisation levels. This is done in such a way, that the Annex I countries take the lead in the level of reduction from the baselines, followed by Annex I but not Annex II, the NICs and, finally, the RIDCs. More specifically, the reduction percentages in Table 7 are chosen such that the median of the global emission level over the six cases for the different SRES scenarios reaches the prescribed global total CO_2-equivalent emissions targets, as described in Figure 2.

Table 7. Configuration for the long-term CO_2-equivalent concentration stabilisation scenarios at 400, 450, 500 and 550 ppm CO_2-equivalent.

Region	Configuration	Year	400 ppm	450 ppm	500 ppm*	550 ppm
Annex II	EU-25: reduced below 1990 level	in 2020	40%	35%	30%	25%
	Others: reduced below 1990 level	in 2020	33%	24%	15%	10%
	Reduction after 2020	per decade	43%	38%	33%	30%
Annex I but not Annex II	Reduced below 1990 level	in 2020	28%	24%	20%	20%
	Reduction after 2020	per decade	40%	34%	27%	25%
Newly industrialised countries (NIC)	Reduced below baseline scenario	in 2020	30%	30%	30%	20%
	Reduction after 2020	per decade	32%	25%	20%	17%
	Reduced threshold NIC-RIDC	per decade after 2020	20%	15%	10%	5%
Rapidly industrialising countries (RIDC)	Reduced below baseline scenario	in 2020	16%	13%	10%	10%
	Reduction below baseline scenario	after 2020	55%	45%	30%	25%
	Reduce threshold RIDC-Other DC	per decade after 2020	30%	20%	10%	5%
Other developing countries (Other DCs)	Follow baseline scenario					
Least developed countries (LDCs)	Follow baseline scenario					

* Up to 2020 the same assumptions as for the political willingness scenario

This study adopts reductions relative to baseline emissions for the NICs for 2020 (option 2 in section 4.2), instead of the absolute limitation targets. As found in Chapter 5, the 2020 reduction settings of the political willingness scenario are also used for the 500 ppm CO_2-eq. scenario. The 2020 reduction settings for the 450 ppm CO_2-eq. scenario are now found somewhere in between, and less stringent targets for the Annex II, Annex I and NICs are assumed for the 550 ppm CO_2-eq. scenario. The (beyond 2020) reduction parameter settings of the 400 ppm CO_2-equivalent scenario are based on those of the 400 ppm CO_2-only scenario of Höhne and Ullrich (2005). The latter was a result of an analysis of their

400 and 450 ppm CO_2-only concentration stabilisation scenarios, as described in Appendix D. The 400 ppm CO_2-only scenario leads to emission reduction targets in the order of -45% compared to 1990 levels in 2050, which corresponds with the 2050 target of the 400 ppm CO_2-eq. scenario. The reduction parameters for the other CO_2-equivalent concentration scenarios beyond 2020 were based on a tuning procedure, as described above.
Figure 13 shows the emission allowances for the four scenarios compared to the 1990 levels of the country groups. Figure 14 shows the emission allowances compared to the baseline emission levels so as to provide better insight into the reduction effort. Figure 15 gives the development compared to the baseline and 1990 emission levels over time (1990-2050) for three example scenarios (400, 450 and 550 ppm CO_2-eq.). This figure also gives the total and per capita emission levels over time.

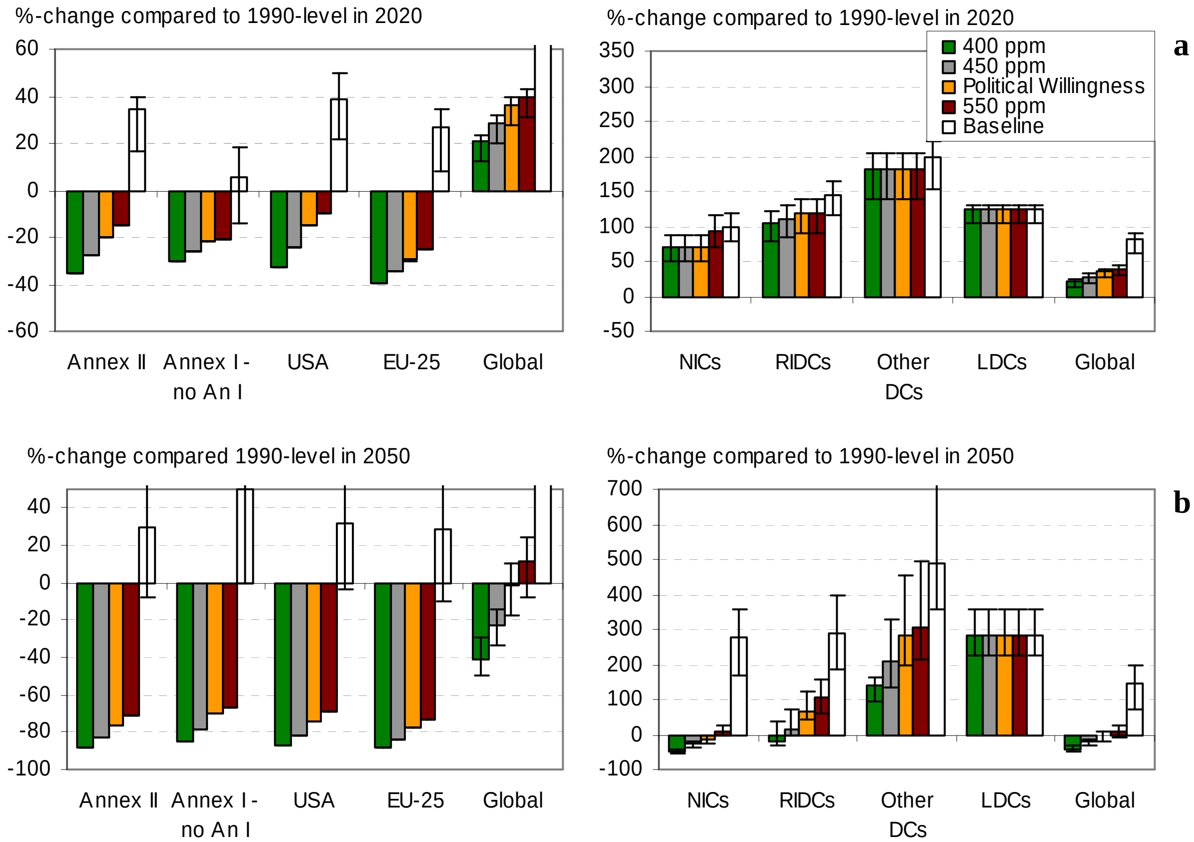


Figure 13. Change in emission allowances compared to 1990 levels in 2020 (a) and 2050 (b) under the 400,450, 500 (Political Willingness) and 550 ppm CO_2-equivalent ppm scenario compared to the baseline emissions for the country groups (including the USA and EU-25). The bars represent the median over the six IMAGE IPCC SRES scenarios, while the error bars are the full range of the scenarios.

Short-term (2020) – As expected, for the 400 and 450 ppm CO_2-eq. scenario, the Annex I and Annex II countries have to reduce more than under the political willingness scenario (here: 500 ppm CO_2-eq. scenario). Under the 550 ppm CO_2-eq. scenario the reductions are much less stringent than under the political willingness scenario. The NICs and RIDCs show reductions from their baselines, similar to those under the political willingness scenario.
Long-term (2050) – After 2020, the Annex I and Annex II emission allowances need to be reduced to levels in the order of 65% (550 ppm) and 85% (400 ppm) below 1990 levels. The reductions compared to the baseline levels are about 10% higher. The NICs are allowed to have their emissions increase until 2010, but then would need to stabilise their

emissions by 2020 for the 550 ppm CO_2-eq. scenario (Figure 15) and would already need to start to reduce their emissions for the 400 ppm CO_2-eq. scenario.

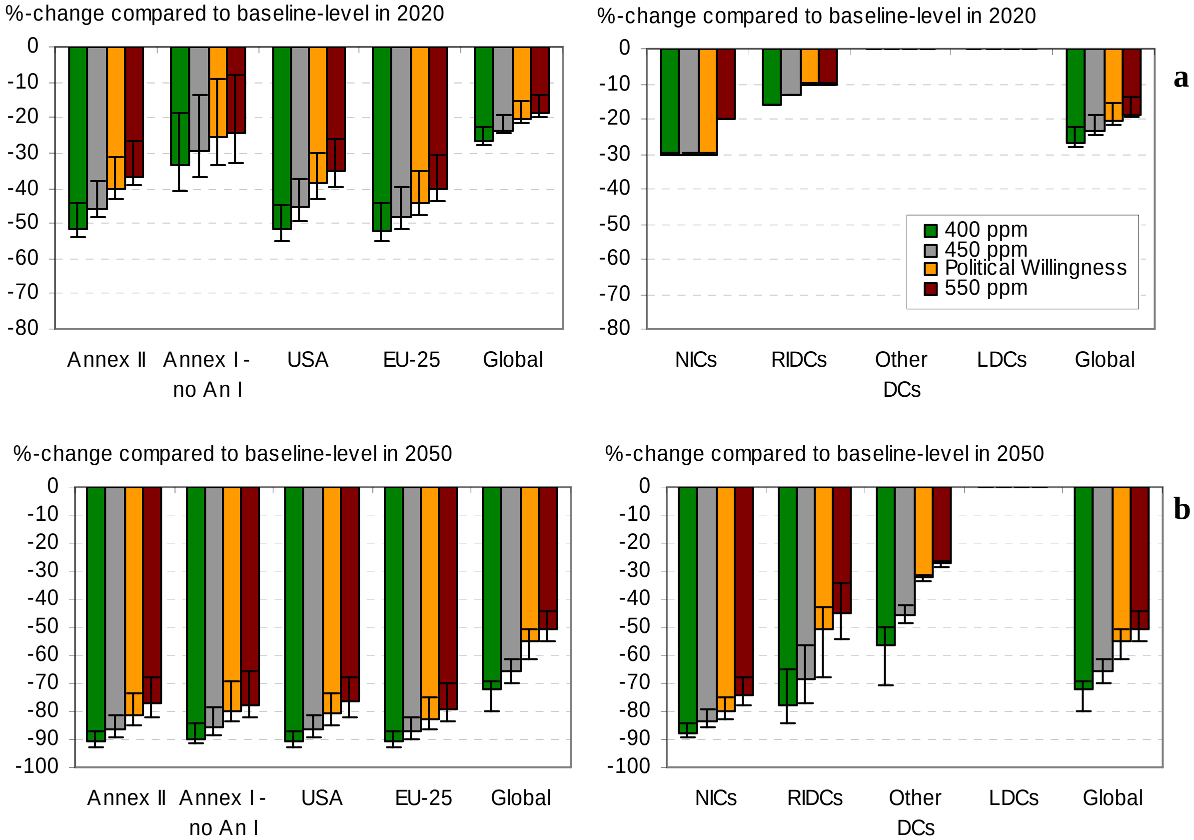


Figure 14. Same as Figure 13, but now compared to the baseline emissions.

The RIDCs are assumed to reduce emissions slightly below baseline levels. But Figure 15 (see also Figure 6) shows the group of countries that are RIDCs in 2000 to change rapidly over time for the 400 ppm CO_2-eq. scenario. After 2020 many RIDCs move to the group of NICs and would have to reduce emissions by 30% per decade. Something similar happens for the 450 ppm CO_2-eq. scenario (Figure 15), whereas for the 500 and 550 ppm CO_2-eq. scenario this change is less abrupt (see also Figure 5). For the 550 ppm CO_2-eq. scenario, RIDCs' emissions may even increase compared to the 1990 levels. This can also be seen on a more detailed level for countries in Figure 16 and 17. The per capita emission levels do converge in time (Figure 15), a process which is somewhat faster for the lower concentration levels. However, even under this stringent concentration target, there are still differences in the per capita emission levels on a country level, as given in Figure 18.

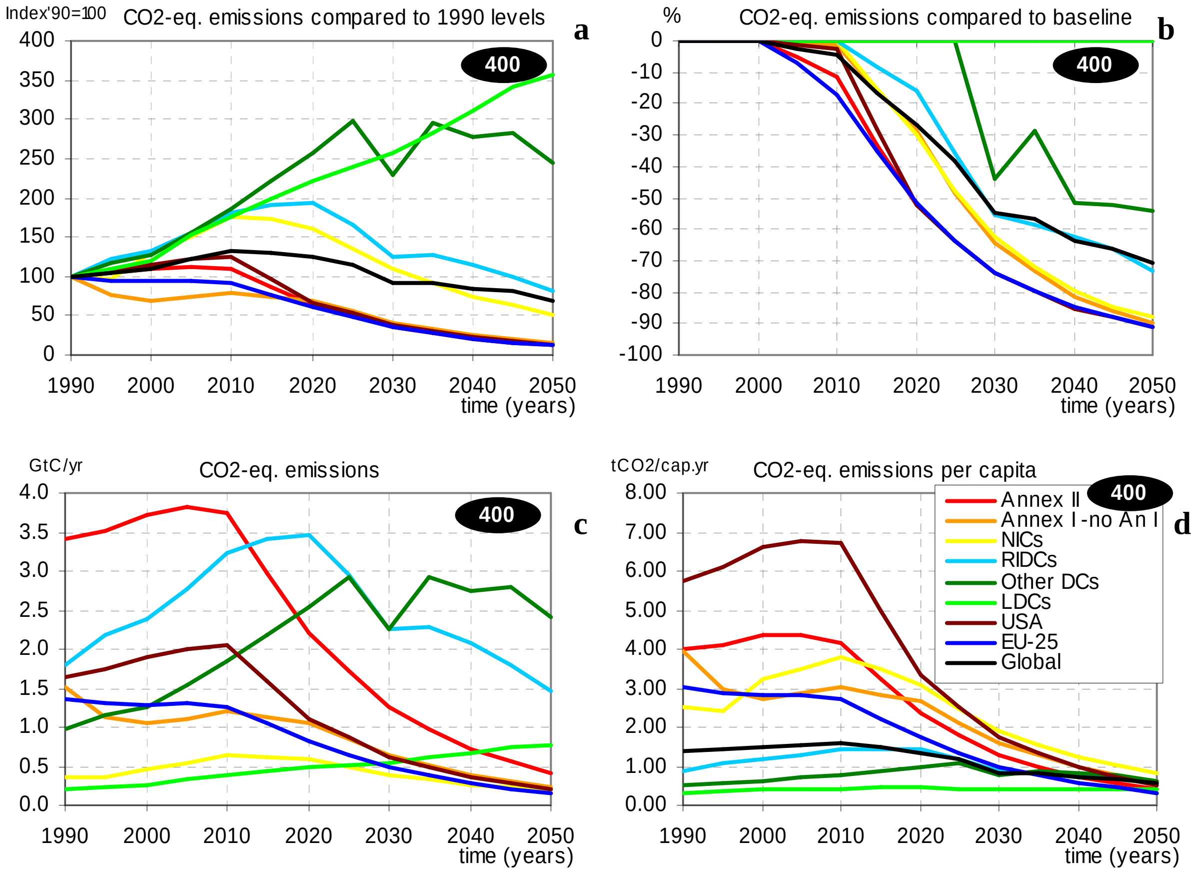


Figure 15. Change in emission allowances compared to the 1990 levels (a), baseline emissions (b) total emissions (c) and per capita emissions (d) under the 400 ppm (upper four figures), 450 ppm (medium four figures) and 550 ppm CO_2-equivalent scenario (lower four figures) for the country groups (including the USA and EU-25) for the median over the six IMAGE IPCC SRES scenarios.

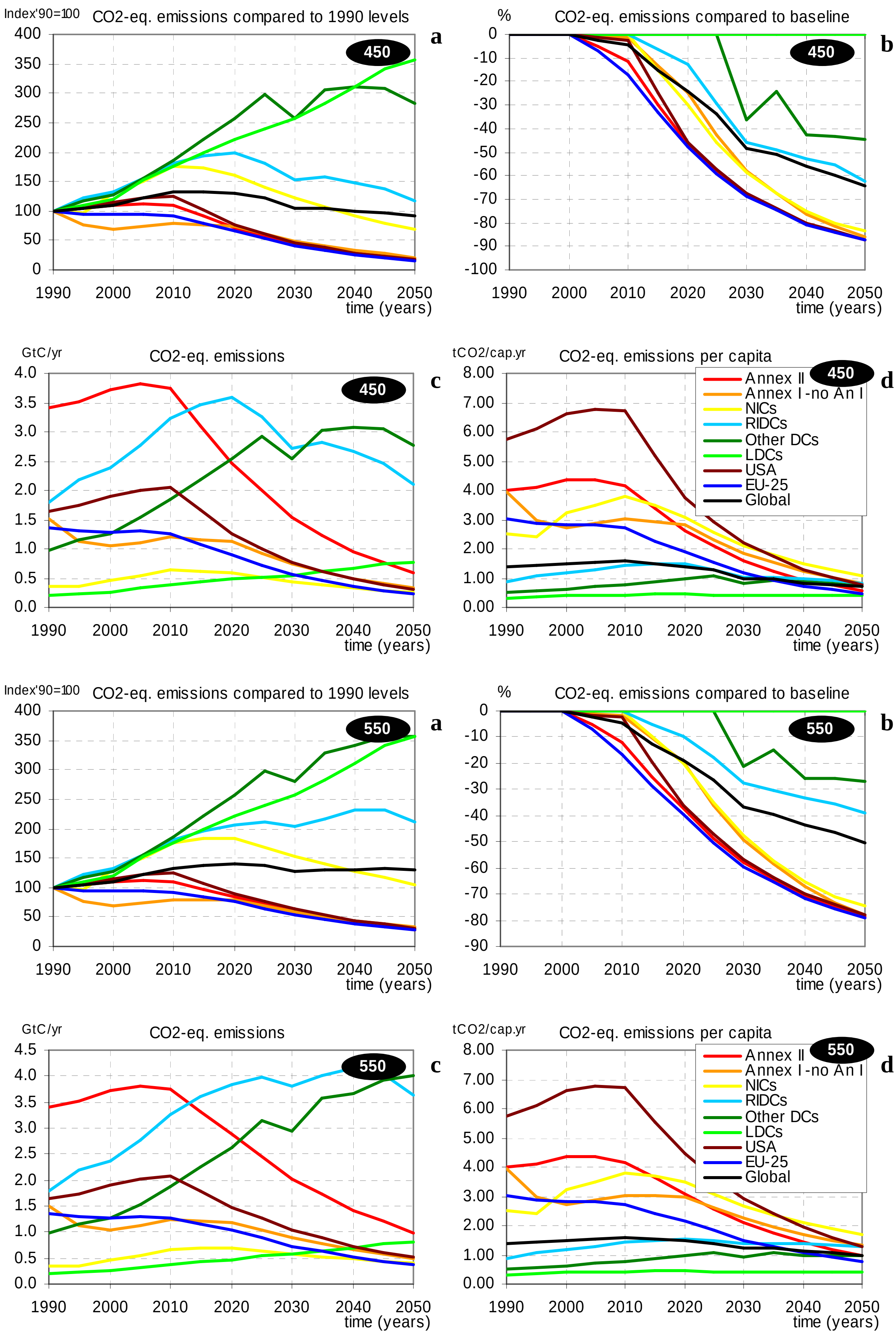


Figure 15. Continued

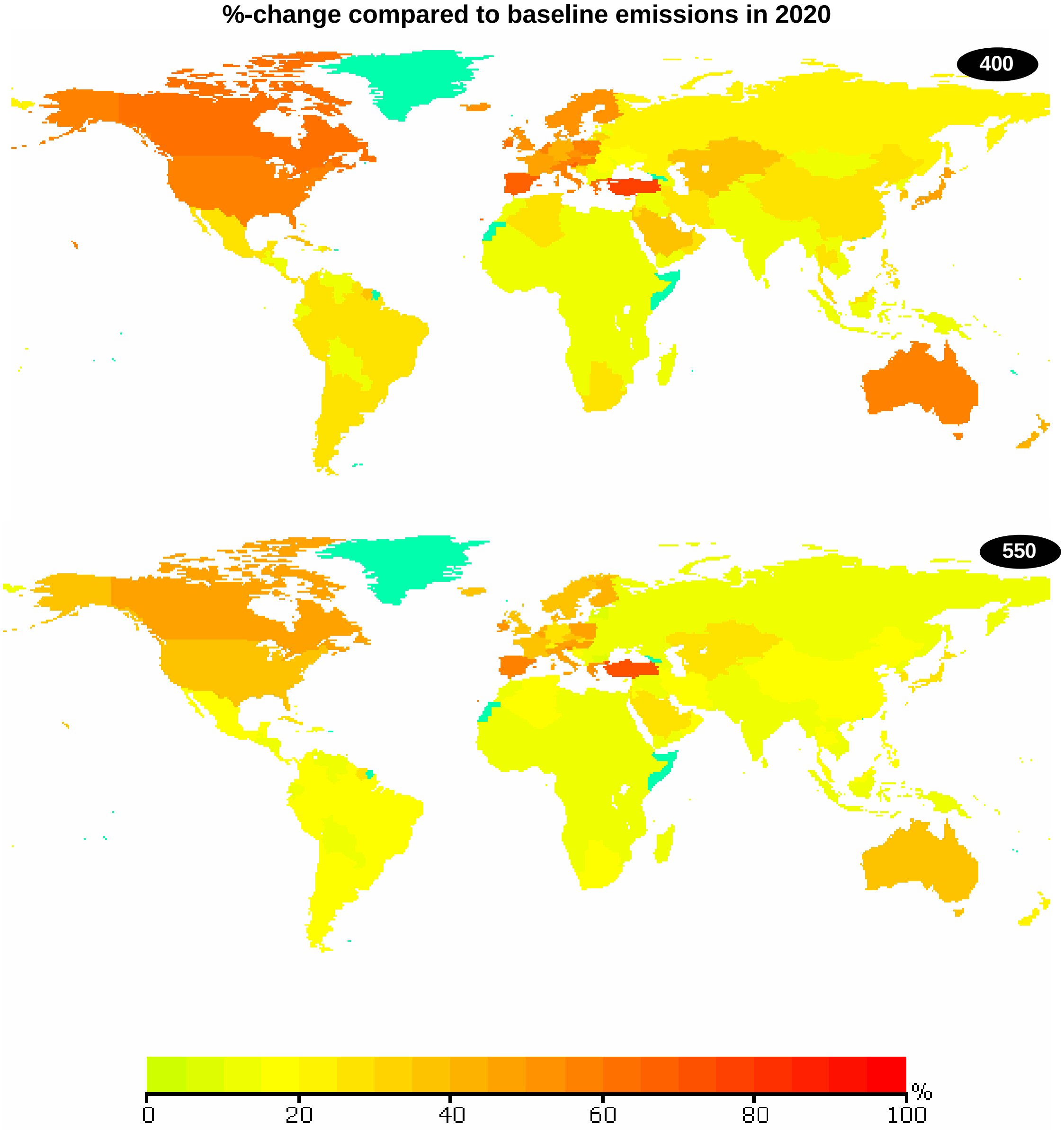


Figure 16. Countries' change in emission allowances compared to the baseline emissions under the 400 ppm CO_2-eq. (upper) and 550 ppm CO_2-eq. (upper) scenario for the IMAGE B2 IPCC SRES scenario in 2020.

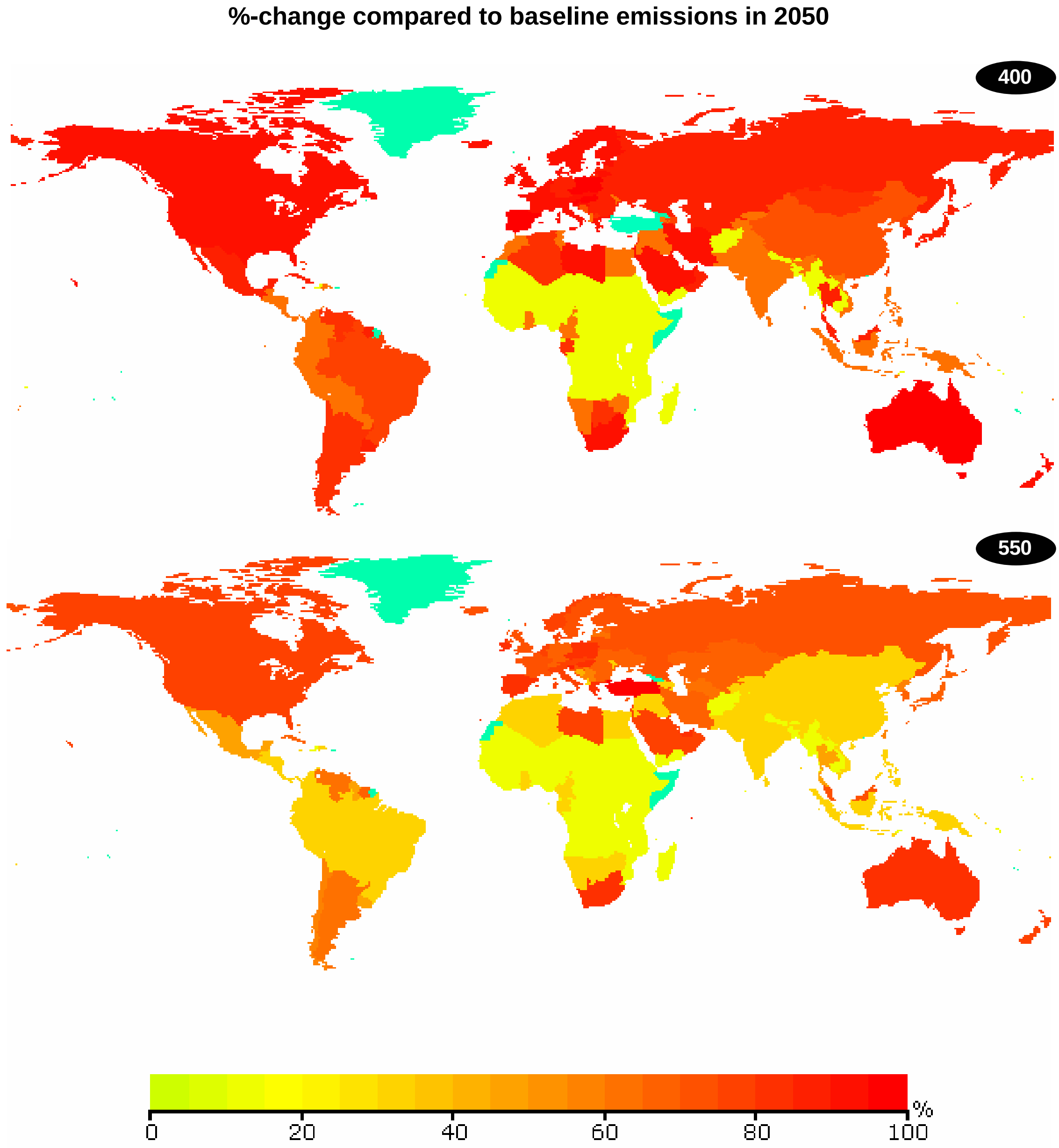


Figure 17. Same as Figure 16, but for 2050.

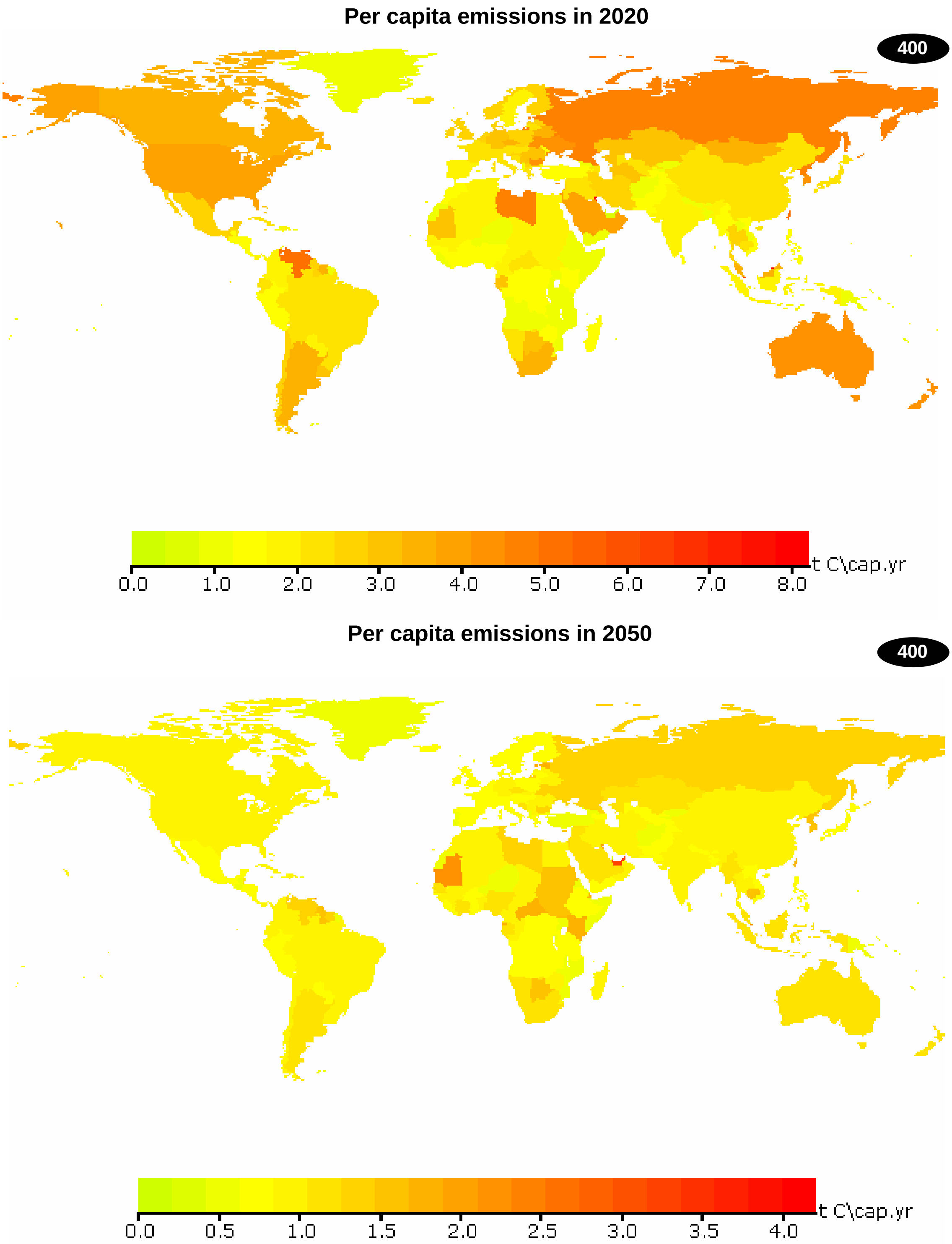


Figure 18. Country per capita emission allowances under the 400 ppm scenario for the IMAGE B2 IPCC SRES scenario in 2020 (upper) and 2050 (lower).

*Table 8. The emission allowances of countries or aggregated groups of countries[30] under the **400, 450, 500 and 550 ppm** scenarios*

	1990	2020				2050			
400 ppm	1990	Baseline	Target	Relative to 1990	Relative baseline	Baseline	Target	Relative to 1990	Relative baseline
	MtCO2eq	MtCO2eq	MtCO2eq	%	%	MtCO2eq	MtCO2eq	%	%
Annex I	17146	21206	11354	-33.8	-46.5	22533	2218	-87.1	-90.1
Non Annex I	13127	32595	28117	114.2	-13.9	56596	17958	36.8	-66.6
World	30273	52981	39471	30.4	-26.7	79588	20177	-33.4	-72.3
01 USA	6024	8344	4036	-33.0	-51.6	7957	747	-87.6	-90.6
02 EU15	4115	5176	2469	-40.0	-52.3	5032	457	-88.9	-90.9
03 EU+10	908	1186	557	-38.6	-52.4	1409	122	-86.6	-91.3
04 RWEU	103	137	69	-33.0	-49.5	136	13	-87.6	-90.6
05 Russian Federation	2929	2680	2109	-28.0	-21.0	3807	456	-84.4	-88.0
06 REEU in Annex I	1415	1245	1019	-28.0	-17.7	1624	220	-84.4	-86.4
07 Japan	1180	1506	791	-33.0	-47.5	1343	146	-87.6	-89.0
08 Rest of Annex I	1046	1545	701	-33.0	-54.6	1521	130	-87.6	-91.4
09 Turkey	277	742	200	-28.0	-73.1	1503	43	-84.4	-97.1
10 REEEU	1017	975	768	-24.5	-21.2	1323	268	-73.6	-79.1
11 Argentina	244	638	536	119.4	-16.0	976	169	-31.0	-82.4
12 Brazil	682	1696	1425	109.1	-16.0	2759	490	-28.2	-81.5
13 Mexico	432	1120	941	117.8	-16.0	1811	289	-33.1	-83.7
14 Venezuela	197	657	657	233.4	0.0	964	207	4.8	-77.9
15 Rest of Latin America	515	1368	1182	129.5	-13.7	2099	639	24.1	-68.8
16 Egypt	126	435	435	245.5	0.0	1141	333	164.4	-64.4
17 South Africa	357	860	723	102.5	-16.0	2236	227	-36.3	-90.0
18 Nigeria	126	405	405	220.9	0.0	966	966	665.4	0.0
19 Rest North Africa	197	617	561	184.5	-9.1	1546	348	76.5	-74.8
20 Rest of Africa	661	1557	1551	134.8	-0.4	3021	2567	288.6	-20.2
21 Saudi Arabia	194	731	512	163.9	-30.0	1608	161	-17.0	-90.0
22 United Arab Emirates	65	237	166	156.7	-30.0	545	52	-19.3	-90.4
23 Rest of Middle East	571	1946	1638	186.7	-15.8	4136	720	26.0	-80.1
24 China	3707	8438	7088	91.2	-16.0	10730	2385	-35.7	-73.1
25 India	1316	4308	4308	227.2	0.0	9497	3398	158.1	-55.0
26 Indonesia	330	1146	1146	247.4	0.0	1723	634	92.1	-62.8
27 Korea (South)	252	982	687	172.9	-30.0	1325	216	-14.2	-84.7
28 Malaysia	89	392	329	269.5	-16.0	648	104	16.2	-85.2
29 Philippines	90	292	245	172.3	-16.0	479	216	139.1	-55.0
30 Singapore	31	148	103	230.8	-30.0	279	33	4.0	-89.0
31 Thailand	174	559	470	169.8	-16.0	920	174	-0.3	-83.3
32 Rest of Asia	1037	2365	2359	127.5	-0.3	3651	2155	107.9	-47.1

Source: FAIR 2.1 world model

[30] **02 EU15, Old EU Member states:** Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom; **03 EU+10, New EU Member states:** Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia; **04 RWEU (Rest of Western Europe):** Iceland, Liechtenstein, Monaco, Norway, San Marino, Switzerland; **06 REEU (Rest of Eastern Europe in Annex I):** Belarus, Bulgaria, Croatia, Romania, Ukraine; **08 Rest of Annex I:** Australia, Canada, New Zealand; **10 REEU (Rest of former soviet states):** Albania, Armenia, Azerbaijan, Belarus, Bosnia & Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, FYR Macedonia, Moldova, Serbia & Montenegro, Tajikistan, Turkmenistan, Uzbekistan; **15 Rest of Latin America:** Bahamas, Barbados, Belize, Bolivia, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Saint Kitts & Nevis, Saint Lucia, Saint Vincent & Grenadines, Suriname, Trinidad & Tobago, Uruguay; **19 Rest of North Africa:** Algeria, Libya, Morocco, Tunisia; **20 Rest of Africa:** Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Dem. Republic Congo, Côte d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Rwanda, Sao Tome & Principe, Senegal, Seychelles, Sierra Leone, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe; **23 Rest of Middle East:** Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Syria, Yemen; **24 Rest of Asia:** Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia, Cook Islands, Fiji, Kiribati, Korea (North), Laos, Maldives, Marshall Islands, Federated States of Micronesia, Mongolia, Myanmar, Nauru, Nepal, Niue, Pakistan, Palau, Papua New Guinea, Samoa, Solomon Islands, Sri Lanka, Taiwan, Timor-Leste (East Timor), Tonga, Tuvalu, Vanuatu, Vietnam.

Table 8. Continued

450 ppm	1990	2020				2050			
	1990	Baseline	Target	Relative to 1990	Relative baseline	Baseline	Target	Relative to 1990	Relative baseline
	MtCO2eq	MtCO2eq	MtCO2eq	%	%	MtCO2eq	MtCO2eq	%	%
Annex I	17146	21206	12480	-27.2	-41.2	22533	3168	-81.5	-85.9
Non Annex I	13127	32595	28657	118.3	-12.3	56596	24336	85.4	-57.8
World	30273	52981	41137	35.9	-23.7	79588	27504	-9.1	-65.4
01 USA	6024	8344	4578	-24.0	-45.1	7957	1091	-81.9	-86.2
02 EU15	4115	5176	2675	-35.0	-48.3	5032	638	-84.5	-87.3
03 EU+10	908	1186	603	-33.6	-48.5	1409	176	-80.7	-87.5
04 RWEU	103	137	79	-24.0	-42.8	136	19	-81.9	-86.3
05 Russian Federation	2929	2680	2226	-24.0	-16.6	3807	640	-78.2	-83.2
06 REEU in Annex I	1415	1245	1076	-24.0	-13.1	1624	309	-78.2	-81.0
07 Japan	1180	1506	897	-24.0	-40.4	1343	214	-81.9	-84.0
08 Rest of Annex I	1046	1545	795	-24.0	-48.6	1521	189	-81.9	-87.5
09 Turkey	277	742	211	-24.0	-71.6	1503	61	-78.2	-96.0
10 REEEU	1017	975	774	-23.8	-20.5	1323	366	-64.0	-72.1
11 Argentina	244	638	555	127.2	-13.0	976	234	-4.1	-75.6
12 Brazil	682	1696	1476	116.5	-13.0	2759	786	15.3	-66.3
13 Mexico	432	1120	974	125.6	-13.0	1811	415	-3.8	-77.0
14 Venezuela	197	657	657	233.4	0.0	964	277	40.7	-70.3
15 Rest of Latin America	515	1368	1208	134.6	-11.7	2099	829	61.1	-59.1
16 Egypt	126	435	435	245.5	0.0	1141	628	398.2	-45.0
17 South Africa	357	860	748	109.7	-13.0	2236	316	-11.5	-86.0
18 Nigeria	126	405	405	220.9	0.0	966	966	665.4	0.0
19 Rest North Africa	197	617	572	189.8	-7.4	1546	572	190.0	-63.3
20 Rest of Africa	661	1557	1552	134.9	-0.3	3021	2633	298.6	-17.1
21 Saudi Arabia	194	731	512	163.9	-30.0	1608	216	11.3	-86.5
22 United Arab Emirates	65	237	166	156.7	-30.0	545	70	8.3	-87.2
23 Rest of Middle East	571	1946	1671	192.4	-14.1	4136	1036	81.2	-72.8
24 China	3707	8438	7341	98.0	-13.0	10730	3546	-4.3	-62.3
25 India	1316	4308	4308	227.2	0.0	9497	5224	296.8	-45.0
26 Indonesia	330	1146	1146	247.4	0.0	1723	850	157.8	-45.0
27 Korea (South)	252	982	687	172.9	-30.0	1325	290	15.1	-79.4
28 Malaysia	89	392	341	282.7	-13.0	648	144	61.5	-79.4
29 Philippines	90	292	254	182.0	-13.0	479	263	192.2	-45.0
30 Singapore	31	148	103	230.8	-30.0	279	44	39.6	-85.3
31 Thailand	174	559	486	179.4	-13.0	920	257	47.7	-75.1
32 Rest of Asia	1037	2365	2359	127.5	-0.3	3651	2357	127.3	-39.7

Note: numbers show the median over the six IPCC SRES scenarios.
Source: FAIR 2.1 world model

Table 8. Continued

500 ppm	1990	2020				2050			
	1990	Baseline	Target	Relative to 1990	Relative baseline	Baseline	Target	Relative to 1990	Relative baseline
	MtCO2eq	MtCO2eq	MtCO2eq	%	%	MtCO2eq	MtCO2eq	%	%
Annex I	17146	21206	13605	-20.7	-35.8	22533	4456	-74.0	-80.1
Non Annex I	13127	32595	29198	122.4	-10.6	56596	31300	138.4	-44.6
World	30273	52981	42802	41.4	-20.6	79588	35756	18.1	-55.1
01 USA	6024	8344	5121	-15.0	-38.6	7957	1540	-74.4	-80.5
02 EU15	4115	5176	2881	-30.0	-44.3	5032	866	-78.9	-82.8
03 EU+10	908	1186	649	-28.6	-44.6	1409	255	-72.0	-81.8
04 RWEU	103	137	88	-15.0	-36.0	136	26	-74.4	-80.6
05 Russian Federation	2929	2680	2344	-20.0	-12.2	3807	912	-68.9	-76.1
06 REEU in Annex I	1415	1245	1132	-20.0	-8.6	1624	440	-68.9	-72.9
07 Japan	1180	1506	1003	-15.0	-33.4	1343	302	-74.4	-77.4
08 Rest of Annex I	1046	1545	889	-15.0	-42.5	1521	267	-74.4	-82.4
09 Turkey	277	742	222	-20.0	-70.1	1503	86	-68.9	-94.2
10 REEEU	1017	975	781	-23.2	-19.8	1323	462	-54.6	-65.1
11 Argentina	244	638	575	135.0	-10.0	976	294	20.3	-69.3
12 Brazil	682	1696	1527	124.0	-10.0	2759	1210	77.5	-44.3
13 Mexico	432	1120	1008	133.4	-10.0	1811	535	23.9	-65.5
14 Venezuela	197	657	657	233.4	0.0	964	337	70.7	-64.0
15 Rest of Latin America	515	1368	1234	139.7	-9.8	2099	1099	113.5	-46.2
16 Egypt	126	435	435	245.5	0.0	1141	799	534.1	-30.0
17 South Africa	357	860	774	116.9	-10.0	2236	396	11.1	-82.5
18 Nigeria	126	405	405	220.9	0.0	966	966	665.4	0.0
19 Rest North Africa	197	617	582	195.2	-5.7	1546	752	281.1	-51.7

	1990	2020				2050			
500 ppm	1990	Baseline	Target	Relative to 1990	Relative baseline	Baseline	Target	Relative to 1990	Relative baseline
	MtCO2eq	MtCO2eq	MtCO2eq	%	%	MtCO2eq	MtCO2eq	%	%
20 Rest of Africa	661	1557	1553	135.1	-0.3	3021	2759	317.7	-12.5
21 Saudi Arabia	194	731	512	163.9	-30.0	1608	262	35.1	-83.7
22 United Arab Emirates	65	237	166	156.7	-30.0	545	85	31.4	-84.4
23 Rest of Middle East	571	1946	1703	198.1	-12.5	4136	1328	132.5	-63.9
24 China	3707	8438	7594	104.9	-10.0	10730	5963	60.8	-39.3
25 India	1316	4308	4308	227.2	0.0	9497	6648	405.0	-30.0
26 Indonesia	330	1146	1146	247.4	0.0	1723	1206	265.5	-30.0
27 Korea (South)	252	982	687	172.9	-30.0	1325	352	39.7	-75.0
28 Malaysia	89	392	353	295.9	-10.0	648	181	102.7	-72.3
29 Philippines	90	292	263	191.7	-10.0	479	335	271.9	-30.0
30 Singapore	31	148	103	230.8	-30.0	279	53	69.4	-82.1
31 Thailand	174	559	503	189.1	-10.0	920	361	107.2	-64.0
32 Rest of Asia	1037	2365	2359	127.5	-0.2	3651	2661	156.6	-30.3

Note: numbers show the median over the six IPCC SRES scenarios.
Source: FAIR 2.1 world model

Table 8. Continued.

	1990	2020				2050			
550 ppm	1990	Baseline	Target	Relative to 1990	Relative baseline	Baseline	Target	Relative to 1990	Relative baseline
	MtCO2eq	MtCO2eq	MtCO2eq	%	%	MtCO2eq	MtCO2eq	%	%
Annex I	17146	21206	14245	-16.9	-32.8	22533	5216	-69.6	-76.7
Non Annex I	13127	32595	29545	125.1	-9.5	56596	34236	160.8	-39.8
World	30273	52981	43789	44.6	-18.8	79588	39451	30.3	-50.4
01 USA	6024	8344	5422	-10.0	-35.0	7957	1860	-69.1	-76.5
02 EU15	4115	5176	3086	-25.0	-40.4	5032	1059	-74.3	-78.9
03 EU+10	908	1186	694	-23.6	-40.7	1409	295	-67.5	-78.9
04 RWEU	103	137	93	-10.0	-32.2	136	32	-69.1	-76.6
05 Russian Federation	2929	2680	2344	-20.0	-12.2	3807	989	-66.3	-74.0
06 REEU in Annex I	1415	1245	1132	-20.0	-8.6	1624	478	-66.3	-70.6
07 Japan	1180	1506	1062	-10.0	-29.4	1343	364	-69.1	-72.7
08 Rest of Annex I	1046	1545	941	-10.0	-39.1	1521	323	-69.1	-78.7
09 Turkey	277	742	222	-20.0	-70.1	1503	94	-66.3	-93.8
10 REEEU	1017	975	839	-17.5	-13.9	1323	551	-45.8	-58.4
11 Argentina	244	638	575	135.0	-10.0	976	329	34.4	-65.7
12 Brazil	682	1696	1527	124.0	-10.0	2759	1676	145.9	-38.1
13 Mexico	432	1120	1008	133.4	-10.0	1811	641	48.4	-60.8
14 Venezuela	197	657	657	233.4	0.0	964	376	90.6	-59.8
15 Rest of Latin America	515	1368	1250	142.7	-8.7	2099	1214	135.9	-39.5
16 Egypt	126	435	435	245.5	0.0	1141	856	579.4	-25.0
17 South Africa	357	860	774	116.9	-10.0	2236	443	24.0	-80.4
18 Nigeria	126	405	405	220.9	0.0	966	966	665.4	0.0
19 Rest North Africa	197	617	582	195.2	-5.7	1546	826	319.0	-45.8
20 Rest of Africa	661	1557	1553	135.1	-0.3	3021	2791	322.5	-10.9
21 Saudi Arabia	194	731	585	201.6	-20.0	1608	334	72.5	-79.2
22 United Arab Emirates	65	237	189	193.4	-20.0	545	108	67.8	-80.1
23 Rest of Middle East	571	1946	1748	205.9	-10.2	4136	1516	165.4	-59.0
24 China	3707	8438	7594	104.9	-10.0	10730	7399	99.6	-29.0
25 India	1316	4308	4308	227.2	0.0	9497	7123	441.1	-25.0
26 Indonesia	330	1146	1146	247.4	0.0	1723	1292	291.6	-25.0
27 Korea (South)	252	982	785	211.9	-20.0	1325	449	78.3	-68.1
28 Malaysia	89	392	353	295.9	-10.0	648	208	133.1	-69.0
29 Philippines	90	292	263	191.7	-10.0	479	359	298.5	-25.0
30 Singapore	31	148	118	278.1	-20.0	279	68	116.2	-77.2
31 Thailand	174	559	503	189.1	-10.0	920	431	147.5	-52.0
32 Rest of Asia	1037	2365	2361	127.7	-0.2	3651	2760	166.2	-26.4

Note: numbers show the median over the six IPCC SRES scenarios.
Source: FAIR 2.1 world model

6.2 *Abatement costs and financial flows*

While the previous section showed the different cases explored to lead to a wide range of future emission allowances per country, this section explores the consequences of these climate regimes in terms of abatement costs using the abatement costs model of the FAIR 2.1 world model (den Elzen and Meinshausen, 2005a; den Elzen and Lucas, 2005b; den Elzen et al., 2005c). This model makes use of aggregated permit demand and supply curves, derived from Marginal Abatement Cost (MAC) curves for the different regions, gases and sources.[31] The permit demand and supply curves are used to determine the international market equilibrium permit price (henceforth known simply as “permit price”) on the basis of the same methodology as applied by Ellerman and Decaux (1998). This methodology distributes the regional emission reduction objective over the different gases and sources following a least-cost approach, taking full advantage of the flexible Kyoto Mechanisms as defined under the Kyoto Protocol, i.e. International Emissions Trading (IET), Joint Implementation (JI) and the Clean Development Mechanism (CDM). Subsequently, the permit price is used to determine the buyers and sellers on the international trading market, the accompanying financial flows of permit trading and the regional abatement costs resulting from domestic and external abatements. The banked emission allowances of the FSU during the Kyoto period are all fully used in the second commitment period (2015), while banking and/or borrowing of permits between periods after Kyoto is not assumed.
Different sets of baseline- and time-dependent MAC curves for different emission sources are used here. Response curves from the TIMER energy model are used for the energy CO_2 emissions (van Vuuren et al., 2004a), including technological developments, learning effects and system inertia. For CO_2 sinks we use the MAC curves of the IMAGE model (van Vuuren et al., 2004b). For non-CO_2, we use exogenously determined MAC curves from EMF-21 (DeAngelo et al., 2004; Delhotal et al., 2004; Schaefer et al., 2004) based on detailed abatement options. As these curves were constructed for 2010 only, we assume increases in the abatement potentials due to the technology process and removal of implementation barriers and a relatively conservative value of an increasing potential (at constant costs) for all other non-CO_2 MAC curves of 0.4% per year. There are still some agricultural emission sources of CH_4 and N_2O remaining, where no MAC curves were available (e.g. for N_2O agricultural waste burning, indirect fertiliser, animal waste and domestic sewage). As it is unlikely that these sources will remain unabated under ambitious climate targets, we assume a linear reduction towards a maximum of 35% compared to the baseline levels within a period of 30 years (2040). For a detailed description of the MAC curves please refer to van Vuuren et al. (2004a; 2004b) and den Elzen and Meinshausen (2005a).
The CO_2 MAC curves occur at the level of the 17 IMAGE 2.2 world regions, and the non-CO_2 MAC curves at the level of the 19 regions (EMF regions), and here these regional MAC curves (expressed as costs of abating a percentage of the baseline emissions) are applied to all countries and aggregated groups of countries (Appendix B) belonging to a region. Since this is a limitation of the costs analysis, this study is not going to present costs at the disaggregated level of countries (or aggregated groups of countries), but only at the aggregated level of the country. This study should therefore be seen as a first attempt and a(n) (preliminary) analysis of the distribution of costs among the various country groups of the proposal.

[31] A MAC curve, differing per country, reflects the additional costs of reducing the last unit of carbon as a function of the level of abatement.

Estimating costs of regimes is beset with substantial uncertainties (van Vuuren et al., 2003). The cost figures are very dependent on the assumptions about abatement potentials and reduction costs for all greenhouse gases. Obviously, the uncertainties increase for medium- to long-term calculations. Therefore, we focus on the short-term (2020) only. The net regional costs or gains for the different concentration stabilisation levels result from the costs of domestic abatement combined with the costs or gains from emissions trading. Next, the financial funding related to the support of (the incremental costs of) mitigation cost of reaching their targets in NICs and RIDCs from the Annex II are simply calculated as, i.e. NICs fund 50% of their mitigation effort, RIDCs fund only 10%.
Given the large differences in income between the regions, the costs (or gains) are compared to regional GDP levels (in PPP). The ratio is further referred to as "effort rate", giving an indication of costs in comparison to the "carrying capacity" of the local economy.

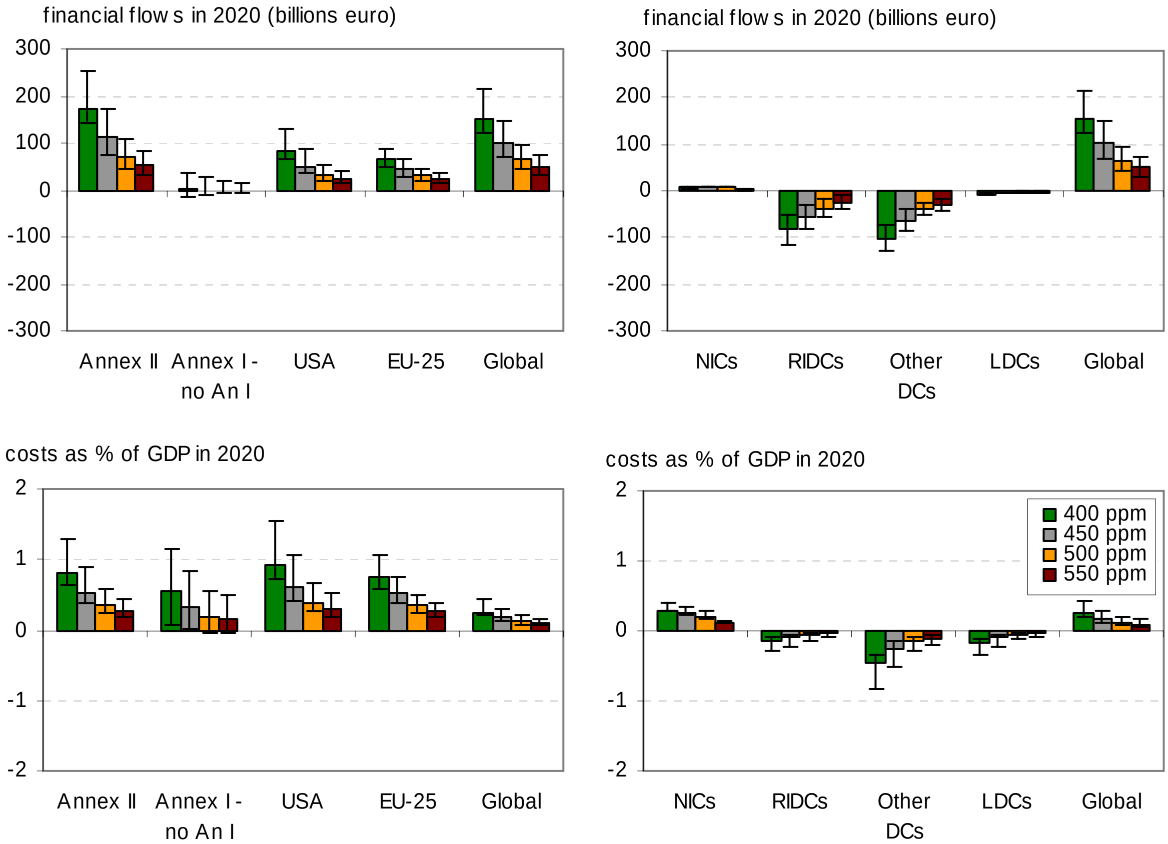


Figure 19. Financial flows (upper) and abatement costs in 2020 as percentage of GDP for the country groups (including the USA and EU-25) for the median over the six IMAGE IPCC SRES scenarios. The bars represent the median over the six IMAGE IPCC SRES scenarios, and the error bars the full range of the scenarios. Note: negative values stand for gains.

Although the methodology based on MAC curves has the great advantage of being transparent and easy to apply, it also has a number of limitations. First of all, MAC curves only represent direct cost effects with feedback to the overall economy, but not the various linkages and rebound effects via the economy or impacts of carbon leakage. In other words, there is no direct link with macro-economic indicators such as GDP losses or other measures of income of utility loss. Furthermore, the MAC curves have been created outside the system and can therefore not respond to the actual interactions resulting from mitigation action such as those resulting from abatement efforts in other countries (carbon leakage, technology transfer). Finally, using the MAC curve methodology, we found that emission

reductions do not lead to structural changes of the system and result in an unaffected baseline. For a further discussion on the limitations, but also on the strengths of this cost methodology we refer to den Elzen et al. (2005c).
The trading of emission permits results in financial flows from buying regions to selling regions. The financial flows involved in trading increase for the lower concentration targets, as a result of the larger emission reduction required and resulting higher permit prices. The RIDCs, Other DCs and LDCs are permit-exporting countries, reducing their emissions more than they are obliged to, while mainly the Annex II countries act as permit importing countries. For this reason, their total abatement costs also include permit expenses from permit trading. The Annex I (but not Annex II) countries hardly gain from permit-exporting, and the same holds true for the NICs.
The effort rates at the level of the six country groups and the global effort rate are presented in Figure 19. Similar to the financial flows, the effort rates highly differ across the various concentration stabilisation levels and regions. These differences can be explained by differences in regional reduction targets, reduction potentials and income levels. The global costs increase for the lower concentration stabilisation levels. The error bars in the figure also illustrate that the global and regional costs are as much influenced by the baseline emissions as by the final concentration stabilisation level.
Annex I regions – The effort rates of the Annex II and Annex I regions are about 0.25-1% of GDP for 400 and 450 ppm CO_2-eq. Although the differences are small, total abatement costs tend to be relatively high for the USA, and relatively low for Europe and Japan (regions with medium per capita emissions). For 500 and 550 ppm CO_2-eq. the effort rates are smaller, ranging from 0-0.5% of GDP.
Non-Annex I regions – In line with the emission reduction objectives, the costs between the non-Annex I regions are also much more differentiated than between the Annex I regions. The NICs are confronted with the highest effort rates (0.4-0.75% of GDP for the 400 and 450 ppm CO_2-eq. concentration levels), comparable to those found for the Annex I regions. This is mainly due to their relatively high per capita emissions and medium income. RIDCs have lower costs compared to the NICs. The RIDCs, Other DCs and LDCs gain for all concentration levels, up to almost 0.5% of their GDP. This is due to their relatively high gains from emission trading, which partly compensates for their emission control costs. In conclusion, the effort rates for NICs and the gains for RIDCs, Other DCs and LDCs increase for lower concentration levels.

Main findings:

- For the 500 and 550 ppm CO_2-equivalent scenario the short-term reduction targets for the country groups are similar to those under the political willingness scenario, or even smaller (550 ppm). However, on the long-term the Annex I and Annex II emissions have to reduce drastically.
- For the 500 and 550 ppm CO_2-equivalent scenario the NICs are allowed to grow up to 2010 but then will need to stabilise up to 2020. For the other country groups (RIDCs, Other DCs and LDCs) there is a gradual shift among the different country groups, towards finally the NICs group. RIDCs are assumed to reduce emissions slightly below baseline.
- Under the most stringent 400 and 450 ppm CO_2-equivalent scenario, even more ambitious reductions will be necessary for the Annex I countries up to 2020 and afterwards than under the political willingness scenario.
- For the 400 and 450 ppm CO_2-equivalent scenario, the emissions of the NICs could grow until 2010, stabilise up to 2020 and then would have to be reduced substantially. RIDCs are assumed to reduce emissions slightly below baseline

levels. However, to reach the low emission levels in 2050, a large group of countries that were RIDCs, but also Other DCs and LDCs in 2020, would have to move to the country group of NICs as of 2030.

- The global abatement costs and financial flows related to the use of the Kyoto Mechanisms very much depend on the concentration stabilisation level and the baseline emissions. For the abatement costs or gains, the financial costs or revenues also play an important role. This occurs, in particular, in the financial transfers from permit trading from the Annex II countries to the RIDCs, Other DCs and to a lesser extent, to the LDCs, but also from the financial funding related to the support of the mitigation activities of the NICs and RIDCs (from Annex II countries). It seems that the Annex II, Annex I but not Annex II and NICs all have about similar effort rates (abatement costs as % of GDP), whereas RIDCs, Other DCs, and, to a lesser extent, LDCs all gain from the financial transfers from emission trading. The NICs are confronted with relatively low to average abatement costs, which are related to their higher ability to pay. However, the NICs group also include major oil-exporting countries, such as Saudi Arabia and Kuwait. Compensation of these countries to support their mitigation activities has turned out to be a contentious issue, and should be further assessed by the researchers involved in the design of the original proposal.

7 Conclusions

The aim of this study was to assess the emission and cost implications of the “South–North Dialogue – Equity in the Greenhouse” proposal for international climate policy after 2012, as described in Ott et al. (2004). This should help both the drafters of the proposal and others to evaluate the appropriateness of the proposal in arriving at an equitable approach for differentiating mitigation commitments. In analysing the implications, we combined the proposal with different long-term greenhouse gas concentration stabilisation levels. In addition, the environmental effectiveness of a “political willingness” scenario has been explored. The study updates the earlier analysis of Höhne and Ullrich (2005) in four ways:

(i) The use of baseline scenarios at the level of individual countries is based on an improved downscaling method that tries to deal with the limits of present down-scaling methods.

(ii) The historical and base-year greenhouse gas emissions are based on the same data sources as in the original study.

(iii) Calculations of the multi-gas emission pathways and emission allowances are done in more consistent way, as the calculations of the countries’ emission allowances make use of the global CO_2-equivalent emission targets for the emission pathways (in stead of CO2-only pathways as in Höhne and Ullrich, 2005). These targets are expressed in terms of CO_2-equivalent emissions of the six Kyoto greenhouse gases (excluding LUCF CO_2). This methodology better accounts for the time-dependent share of non-CO_2, LUCF CO_2 and fossil CO_2 emissions in the global CO_2-equivalent emission pathways.

(iv) These emission pathways allow for an overshoot of the concentration levels, leading to less stringent short-term global emission targets, and thus less severe short-term Annex I reduction commitments, whereas the earlier study revealed almost unrealistic high short-term reductions for the Annex I countries in particular.

The following conclusions can be drawn from the analysis of the “political willingness” scenario and the implementation of the proposal for the scenarios for stabilisation of greenhouse gas concentrations at 400, 450, 500 and 550 ppm CO_2–equivalents:

- The “political willingness” scenario assumes reductions in the order of 20% below 1990 levels for the Annex I countries in 2020, i.e. the EU-25 (30% below 1990 levels) and the USA (15% below). Under this scenario, stabilisation of CO_2-equivalent concentration at 500 ppm (about 425-450 ppm CO_2 only) is kept within reach in 2020, but substantial reductions have to occur after 2020 (global reduction rates may exceed the maximum reduction rates of 2.5% per year for a couple of decades (e.g., den Elzen and Meinshausen, 2005a).

- However for this “political willingness” scenario, the option of stabilising the CO_2-equivalent concentration at 400 and 450 ppm CO_2-equivalent moves out of reach, as this would require a doubling of the maximum reduction rates to about 5% per year, which is very likely to result in high costs. Therefore this scenario seems unlikely to be adequate in limiting global mean surface temperature increase to 2^o Celsius above pre-industrial levels.

- For the 500 and 550 ppm CO_2-equivalent scenario the short-term reductions for the country groups are comparable to those under the political willingness scenario, or even smaller (550 ppm). However, the Annex I and Annex II have to reduce drastically in the long term.

- For the 500 and 550 ppm CO_2-equivalent scenario the NICs are allowed to grow up to 2010 but then will need to stabilise up to 2020 for the 550 ppm CO_2-eq. scenario. These countries that were RIDCs, Other DCs and LDCs in 2020 gradually shift to the different country groups (higher up in the hierarchy, for example, from Other DCs to RIDCs, or from RIDCs to NICs). RIDCs are assumed to reduce emissions slightly below their baseline scenario.
- Under the most stringent 400 and 450 ppm CO_2-equivalent scenario, even more ambitious reduction targets than under the political willingness scenario would be necessary for the Annex I countries for 2020 and later, i.e. 30% to 35%in 2020 below 1990 levels
- For the 400 and 450 ppm CO_2-equivalent scenario, the emission of the NICs could grow up to 2010, stabilise up to 2020 and then would have to be reduced substantially. RIDCs are assumed to lower emissions slightly below baseline emissions. However, to reach the low emission levels in 2050, a large group of countries that were RIDCs, but also Other DCs and LDCs in 2020, will have to move to the country group of NICs as early as 2030-2040.
- The global abatement costs and financial flows related to the use of the Kyoto Mechanisms very much depend on the concentration stabilisation level and the baseline emissions. For the abatement costs or gains, the financial costs or revenues also play an important role. This occurs, in particular, in the financial transfers from permit trading from the Annex II countries to the RIDCs, Other DCs and to a lesser extent, to the LDCs, but also from the financial funding related to the support of the mitigation activities of the NICs and RIDCs (from Annex II countries). It seems that the Annex II, Annex I but not Annex II and NICs all have about similar effort rates (abatement costs as % of GDP), whereas RIDCs, Other DCs, and, to a lesser extent, LDCs all gain from the financial transfers from emission trading. The NICs are confronted with relatively low to average abatement costs, which are related to their higher ability to pay. However, the NICs group also include major oil-exporting countries, such as Saudi Arabia and Kuwait. Compensation of these countries to support their mitigation activities has turned out to be a contentious issue, and should be further assessed by the researchers involved in the design of the original proposal.

In accordance with the provisions of the Climate Convention, the South–North Dialogue Proposal assumes that developed countries continue to take the lead in mitigation activities and delayed action by developing countries. It assumes that Annex I countries adopt more stringent reduction targets after 2012 than those agreed on in Kyoto and only the most advanced non-Annex I countries (NICs, RIDCs) to have to limit their emissions as early as 2020. LDCs and “other DCs” are assumed to be able to follow their baseline scenario emissions even beyond 2020 to fulfil basic development needs, although the original composition of the latter represents a large share of global greenhouse gas emissions.

The analysis shows that this “philosophy” is generally well reflected in the results, but that stringent stabilisation targets imply little delay time for developing countries, even when the Annex I countries take on ambitious mitigation commitments. Many developing countries would already have to take on quantitative mitigation obligations by 2030 as they graduate to the groups of RIDCs and NICs.

References

Aldy, J.E, Ashton, J., Baron, R., Bodansky, D., Charnovitz, S., Diringer, E., Heller, T.C., Pershing, J., Shukla, P.R., Tubiana, L., Tudela, F. and Wang, X., 2003. Beyond Kyoto, Advancing the international effort against climate change. Pew Center on Global Climate Change, Arlington, US.

Babiker, M.H. and Eckhaus, R.S., 2002. Rethinking the Kyoto targets. Climatic Change, 54: 99-114.

Barrett, S., 2001. Towards a Better Climate Treaty. Policy Matters. World Economics, 3(2): 35-45.

Berk, M.M., van Minnen, J.G. , Metz, B., Moomaw, W, den Elzen, M.G.J., van Vuuren, D.P. and Gupta, J., 2001. Climate OptiOns for the Longterm (COOL) Global Dialogue Synthesis Report. RIVM report 490200003, RIVM, Bilthoven, The Netherlands.

Bodansky, D., 2004. International climate efforts beyond 2012: a survey of approaches, Pew Center on global climate change, www.pewclimate.org, Arlington, USA.

Cooper, R., 2001. The Kyoto Protocol: A Flawed Concept. Environmental Law Reporter, 31: 11,484-11,492.

Criqui, P., Kitous, A., Berk, M.M., den Elzen, M.G.J., Eickhout, B., Lucas, P., van Vuuren, D.P., Kouvaritakis, N. and Vanregemorter, D., 2003. Greenhouse gas reduction pathways in the UNFCCC Process up to 2025 - Technical Report. B4-3040/2001/325703/MAR/E.1 for the DG Environment, CNRS-IEPE, Grenoble, France.

de Vries, H.J.M., van Vuuren, D.P., den Elzen, M.G.J. and Janssen, M.A., 2002. The Targets Image Energy model regional (TIMER) - Technical documentation. MNP-report 461502024, Netherlands Environmental Assessment Agency (MNP), Bilthoven, the Netherlands.

DeAngelo, B. J., DelaChesnaye, F. C., Beach, R. H., Sommer, A. and Murray, B. C., 2004. Methane and nitrous oxide mitigation in agriculture. Energy Journal, (in press).

Delhotal, K. C., DelaChesnaye, F. C., Gardiner, A., Bates, J. and Sankovski, A., 2004. Mitigation of methan and nitrous oxide emissions from waste, energy and industry. Energy Journal, (in press).

den Elzen, M.G.J and Meinshausen, M., 2005a. Meeting the EU 2°C climate target: global and regional emission implications. MNP-report 728001031 (www.mnp.nl/en), Netherlands Environmental Assessment Agency (MNP), Bilthoven, the Netherlands.

den Elzen, M.G.J and Meinshausen, M., 2005b. Multi-gas emission pathways for meeting the EU 2°C climate target, Scientific Symposium “Avoiding Dangerous Climate Change” (http://www.stabilisation2005.com/), Met Office, Exeter, United Kingdom.

den Elzen, M.G.J., 2002. Exploring climate regimes for differentiation of future commitments to stabilise greenhouse gas concentrations. Integrated Assessment, 3(4): 343-359.

den Elzen, M.G.J. and Berk, M.M., 2003. How can the Parties fairly and effectively establish future obligations under long-term objectives? In: D. Michel (Editor), Climate policy for the 21st century: meeting the long-term challenge of global warming. Center for Transatlantic Relations, Washington, D.C., pp. 79-112.

den Elzen, M.G.J. and Berk, M.M., 2004. Bottom up approaches for defining future climate mitigation commitments. MNP-report 728001029 (www.mnp.nl/en), Netherlands Environmental Assessment Agency (MNP), Bilthoven, the Netherlands.

den Elzen, M.G.J., Berk, M.M., Lucas, P., Criqui, C. and Kitous, A., 2005a. Multi-Stage: a rule-based evolution of future commitments under the Climate Change Convention. International Environmental Agreements (in press).
den Elzen, M.G.J., Berk, M.M., Lucas, P., Eickhout, B. and Vuuren, D.P. van, 2003. Exploring climate regimes for differentiation of commitments to achieve the EU climate target. MNP-report 728001023 (www.mnp.nl/en), Netherlands Environmental Assessment Agency (MNP), Bilthoven, the Netherlands.
den Elzen, M.G.J. and de Moor, A.P.G., 2001. Evaluating the Bonn agreement and some key issues. MNP-report 728001016 (www.mnp.nl/en), Netherlands Environmental Assessment Agency (MNP), Bilthoven, the Netherlands.
den Elzen, M.G.J. and de Moor, A.P.G., 2002a. Analysing the Bonn Agreement and Marrakesh Accords: Economic efficiency & environmental effectiveness. Ecological Economics, 43: 141-158.
den Elzen, M.G.J. and de Moor, A.P.G.. 2002b. Evaluating the Bonn-Marrakesh Agreement. Climate Policy, 2: 111-117.
den Elzen, M.G.J., Fuglestvedt, J. S., Höhne, N., Trudinger, C.M., Lowe, J., Matthews, B.J.H., Romstadt, B., Pires de Campos, C. and Andranova, N., 2005b. Analysing countries' contribution to climate change: Scientific uncertainties and methodological choices. Environmental Science Policy (in press).
den Elzen, M.G.J. and Lucas, P., 2003. FAIR 2.0: a decision-support model to assess the environmental and economic consequences of future climate regimes. MNP-report 550015001, www.mnp.nl/fair, Netherlands Environmental Assessment Agency (MNP), Bilthoven, the Netherlands.
den Elzen, M.G.J. and Lucas, P., 2005a. Countries' emission allowances and abatement costs for regimes for post-2012 commitments. Environmental Science and Policy (in preparation).
den Elzen, M.G.J. and Lucas, P., 2005b. The FAIR model: a tool to analyse environmental and costs implications of climate regimes. Environmental Modeling and Assessment, 10(2): 115-134.
den Elzen, M.G.J., Lucas, P. and van Vuuren, D.P., 2005c. Abatement costs of post-Kyoto climate regimes. Energy Policy, 33(16): pp. 2138-2151.
den Elzen, M.G.J. and Schaeffer, M., 2002. Responsibility for past and future global warming: uncertainties in attributing anthropogenic climate change. Climatic change, 54: 29-73.
den Elzen, M.G.J., Schaeffer, M. and Eickhout, B., 2002. Responsibility for past and future global warming: time horizon and non-linearities in the climate system. MNP-report 728001022, Netherlands Environmental Assessment Agency (MNP), Bilthoven, the Netherlands.
den Elzen, M.G.J., Schaeffer, M. and Lucas, P., 2005d. Differentiating future commitments on the basis of countries' relative historical responsibility for climate change: uncertainties in the 'Brazilian Proposal' in the context of a policy implementation. Climatic Change, 71(3): 277-301.
Edmonds, J. and Wise, M.A., 1999. Exploring a Technology Strategy for stabilising atmospheric CO2. In: C. Carraro (Editor), International Environmental Agreements on Climate Change. Kluwer Academic Publishers, Dordrecht, Netherlands, pp. 19.
Ellerman, A.D. and Decaux, A., 1998. Analysis of Post-Kyoto CO2 emissions trading using marginal abatement curves. Report No 40, MIT, Cambridge, MA.
EPA, 2004. Global Non-CO_2 Greenhouse Gas Emissions: 1990 - 2020., Partial draft data available online at: http://www.epa.gov/ghginfo/reports/index.htm.
European-Council, 2005. Presidency conclusions, European Council, Brussels.

Folland, C. K., Rayner, N. A., Brown, S. J., Smith, T. M., Shen, S. S. P., Parker, D. E., Macadam, I., Jones, P. D., Jones, R. N., Nicholls, N. and Sexton, D. M. H., 2001. Global temperature change and its uncertainties since 1861. Geophysical Research Letters, 28(13): 2621-2624.

Gaffin, S., Xing, X. and Yetman, G., 2004. Downscaling and Geo-spatial Gridding of Socio-Economic Projections from the IPCC Special Report on Emissions Scenarios (SRES). Global Environmental Change, 105-123(14).

Hare, W.L. and Meinshausen, M., 2004. How much warming are we committed to and how much can be avoided?, Potsdam Institute for Climate Impact Research (PIK), Potsdam, Germany.

Höhne, N., den Elzen, M.G.J. and Weiss, M., 2004. Common but differentiated convergence (CDC), a new conceptual approach to long-term climate policy. Climate Policy (submitted).

Höhne, N., Galleguillos, C., Blok, K., Harnisch, J. and Phylipsen, D., 2003. Evolution of commitments under the UNFCCC: Involving newly industrialized countries and developing countries. Research-report 20141255, UBA-FB 000412, ECOFYS Gmbh, Berlin.

Höhne, N., Phylipsen, D., Ullrich, S. and Blok, K., 2005. Options for the second commitment period of the Kyoto Protocol, research report for the German Federal Environmental Agency. Climate Change 02/05, ISSN 1611-8855, available at www.umweltbundesamt.de, ECOFYS Gmbh, Berlin.

Höhne, N. and Ullrich, S., 2005. Emission allowances under the proposal of the "South north dialogue - equity in the greenhouse". Research-report DM 70096, ECOFYS, Cologne, Germany.

Houghton, R.A., 2003. Emissions (and Sinks) of Carbon from Land-Use Change." (Estimates of national sources and sinks of carbon resulting from changes in land use, 1950 to 2000). Report to the World Resources Institute from the Woods Hole Research Center. Available at: http://cait.wri.org.

IEA, 2002. CO_2 Emissions from Fuel Combustion (2002 edition). International Energy Agency, Available online at: http://data.iea.org/ieastore/co2_main.asp., Paris, France.

IMAGE-team, 2001. The IMAGE 2.2 implementation of the SRES scenarios. A comprehensive analysis of emissions, climate change and impacts in the 21st century. CD-ROM publication 481508018, Bilthoven, the Netherlands.

IPCC, 2001. Climate Change 2001: Mitigation. Cambridge University Press, Cambridge, UK.

Kameyama, Y., 2004. The future climate regime: a regional comparison of proposals. International Environmental Agreements: Politics, Law and Economics, 4: 307-326.

Lucas, P.L., den Elzen, M.G.J. and van Vuuren, D.P., 2005. A Multi-gas abatement analysis of the Marrakesh Accords. MNP-report 550006001, Netherlands Environmental Assessment Agency (MNP), Bilthoven, the Netherlands.

Marland, G., Boden, T.A. and Andres, R. J., 2003. Global, Regional, and National Fossil Fuel CO_2 Emissions. In: O.R.N.L. Carbon Dioxide Information Analysis Center, U.S. Department of Energy (Editor), Trends: A Compendium of Data on Global Change, Oak Ridge, Tennesse., U.S.A. Available online at: http://cdiac.esd.ornl.gov/trends/emis/meth_reg.htm.

Murphy, J.M., Sexton, D.M.H., Barnett, D.N., Jones, G.S., Webb, M.J., Collins, M. and Stainforth, D.A, 2004. Quantification of modelling uncertainties in a large ensemble of climate change simulations. Nature, 430: 768-772.

Nakicenovic, N. et al., 2000. Special Report on emissions scenarios. IPCC Special Reports. Cambridge University Press, Cambridge, UK.

Olivier, J.G.J. and Berdowski, J.J.M., 2001. Global emissions sources and sinks. In: J. Berdowski, R. Guicherit and B.J. Heij (Editors), The Climate System. A.A. Balkema Publishers/Swets & Zeitlinger Publishers, Lisse, The Netherlands. ISBN 90 5809 255 0, pp. 33-78.

Ott, H E., Winkler, H., Brouns, B., Kartha, S., Mace, M., Huq, S., Kameyama, Y., Sari, A.P., Pan, J., Sokona, Y., Bhandari, P.M., Kassenberg, A., La Rovere, E.L. and Rahman, A., 2004. South-North dialogue on equity in the greenhouse. A proposal for an adequate and equitable global climate agreement, S. Eschborn, Gesellschaft für Technische Zusammenarbeit, www.erc.uct.ac.za/recentpub.htm or www.south-north-dialogue.net.

Pan, J., 2002. Understanding human development potentials and demands for greenhouse gas emissions: with empirical analysis using time series and cross-sectional data, Chinese Academy of Social Sciences, Beijing, China.

Phylipsen, G J M, Höhne, N. and Janzic, R., 2005. Implementing Triptych 6.0 - Technical report. DM 70046/ICC03080, Ecofys.

Pitcher, H., 2004. Review of downscaled datasets provided by CIESIN, Joint Global Change Research Insitute, Washington D.C.

Samaniego, J. and Figueres, C., 2002. Evolving to a sector-based Clean Development Mechanisms. In: K.A. Baumert, O. Blanchard, Llose and J.F. Perkaus (Editors), Options for protecting the climate. WRI, Washington.

Schaefer, D. O., Godwin, D. and Harnisch, J., 2004. Estimating future emissions and potential reductions of HFCs, PFCs and SF6. Energy Journal, (in press).

Schelling, T.C., 2002. What makes greenhouse sense? Time to rethink the Kyoto Protocol. Foreign Affairs, 81(3): 2-9.

Schimel, D., Grubb, M., Joos, F., Kaufmann, R. , Moss, R. , Ogana, W. , Richels, R. and Wigley, T. M. L., 1997. Stabilization of Atmospheric Greenhouse Gases: Physical, Biological and Socio-Economic Implications. ISBN 92-9169-102-X, IPCC, Geneva.

Sterk, W. and Wittneben, B., 2005. Addressing Opportunities and Challenges of a Sectoral Approach to the Clean Development Mechanism, JIKO Policy Paper 1/2005, August 2005, Wuppertal Institute, Wuppertal. Available at http://www.wupperinst.org/jiko.

Torvanger, A. and Godal, O., 2004. An evaluation of pre-Kyoto differentiation proposals for national greenhouse gas abatement targets. International Environmental Agreements: Politics, Law and Economics, 4(65-91).

UN, 2004a. World Population Prospects: the 2004 revision, United Nations Department for Economic and Social Information and Policy Analysis, New York, USA.

UN, 2004b. World Population to 2300, United Nations, New York.

UNFCCC, 1992. United Nations General Assemby, United Nations Framework Convention on Climate Change, http://www.unfccc.int/resources, United Nations, New York.

UNFCCC, 1997. Paper no. 1: Brazil; Proposed Elements of a Protocol to the United Nations Framework Convention on Climate Change. UNFCCC/AGBM/1997/MISC.1/Add.3 GE.97, Bonn.

UNSTAT, 2005. National Accounts Main Aggregates Database, United Nations Statistics Division, New York, USA.

van Vuuren, D.P., de Vries, H.J.M., Eickhout, B. and Kram, T., 2004a. Responses to Technology and Taxes in a Simulated World. Energy Economics, 26(579-601).

van Vuuren, D.P., den Elzen, M.G.J. and Berk, M.M., 2002. An evaluation of the level of ambition and implications of the Bush Climate Change Initiative. Climate Policy, 2: 293-301.

van Vuuren, D.P., den Elzen, M.G.J., Berk, M.M., Lucas, P., Eickhout, B., Eerens, H. and Oostenrijk, R, 2003. Regional costs and benefits of alternative post-Kyoto climate regimes. RIVM-report 728001025, www.mnp.nl/en, Netherlands Environmental Assessment Agency (MNP), Bilthoven, the Netherlands.

van Vuuren, D.P., Eickhout, B., Lucas, P.L. and den Elzen, M.G.J., 2004b. Long-term multi-gas scenarios to stabilise radiative forcing - exploring costs and benefits within an integrated assessment framework. Energy Journal (accepted).

van Vuuren, D.P., Lucas, P.L. and Hilderink, H., 2005. Downscaling drivers of global environmental change scenarios: Enabling use of the IPCC SRES scenarios at the national and grid level. Global Environmental Change (submitted).

WBGU, 2003. Climate Protection Strategies for the 21st Century. Kyoto and Beyond. German Advisory Council on Global Change, Berlin.

White-House, 2002. Executive Summary of Bush Climate Change Initiative.

Wigley, T. M. L. and Raper, S. C. B., 2001. Interpretation of high projections for global-mean warming. Science, 293(5529): 451-454.

Winkler, H., Brouns, B. and Kartha, S., 2005. Future mitigation commitments: Differentiating among non-Annex I countries. Climate Policy (submitted).

Winkler, H., Spalding-Fecher, R., Mwakasonda, S. and Davidson, O., 2002. Sustainable development policies and measures: starting from development to tackle climate change. In: K.A. Baumert, O. Blanchard, Llose and J.F. Perkaus (Editors), Options for protecting the climate. WRI, Washington DC, pp. 61-87.

WorldBank, 2004. World Bank Development indicators 2004. Oxford University Press, New York, USA.

Appendix A The impact of the downscaling method on the countries' baseline scenarios

This appendix compares the downscaled information on the countries' population (Table A.1), per capita income (Table A.2) and emissions (Table A.3) in 2050 from the IMAGE 2.2 IPCC SRES scenarios of the linear downscaling method used by Höhne and Ullrich (2005) with the non-linear downscaling method of van Vuuren et al. (2005) used by this study.
The tables also show the relative differences between the data of each of the studies, both for the base year (2000) and the year 2050. The last three columns give the numbers relative to the 2000 levels (growth-factors) and the relative differences. Here, the relative growth factors are compared to the 2000 levels for each of the studies; in this way, only the differences due to the downscaling method are reflected, and not the differences resulting from the differences in the 2000 estimates.
Appendix A also reflects the global estimates, which the linear downscaling method used by Höhne and Ullrich (2005) may differ from the global estimate of the original IMAGE 2.2 IPCC scenarios (for example, the global 2050 per capita income is about 15% higher). The non-linear downscaling methodology of van Vuuren et al. (2005) is, however, always consistent with the original source, by ensuring that aggregation is retained in the original dataset.
Finally, the row "Average difference" indicates the average of all the relative differences (in absolute terms) for all countries. This is calculated as the sum of the absolute relative differences in the countries included (but only those where data was available for both studies) divided by the number of countries. This number is given for both the studies for the year 2000 (fourth column, using the absolute numbers) and the year 2050 (seventh column, using the absolute numbers) and for the year 2050 (last column, using the growth factors relative to their 2000 levels).

Table A.1. Comparison of the downscaled information of the countries' population (in million) in 2000 and 2050 for the IMAGE 2.2 IPCC SRES scenarios with reference to the linear downscaling method used by Höhne and Ullrich (2005), and the non-linear downscaling method of van Vuuren et al. (2005) used in our study, along with the relative differences between them.

	Population – base-year (2000)			**Population – 2050**			**Population relative to 2000-levels in 2050**		
Country	**Höhne and Ullrich (2005)**	**This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**	**Linear downscaling method Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**
Afghanistan	21.8	21.4	1.7	33.6	68.5	-50.9	1.5	3.2	-51.7
Albania	3.1	3.1	0.7	3.0	3.7	-20.9	0.9	1.2	-21.4
Algeria	30.3	30.2	0.2	60.4	57.0	6.0	2.0	1.9	5.9
Angola	13.1	12.4	6.0	29.2	62.4	-53.3	2.2	5.0	-55.9
Antigua & Barbuda	0.1	1.0	-93.5	0.1	1.0	-90.6	1.5	1.0	45.8
Argentina	37.0	37.1	-0.1	54.0	52.2	3.4	1.5	1.4	3.6
Armenia	3.8	3.1	21.7	3.9	2.7	46.0	1.0	0.9	20.0
Australia	19.1	19.2	-0.1	22.0	20.2	9.0	1.2	1.1	9.1
Austria	8.1	8.1	-0.3	8.8	8.4	3.9	1.1	1.0	4.2
Azerbaijan	8.0	8.2	-1.4	8.3	13.4	-37.9	1.0	1.6	-37.0
Bahamas	0.3	0.3	0.4	0.4	0.4	15.5	1.5	1.3	15.1
Bahrain	0.6	0.7	-5.5	1.3	1.4	-1.5	2.1	2.0	4.2

	Population – base-year (2000)			Population – 2050			Population relative to 2000-levels in 2050		
Country	Höhne and Ullrich (2005)	This study	Difference (%)	Linear downscaling method- Höhne and Ullrich (2005)	Non-linear downscaling of This study	Difference (%)	Linear downscaling method Höhne and Ullrich (2005)	Non-linear downscaling of This study	Difference (%)
Bangladesh	137.4	138.0	-0.4	212.5	233.4	-9.0	1.5	1.7	-8.6
Barbados	0.3	0.3	0.0	0.4	0.3	43.9	1.5	1.0	43.9
Belarus	10.2	10.0	1.5	10.6	9.9	6.8	1.0	1.0	5.2
Belgium	10.2	10.3	0.0	11.1	11.6	-3.8	1.1	1.1	-3.8
Belize	0.2	0.2	-5.8	0.3	0.4	-20.0	1.5	1.7	-15.1
Benin	6.3	6.2	0.8	13.9	13.7	1.9	2.2	2.2	1.1
Bhutan	2.1	2.1	1.1	3.2	5.0	-36.1	1.5	2.4	-36.8
Bolivia	8.3	8.3	0.1	12.1	15.8	-23.0	1.5	1.9	-23.2
Bosnia & Herzegovina	4.0	4.0	0.0	3.8	3.9	-3.8	0.9	1.0	-3.8
Botswana	1.5	1.7	-10.7	3.4	1.7	97.4	2.2	1.0	121.0
Brazil	170.4	171.8	-0.8	248.5	230.3	7.9	1.5	1.3	8.8
Brunei	0.3	0.3	-1.7	0.4	0.6	-29.1	1.3	1.9	-27.9
Bulgaria	7.9	8.1	-1.8	7.5	6.0	25.0	0.9	0.7	27.4
Burkina Faso	11.5	11.9	-3.1	25.6	38.2	-33.0	2.2	3.2	-30.8
Burundi	6.4	6.3	1.4	14.1	16.7	-15.6	2.2	2.7	-16.8
Cambodia	13.1	13.1	-0.3	17.5	27.2	-35.8	1.3	2.1	-35.5
Cameroon	14.9	15.1	-1.6	33.0	21.2	55.4	2.2	1.4	58.0
Canada	0.4	0.4	-2.0	0.9	0.7	38.3	2.2	1.6	41.1
Cape Verde	30.8	30.8	0.0	42.3	42.3	-0.1	1.4	1.4	-0.1
Central African Republic	3.7	3.7	0.1	8.3	5.6	46.4	2.2	1.5	46.3
Chad	7.9	7.9	0.3	17.5	22.7	-22.9	2.2	2.9	-23.2
Chile	15.2	15.2	-0.1	22.2	21.6	2.9	1.5	1.4	3.0
China	1260.2	1275.2	-1.2	1300.1	1311.8	-0.9	1.0	1.0	0.3
Colombia	42.1	42.1	0.0	61.4	66.7	-7.9	1.5	1.6	-7.8
Comoros	0.7	0.7	0.1	1.6	1.5	3.2	2.2	2.2	3.0
Congo	3.0	3.4	-12.4	6.7	9.4	-28.8	2.2	2.7	-18.7
Cook Islands	0.0	0.0	7.0	0.0	0.0	75.1	1.1	0.7	63.7
Costa Rica	4.0	3.9	2.4	5.9	6.4	-8.9	1.5	1.6	-11.1
Côte d'Ivoire	16.0	15.8	1.2	35.6	23.7	49.8	2.2	1.5	48.0
Croatia	4.7	4.4	4.7	4.4	4.1	8.3	0.9	0.9	3.5
Cuba	11.2	11.2	0.0	16.3	9.7	67.9	1.5	0.9	67.9
Cyprus	0.8	0.8	0.1	1.6	0.9	76.7	2.1	1.2	76.5
Czech Republic	10.3	10.3	0.0	9.7	9.9	-2.2	0.9	1.0	-2.2
Dem. Republic Congo	50.9	48.6	4.9	113.1	135.8	-16.7	2.2	2.8	-20.6
Denmark	5.4	5.3	1.0	5.8	5.9	-1.8	1.1	1.1	-2.8
Djibouti	0.6	0.7	-5.1	1.4	1.2	18.5	2.2	1.8	24.9
Dominica	0.1	0.1	-9.3	0.1	0.1	28.5	1.5	1.0	41.6
Dominican Republic	8.4	8.4	0.2	12.2	11.5	6.2	1.5	1.4	5.9
Ecuador	12.6	12.4	1.8	18.4	18.5	-0.3	1.5	1.5	-2.1
Egypt	67.9	67.8	0.1	135.4	149.7	-9.6	2.0	2.2	-9.7
El Salvador	6.3	6.2	1.1	9.2	9.6	-4.5	1.5	1.5	-5.6
Equatorial Guinea	0.5	0.5	0.1	1.0	1.0	-2.2	2.2	2.3	-2.3
Eritrea	3.7	3.7	-1.4	8.1	8.9	-8.3	2.2	2.4	-6.9
Estonia	1.4	1.4	1.9	1.4	0.8	76.3	1.0	0.6	72.9
Ethiopia	62.9	65.6	-4.1	139.7	146.2	-4.5	2.2	2.2	-0.4
Federated States of Micronesia	0.1	0.1	14.6	0.1	0.1	25.8	1.2	1.0	9.7
Fiji	0.8	0.8	0.0	0.9	0.7	41.4	1.2	0.8	41.4
Finland	5.2	5.2	-0.1	5.6	5.6	0.9	1.1	1.1	1.0
France	61.4	59.3	3.5	66.7	68.3	-2.4	1.1	1.2	-5.7
FYR Macedonia	2.0	2.0	0.5	1.9	2.4	-19.9	0.9	1.2	-20.3
Gabon	1.2	1.3	-2.2	2.7	2.1	28.2	2.2	1.7	31.1
Gambia	1.3	1.3	-0.7	2.9	2.5	15.1	2.2	1.9	15.9
Georgia	5.3	1.0	426.2	5.5	1.0	445.4	1.0	1.0	3.7
Germany	82.0	82.3	-0.3	89.1	89.9	-1.0	1.1	1.1	-0.6
Ghana	19.3	19.6	-1.5	42.9	34.1	25.6	2.2	1.7	27.5
Greece	10.6	10.9	-2.7	11.5	11.1	4.2	1.1	1.0	7.1
Grenada	0.1	0.1	15.4	0.1	0.1	104.5	1.5	0.8	77.2
Guatemala	11.4	11.4	-0.3	16.6	26.3	-36.7	1.5	2.3	-36.5
Guinea	8.2	8.1	0.5	18.1	17.3	4.7	2.2	2.1	4.2
Guinea-Bissau	1.2	1.4	-12.3	2.7	4.3	-37.5	2.2	3.1	-28.8
Guyana	0.8	0.8	0.2	1.1	0.4	151.6	1.5	0.6	151.1
Haiti	8.1	8.0	1.7	11.9	12.4	-4.2	1.5	1.5	-5.8
Honduras	6.4	6.5	-0.6	9.4	12.5	-25.4	1.5	1.9	-24.9
Hungary	10.0	10.0	-0.4	9.4	8.7	8.6	0.9	0.9	9.1

	Population – base-year (2000)			Population – 2050			Population relative to 2000-levels in 2050		
Country	**Höhne and Ullrich (2005)**	**This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**	**Linear downscaling method Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**
Iceland	0.3	0.3	-1.1	0.3	0.3	-11.2	1.1	1.2	-10.3
India	1008.9	1016.9	-0.8	1559.9	1400.7	11.4	1.5	1.4	12.2
Indonesia	212.1	211.6	0.3	283.1	260.8	8.5	1.3	1.2	8.3
Iran	70.3	66.4	5.9	146.2	107.7	35.7	2.1	1.6	28.2
Iraq	22.9	23.2	-1.2	47.7	61.2	-22.0	2.1	2.6	-21.1
Ireland	3.8	3.8	-0.4	4.1	5.2	-20.4	1.1	1.4	-20.1
Israel	6.0	6.0	0.0	12.6	10.5	19.5	2.1	1.7	19.5
Italy	57.5	57.5	0.0	62.5	51.2	21.9	1.1	0.9	21.9
Jamaica	2.6	2.6	-0.1	3.8	3.6	4.9	1.5	1.4	5.1
Japan	127.1	127.0	0.0	132.3	132.9	-0.4	1.0	1.0	-0.5
Jordan	4.9	5.0	-2.4	10.2	10.6	-3.8	2.1	2.1	-1.4
Kazakhstan	16.2	15.6	3.4	16.8	16.8	-0.4	1.0	1.1	-3.6
Kenya	30.7	30.5	0.4	68.1	35.2	93.4	2.2	1.2	92.7
Kiribati	0.1	0.1	-1.3	0.1	0.1	-2.2	1.2	1.2	-0.9
Korea (North)	22.3	22.3	0.0	23.0	23.4	-1.6	1.0	1.0	-1.6
Korea (South)	46.7	46.8	-0.2	48.2	48.1	0.2	1.0	1.0	0.4
Kuwait	1.9	2.2	-14.8	4.0	5.3	-25.4	2.1	2.4	-12.4
Kyrgyzstan	4.9	4.9	0.0	5.1	8.4	-39.6	1.0	1.7	-39.6
Laos	5.3	5.3	0.0	7.0	10.9	-35.2	1.3	2.1	-35.2
Latvia	2.4	2.4	2.0	2.5	1.7	50.2	1.0	0.7	47.3
Lebanon	3.5	3.5	0.5	7.3	5.1	43.5	2.1	1.5	42.8
Lesotho	2.0	1.8	14.0	4.5	1.7	165.3	2.2	1.0	132.7
Liberia	2.9	2.9	-1.0	6.5	8.8	-26.7	2.2	3.0	-25.9
Libya	5.3	5.2	1.0	10.5	11.0	-3.9	2.0	2.1	-4.8
Liechtenstein	0.0	0.0	-0.2	0.0	0.0	-18.4	1.1	1.3	-18.2
Lithuania	3.7	3.5	5.6	3.8	3.2	19.2	1.0	0.9	12.9
Luxembourg	0.4	0.4	0.4	0.5	0.8	-42.1	1.1	1.9	-42.3
Madagascar	16.0	16.0	0.0	35.5	39.0	-9.0	2.2	2.4	-9.0
Malawi	11.3	11.4	-0.5	25.1	36.2	-30.6	2.2	3.2	-30.2
Malaysia	22.2	23.0	-3.4	29.7	36.1	-17.8	1.3	1.6	-14.9
Maldives	0.3	0.3	0.0	0.4	0.8	-42.8	1.5	2.7	-42.8
Mali	11.4	11.9	-4.6	25.2	41.6	-39.4	2.2	3.5	-36.4
Malta	0.4	0.4	0.2	0.4	0.5	-6.4	1.1	1.2	-6.5
Marshall Islands	0.1	0.1	0.1	0.1	0.1	8.4	1.2	1.1	8.3
Mauritania	2.7	2.6	0.8	5.9	6.7	-11.5	2.2	2.5	-12.2
Mauritius	1.2	1.2	-2.1	2.6	1.2	119.6	2.2	1.0	124.2
Mexico	98.9	98.9	-0.1	144.2	136.2	5.9	1.5	1.4	5.9
Moldova	4.3	4.3	0.3	4.5	4.4	1.2	1.0	1.0	0.9
Monaco	0.0	0.0	-0.1	0.0	0.0	-20.5	1.1	1.4	-20.4
Mongolia	2.5	2.5	1.3	2.6	3.5	-25.9	1.0	1.4	-26.9
Morocco	29.9	29.1	2.6	59.6	55.4	7.5	2.0	1.9	4.7
Mozambique	18.3	17.9	2.4	40.6	43.2	-5.9	2.2	2.4	-8.2
Myanmar	47.7	47.5	0.4	63.7	58.0	9.9	1.3	1.2	9.4
Namibia	1.8	1.9	-7.2	3.9	3.6	9.3	2.2	1.9	17.9
Nauru	0.0	0.0	0.1	0.0	0.0	-20.0	1.1	1.4	-20.1
Nepal	23.0	23.5	-2.0	35.6	47.2	-24.6	1.5	2.0	-23.0
Netherlands	16.1	15.9	1.1	17.5	18.5	-5.8	1.1	1.2	-6.8
New Zealand	3.8	3.8	-0.1	4.3	3.4	28.8	1.2	0.9	29.0
Nicaragua	5.1	5.1	0.0	7.4	10.7	-31.1	1.5	2.1	-31.1
Niger	10.8	10.7	0.8	24.0	49.0	-50.9	2.2	4.6	-51.4
Nigeria	113.9	114.7	-0.8	252.8	226.0	11.8	2.2	2.0	12.7
Niue	0.0	0.0	-0.8	0.0	1.0	-99.8	1.2	495.8	-99.8
Norway	4.5	4.5	-0.1	4.9	5.5	-12.4	1.1	1.2	-12.3
Oman	2.5	2.6	-2.7	5.3	7.3	-27.6	2.1	2.8	-25.6
Pakistan	141.3	142.7	-1.0	218.4	332.0	-34.2	1.5	2.3	-33.6
Palau	0.0	0.0	-0.1	0.0	0.0	-25.3	1.2	1.5	-25.2
Panama	2.9	2.9	-3.2	4.2	5.1	-18.3	1.5	1.7	-15.6
Papua New Guinea	4.8	5.3	-9.8	5.5	8.0	-30.9	1.2	1.5	-23.4
Paraguay	5.5	5.5	0.5	8.0	12.2	-34.4	1.5	2.2	-34.7
Peru	25.7	26.0	-1.1	37.4	40.9	-8.4	1.5	1.6	-7.4
Philippines	75.7	75.7	-0.1	101.0	114.3	-11.6	1.3	1.5	-11.6
Poland	38.6	38.7	-0.2	36.5	37.6	-3.1	0.9	1.0	-3.0
Portugal	10.0	10.0	0.0	10.9	10.3	5.8	1.1	1.0	5.8
Qatar	0.6	0.6	-2.7	1.2	0.9	26.2	2.1	1.6	29.7
Romania	22.4	22.5	-0.2	21.2	20.9	1.5	0.9	0.9	1.7

	Population – base-year (2000)			Population – 2050			Population relative to 2000-levels in 2050		
Country	**Höhne and Ullrich (2005)**	**This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**	**Linear downscaling method Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**
Russian Federation	145.5	145.6	-0.1	150.8	133.5	12.9	1.0	0.9	13.0
Rwanda	7.6	7.7	-1.5	16.9	14.2	19.1	2.2	1.8	20.9
Saint Kitts & Nevis	0.0	0.0	-8.8	0.1	0.0	63.8	1.5	0.8	79.5
Saint Lucia	0.1	0.1	1.4	0.2	0.2	41.3	1.5	1.0	39.4
Saint Vincent & Grenadines	0.1	0.1	-3.8	0.2	0.1	36.8	1.5	1.0	42.2
Samoa	0.2	0.2	-8.3	0.2	0.2	3.2	1.2	1.0	12.5
San Marino	0.0	0.0	-1.0	0.0	0.0	-23.3	1.1	1.4	-22.6
Sao Tome & Principe	0.1	0.1	-7.6	0.3	0.3	2.7	2.2	2.0	11.2
Saudi Arabia	20.3	22.1	-8.1	42.3	58.5	-27.6	2.1	2.6	-21.2
Senegal	9.4	9.4	0.3	20.9	18.7	11.7	2.2	2.0	11.4
Serbia & Montenegro	10.6	10.6	0.0	10.0	10.3	-3.0	0.9	1.0	-3.0
Seychelles	0.1	0.1	2.0	0.2	0.1	110.1	2.2	1.1	106.0
Sierra Leone	4.4	4.4	-0.2	9.8	9.2	5.9	2.2	2.1	6.2
Singapore	4.0	4.0	0.0	5.4	4.5	18.2	1.3	1.1	18.1
Slovakia	5.4	5.4	0.1	5.1	5.6	-9.6	0.9	1.0	-9.8
Slovenia	2.0	2.0	-0.1	1.9	1.8	3.5	0.9	0.9	3.6
Solomon Islands	0.4	0.4	2.4	0.5	0.8	-33.5	1.2	1.8	-35.0
South Africa	43.3	44.0	-1.6	96.2	51.5	86.6	2.2	1.2	89.6
Spain	39.9	40.8	-2.1	43.3	41.0	5.6	1.1	1.0	7.8
Sri Lanka	18.9	18.6	1.8	29.3	19.1	52.8	1.5	1.0	50.1
Sudan	31.1	31.4	-1.1	69.0	50.0	38.2	2.2	1.6	39.7
Suriname	0.4	0.4	-1.9	0.6	0.4	40.8	1.5	1.0	43.5
Swaziland	0.9	1.0	-11.4	2.1	1.3	56.0	2.2	1.3	76.2
Sweden	8.8	8.9	-0.2	9.6	9.6	-0.1	1.1	1.1	0.1
Switzerland	7.2	7.2	0.0	7.8	6.6	17.4	1.1	0.9	17.5
Syria	16.2	16.6	-2.2	33.7	35.6	-5.5	2.1	2.2	-3.4
Taiwan	22.2	22.2	0.1	22.9	22.8	0.4	1.0	1.0	0.3
Tajikistan	6.1	6.1	0.0	6.3	11.3	-44.1	1.0	1.9	-44.1
Tanzania	35.1	34.8	0.8	78.0	94.9	-17.9	2.2	2.7	-18.5
Thailand	62.8	60.9	3.1	83.8	68.4	22.5	1.3	1.1	18.8
Timor-Leste (East Timor)	0.7	0.7	5.0	1.0	1.3	-25.4	1.3	1.9	-28.9
Togo	4.5	4.6	-0.8	10.1	8.7	15.6	2.2	1.9	16.5
Tonga	0.1	0.1	-1.8	0.1	0.1	35.8	1.2	0.8	38.3
Trinidad & Tobago	1.3	1.3	0.4	1.9	1.2	52.1	1.5	1.0	51.4
Tunisia	9.5	9.5	-0.6	18.9	15.0	26.1	2.0	1.6	26.9
Turkey	66.7	68.3	-2.4	138.6	99.8	38.9	2.1	1.5	42.2
Turkmenistan	4.7	4.6	2.0	4.9	8.9	-44.8	1.0	1.9	-45.9
Tuvalu	0.0	0.0	5.8	0.0	0.0	13.4	1.2	1.1	7.1
Uganda	23.3	23.5	-0.8	51.7	89.1	-41.9	2.2	3.8	-41.5
Ukraine	49.6	49.7	-0.2	51.4	40.4	27.1	1.0	0.8	27.4
United Arab Emirates	2.6	2.8	-7.6	5.4	4.3	24.6	2.1	1.5	34.8
United Kingdom	59.4	58.7	1.3	64.6	73.8	-12.5	1.1	1.3	-13.6
United States of America	287.3	285.0	0.8	394.8	388.0	1.7	1.4	1.4	0.9
Uruguay	3.3	3.3	-0.1	4.9	4.1	20.1	1.5	1.2	20.2
Uzbekistan	24.9	24.9	-0.1	25.8	43.8	-41.2	1.0	1.8	-41.1
Vanuatu	0.2	0.2	0.0	0.2	0.3	-27.8	1.2	1.6	-27.8
Venezuela	24.2	24.3	-0.4	35.2	41.2	-14.5	1.5	1.7	-14.2
Vietnam	78.1	78.1	0.0	104.3	105.6	-1.2	1.3	1.4	-1.2
Yemen	18.3	18.0	1.8	38.2	94.0	-59.4	2.1	5.2	-60.2
Zambia	10.4	10.4	0.0	23.1	25.7	-9.9	2.2	2.5	-9.9
Zimbabwe	12.6	12.6	-0.2	28.0	16.4	71.3	2.2	1.3	71.6
Average difference*			5.7			29.0			25.5
OECD90	859	855	0.5	1021	1012	0.9	1.2	1.2	0.4
E. Europe and FSU	412	406	1.4	416	415	0.1	1.0	1.0	-1.2
Asia	3237	3260	-0.7	4195	4216	-0.5	1.3	1.3	0.2
ALM	1536	1541	-0.3	2952	2987	-1.1	1.9	1.9	-0.8
Annex I	1173	1169	0.3	1337	1295	3.2	1.1	1.1	2.8
non-Annex I	4804	4825	-0.4	7108	7234	-1.7	1.5	1.5	-1.3
Global	6044	5994	0.8	8583	8629	-0.5	1.4	1.4	-1.3

***** Defined as the sum of the absolute differences of the countries included divided by the number of countries (countries were limited to those where data was available for both studies).

Note: the absolute numbers here represent the median over the six scenarios.
Source: FAIR 2.1 world model

Table A.2. Comparison of the downscaled information of the countries' GDP data (in PPP$/cap x year) in 2000 and 2050 in the IMAGE 2.2 IPCC SRES scenarios between the linear downscaling method used by Höhne and Ullrich (2005), and the non-linear downscaling method of van Vuuren et al. (2005) used in this study, along with the relative differences

	Per capita income – base-year (in 1000U$/cap) (2000)			Per capita income – 2050			Per capita income relative to 2000-levels in 2050		
Country	**Höhne and Ullrich (2005)**	**This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**	**Linear downscaling method Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**
Afghanistan		0.4			5.6			12.9	
Albania	3.6	3.7	-3.7	19.3	31.3	-38.5	5.4	8.4	-36.1
Algeria	5.0	5.0	0.5	30.0	25.6	17.4	6.0	5.1	16.8
Angola	2.3	1.8	27.7	11.5	17.1	-33.0	5.0	9.5	-47.5
Antigua & Barbuda		0.0		0.0	0.0				
Argentina	11.5	11.1	3.4	51.7	38.3	35.2	4.5	3.4	30.8
Armenia	2.4	2.2	9.6	16.8	17.5	-3.9	6.9	7.9	-12.3
Australia	24.7	24.0	3.0	56.0	49.5	13.0	2.3	2.1	9.7
Austria	24.3	25.7	-5.6	59.0	49.7	18.6	2.4	1.9	25.6
Azerbaijan	2.6	2.4	9.8	17.8	23.6	-24.3	6.9	10.0	-31.0
Bahamas		15.3			42.2			2.8	
Bahrain	15.3	14.4	6.5	70.3	45.5	54.5	4.6	3.2	45.1
Bangladesh	1.4	1.4	0.0	12.5	11.1	12.3	8.8	7.8	12.3
Barbados		14.1			42.5			3.0	
Belarus	7.0	4.4	57.8	47.9	25.2	90.3	6.9	5.7	20.6
Belgium	24.9	24.3	2.6	60.5	48.4	25.1	2.4	2.0	21.9
Belize		5.1			25.8			5.0	
Benin	0.9	0.9	5.3	6.4	5.7	12.2	6.8	6.4	6.6
Bhutan		2.4			18.4			7.6	
Bolivia	2.3	2.2	4.7	10.3	17.6	-41.5	4.5	8.0	-44.1
Bosnia & Herzegovina	5.5	3.9	40.9	29.3	21.9	33.8	5.4	5.7	-5.1
Botswana		6.9			25.8			3.7	
Brazil	6.9	6.8	2.5	31.2	27.7	13.0	4.5	4.1	10.2
Brunei	16.8	24.6	-31.4	95.5	88.6	7.9	5.7	3.6	57.2
Bulgaria	5.5	5.7	-3.2	29.7	29.3	1.3	5.4	5.1	4.6
Burkina Faso		0.9			7.0			7.5	
Burundi		0.6			4.9			9.0	
Cambodia		1.7			14.2			8.4	
Cameroon	1.6	1.7	-7.3	10.8	9.3	16.4	6.8	5.4	25.5
Canada		4.3			19.3			4.5	
Cape Verde	26.6	25.5	4.5	58.6	50.2	16.9	2.2	2.0	11.8
Central African Republic		1.1			6.9			6.5	
Chad		0.8			6.3			7.9	
Chile	8.9	8.4	5.8	40.0	33.6	19.1	4.5	4.0	12.6
China	3.9	3.5	9.2	25.3	25.7	-1.6	6.5	7.3	-9.8
Colombia	5.9	5.6	4.5	26.4	31.1	-15.3	4.5	5.5	-18.9
Comoros		1.5			9.8			6.6	
Congo	0.9	0.9	-1.1	5.9	5.1	15.2	6.8	5.8	16.5
Cook Islands		3.6			11.3			3.2	
Costa Rica	7.2	8.2	-11.6	36.6	37.7	-2.9	5.1	4.6	9.9
Côte d'Ivoire	1.6	1.5	7.1	10.6	7.6	40.0	6.8	5.2	30.7
Croatia	7.0	8.3	-15.5	37.7	31.4	20.1	5.4	3.8	42.2
Cuba	2.9	2.8	5.8	14.8	14.5	2.3	5.1	5.2	-3.3
Cyprus	18.6	15.7	18.6	85.4	37.0	130.6	4.6	2.4	94.4
Czech Republic	13.0	12.8	1.6	70.0	48.5	44.3	5.4	3.8	42.1
Dem. Republic Congo	0.6	0.6	-1.5	4.3	6.0	-29.3	6.8	9.4	-28.2
Denmark	25.5	26.9	-5.1	62.0	51.0	21.6	2.4	1.9	28.1
Djibouti		1.8			10.1			5.7	
Dominica		5.5			22.1			4.0	
Dominican Republic	5.7	5.6	1.5	29.0	29.6	-2.0	5.1	5.2	-3.4
Ecuador	2.9	3.1	-6.6	13.0	18.4	-29.7	4.5	6.0	-24.7
Egypt	3.2	3.3	-0.6	19.4	19.1	1.7	6.0	5.9	2.3
El Salvador	4.2	4.3	-3.0	21.2	25.3	-16.3	5.1	5.9	-13.7

Country	Per capita income – base-year (in 1000U$/cap) (2000) Höhne and Ullrich (2005)	This study	Difference (%)	Per capita income – 2050 Linear downscaling method- Höhne and Ullrich (2005)	Non-linear downscaling of This study	Difference (%)	Per capita income relative to 2000-levels in 2050 Linear downscaling method Höhne and Ullrich (2005)	Non-linear downscaling of This study	Difference (%)
Equatorial Guinea		15.5			72.0			4.6	
Eritrea	0.8	0.7	12.6	6.4	6.4	-0.7	7.6	8.6	-11.8
Estonia	8.6	9.4	-8.8	59.3	36.9	60.7	6.9	3.9	76.3
Ethiopia	0.6	0.6	-1.1	4.9	6.0	-18.5	7.6	9.2	-17.6
Federated States of Micronesia		1.8		0.0	7.0				
Fiji		4.5			15.6			3.5	
Finland	23.8	23.1	3.3	57.9	45.3	27.8	2.4	2.0	23.7
France	22.1	23.2	-4.9	53.7	46.5	15.5	2.4	2.0	21.4
FYR Macedonia	4.7	6.0	-21.7	25.3	34.8	-27.3	5.4	5.8	-7.2
Gabon	5.9	5.6	4.2	39.9	19.9	100.7	6.8	3.5	92.5
Gambia		1.5			9.9			6.4	
Georgia	2.5	0.0		17.3	0.0				
Germany	23.3	23.9	-2.6	56.6	46.6	21.5	2.4	1.9	24.7
Ghana	1.8	1.8	1.1	12.4	11.3	9.8	6.8	6.2	8.6
Greece	15.0	15.3	-2.1	36.3	37.0	-1.9	2.4	2.4	0.3
Grenada		6.8			24.5			3.6	
Guatemala	3.6	3.6	-1.5	18.1	25.7	-29.5	5.1	7.1	-28.4
Guinea		1.8			10.6			5.8	
Guinea-Bissau		0.7			6.0			8.2	
Guyana		3.7			18.6			5.0	
Haiti	1.4	1.5	-10.4	6.9	15.0	-54.3	5.1	9.9	-48.9
Honduras	2.4	2.3	4.4	12.2	19.8	-38.4	5.1	8.6	-40.9
Hungary	11.3	11.3	0.3	60.8	40.9	48.6	5.4	3.6	48.2
Iceland	26.9	26.4	1.9	65.4	53.3	22.7	2.4	2.0	20.4
India	2.2	2.2	0.3	19.5	15.6	25.0	8.8	7.0	24.6
Indonesia	2.7	2.8	-3.3	15.4	15.4	-0.3	5.7	5.5	3.2
Iran	5.0	5.5	-7.7	23.1	30.1	-23.2	4.6	5.5	-16.7
Iraq	1.4	1.2	13.4	6.4	11.1	-41.9	4.6	9.0	-48.8
Ireland	27.6	27.6	-0.2	67.0	58.5	14.5	2.4	2.1	14.8
Israel	19.0	18.9	0.7	87.3	47.3	84.7	4.6	2.5	83.4
Italy	22.0	22.9	-3.8	53.5	48.4	10.5	2.4	2.1	14.9
Jamaica	3.5	3.4	4.5	17.8	18.1	-1.7	5.1	5.4	-5.9
Japan	24.7	23.8	3.8	46.1	43.3	6.5	1.9	1.8	2.6
Jordan	3.8	3.6	6.8	17.6	21.8	-19.3	4.6	6.1	-24.5
Kazakhstan	4.8	4.2	13.3	32.9	26.7	23.2	6.9	6.3	8.7
Kenya	1.0	0.9	4.8	7.3	6.0	22.0	7.6	6.5	16.4
Kiribati		0.7			3.6			5.2	
Korea (North)		1.4			12.1			8.5	
Korea (South)	13.9	14.0	-0.1	91.2	41.3	120.7	6.5	3.0	120.9
Kuwait	15.3	14.5	6.0	70.4	45.4	55.0	4.6	3.1	46.2
Kyrgyzstan	2.4	1.4	70.6	16.8	15.2	10.5	6.9	10.6	-35.2
Laos		1.4			11.6			8.2	
Latvia	67.8	7.0	870.5	172.6	32.4	433.1	2.5	4.6	-45.1
Lebanon	4.4	3.9	13.7	20.2	16.8	20.2	4.6	4.3	5.7
Lesotho		2.0			12.5			6.3	
Liberia		0.6			4.6			8.0	
Libya	3.3	11.7	-71.4	16.0	45.6	-64.9	4.8	3.9	22.7
Liechtenstein		25.5		0.0	53.1				
Lithuania	6.6	8.0	-18.0	45.2	40.6	11.3	6.9	5.1	35.7
Luxembourg		51.6			102.8			2.0	
Madagascar		0.8			5.8			7.7	
Malawi		0.6			6.6			12.0	
Malaysia	8.6	8.2	4.5	48.7	34.2	42.5	5.7	4.2	36.4
Maldives		9.8			52.1			5.3	
Mali		0.7			5.1			7.5	
Malta	15.3	16.5	-6.9	37.3	43.8	-14.9	2.4	2.7	-8.5
Marshall Islands		1.6		0.0	6.6				
Mauritania		1.7			10.5			6.2	
Mauritius		8.9			30.3			3.4	
Mexico	8.2	8.2	0.4	41.6	35.7	16.6	5.1	4.4	16.1
Moldova	2.1	1.2	77.6	14.5	11.5	26.3	6.9	9.7	-28.9
Monaco		18.1		0.0	41.2				
Mongolia		1.5			15.2			10.2	

Country	Per capita income – base-year (in 1000U$/cap) (2000)			Per capita income – 2050			Per capita income relative to 2000-levels in 2050		
	Höhne and Ullrich (2005)	This study	Difference (%)	Linear downscaling method- Höhne and Ullrich (2005)	Non-linear downscaling of This study	Difference (%)	Linear downscaling method Höhne and Ullrich (2005)	Non-linear downscaling of This study	Difference (%)
Morocco	3.2	3.2	1.4	19.4	17.3	12.3	6.0	5.4	10.8
Mozambique	0.8	0.8	-2.0	3.9	8.7	-54.6	5.0	10.8	-53.7
Myanmar	3.6	1.4	159.5	20.3	8.6	136.4	5.7	6.2	-8.9
Namibia	5.8	5.4	7.4	28.8	27.5	4.7	5.0	5.1	-2.6
Nauru		2.2			8.8			4.0	
Nepal	1.3	1.2	3.6	11.0	11.1	-0.7	8.8	9.1	-4.2
Netherlands	24.6	24.8	-0.8	59.9	49.4	21.1	2.4	2.0	22.1
New Zealand	18.9	18.5	2.2	42.8	40.0	7.0	2.3	2.2	4.7
Nicaragua	2.4	2.3	6.7	12.3	22.7	-45.7	5.1	9.9	-49.1
Niger		0.7			5.8			8.4	
Nigeria	0.9	0.8	12.4	6.2	5.7	7.5	6.8	7.1	-4.3
Niue		2.4		0.0	0.1				
Norway	26.4	32.2	-18.0	64.2	62.6	2.5	2.4	1.9	25.0
Oman	16.7	11.5	45.5	76.7	50.5	51.9	4.6	4.4	4.4
Pakistan	1.8	1.8	0.5	15.4	13.4	15.0	8.8	7.7	14.4
Palau		5.8			18.2			3.2	
Panama	5.6	5.8	-3.0	28.3	28.2	0.3	5.1	4.9	3.5
Papua New Guinea		2.2			10.8			4.9	
Paraguay	4.1	4.2	-2.2	18.5	29.2	-36.5	4.5	6.9	-35.1
Peru	4.5	4.4	3.7	20.3	23.9	-15.2	4.5	5.5	-18.2
Philippines	3.8	3.7	4.7	21.8	21.1	3.3	5.7	5.7	-1.3
Poland	9.0	9.1	-1.0	48.4	38.9	24.3	5.4	4.3	25.6
Portugal	16.4	15.9	3.2	39.8	38.8	2.5	2.4	2.4	-0.6
Qatar	27.2	37.0	-26.5	124.7	87.5	42.5	4.6	2.4	93.8
Romania	6.0	5.2	14.6	32.2	29.5	9.1	5.4	5.6	-4.7
Russian Federation	7.6	6.6	15.0	52.7	32.3	63.2	6.9	4.9	42.0
Rwanda		1.0			7.4			7.3	
Saint Kitts & Nevis		10.4			31.1			3.0	
Saint Lucia		5.1			20.0			3.9	
Saint Vincent & Grenadines		4.9			21.5			4.4	
Samoa		4.7			19.8			4.2	
San Marino		26.0		0.0	54.9				
Sao Tome & Principe		1.0			6.9			6.6	
Saudi Arabia	10.6	11.5	-7.8	48.8	45.1	8.2	4.6	3.9	17.4
Senegal	1.5	1.4	6.5	9.9	7.9	25.4	6.8	5.8	17.8
Serbia & Montenegro	3.4	3.1	9.4	18.2	19.7	-7.3	5.4	6.3	-15.3
Seychelles		32.5			94.2			2.9	
Sierra Leone		0.4			3.4			8.0	
Singapore	22.7	21.8	4.1	128.9	53.8	139.5	5.7	2.5	130.1
Slovakia	10.4	10.5	-1.0	55.8	43.8	27.2	5.4	4.2	28.5
Slovenia	16.1	15.2	5.5	86.2	44.2	95.2	5.4	2.9	85.1
Solomon Islands		1.7			9.7			5.6	
South Africa	8.7	8.7	-0.2	43.3	33.7	28.6	5.0	3.9	28.8
Spain	18.0	18.3	-1.6	43.8	41.3	6.0	2.4	2.3	7.8
Sri Lanka	3.4	3.2	5.5	29.4	17.5	68.1	8.8	5.5	59.3
Sudan	1.6	1.5	8.1	12.4	10.5	18.7	7.6	6.9	9.8
Suriname		2.7			13.8			5.1	
Swaziland		4.0			20.7			5.2	
Sweden	23.0	22.5	2.4	56.0	43.5	28.9	2.4	1.9	25.8
Switzerland	27.5	25.8	6.7	66.9	45.2	48.2	2.4	1.8	38.8
Syria	3.1	3.1	0.5	14.1	23.9	-40.9	4.6	7.8	-41.2
Taiwan	18.5	32.6	-43.2	121.2	102.0	18.9	6.5	3.1	109.3
Tajikistan	1.1	0.7	48.4	7.5	10.4	-27.6	6.9	14.1	-51.2
Tanzania	0.5	0.5	0.3	2.4	5.3	-54.9	5.0	11.1	-55.0
Thailand	5.8	5.8	-0.4	33.0	24.3	36.1	5.7	4.2	36.7
Timor-Leste (East Timor)		0.4		0.0	3.9				
Togo	1.4	1.3	4.5	9.3	8.8	6.0	6.8	6.7	1.4
Tonga		5.8			22.6			3.9	
Trinidad & Tobago	8.5	8.2	3.2	43.0	28.2	52.6	5.1	3.4	47.9
Tunisia	6.1	5.8	5.1	36.3	24.7	47.4	6.0	4.3	40.1
Turkey	6.3	5.7	10.2	29.0	24.5	18.3	4.6	4.3	7.4
Turkmenistan	3.9	3.2	20.8	26.8	31.6	-15.1	6.9	9.8	-29.7
Tuvalu		2.4		0.0	8.9				
Uganda		1.2			8.9			7.6	

	Per capita income – base-year (in 1000U$/cap) (2000)			**Per capita income – 2050**			**Per capita income relative to 2000-levels in 2050**		
Country	**Höhne and Ullrich (2005)**	**This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**	**Linear downscaling method Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**
Ukraine	3.5	3.8	-6.5	24.3	25.7	-5.7	6.9	6.8	0.9
United Arab Emirates	20.3	35.5	-42.7	93.1	83.4	11.6	4.6	2.4	94.9
United Kingdom	21.3	22.7	-6.2	51.7	49.3	4.7	2.4	2.2	11.6
United States of America	31.3	31.3	-0.2	66.3	64.0	3.6	2.1	2.0	3.8
Uruguay	8.5	8.1	4.0	38.0	28.6	33.1	4.5	3.5	27.9
Uzbekistan	2.2	1.4	56.9	15.2	13.4	13.7	6.9	9.5	-27.5
Vanuatu		2.9			13.3			4.6	
Venezuela	5.5	5.2	6.7	24.8	26.0	-4.6	4.5	5.0	-10.5
Vietnam	1.9	1.9	3.4	10.9	13.6	-20.3	5.7	7.4	-22.9
Yemen	0.7	0.8	-6.1	3.3	10.9	-70.0	4.6	14.4	-68.1
Zambia	0.7	0.7	1.9	3.7	6.4	-42.6	5.0	8.9	-43.7
Zimbabwe	2.5	2.4	5.4	12.5	15.9	-21.4	5.0	6.7	-25.5
Average difference*			17.8			31.8			28.5
OECD90	25.7	25.86	-0.7	57.6	52.9	8.9	2.2	2.0	9.6
E. Europe and FSU	6.7	5.84	14.4	40.6	28.4	43.3	6.1	4.9	25.2
Asia	3.3	3.23	1.2	21.8	19.1	14.2	6.7	5.9	12.8
ALM	4.1	4.16	-2.6	18.4	17.7	3.9	4.5	4.3	6.7
Annex I	20.1	20.75	-3.0	55.2	47.8	15.5	2.7	2.3	19.1
non-Annex I	3.5	3.48	-0.2	20.2	18.4	9.7	5.8	5.3	9.8
Global	6.9	6.77	1.8	22.1	22.5	-1.8	3.2	3.3	-3.5

*** Def**ined as the sum of the absolute differences of the countries included (only those where data was available for both studies) divided by the number of countries.
Note: the absolute numbers here represent the median over the six scenarios
Source: FAIR 2.1 world model

Table A.3. Comparison of the downscaled information on countries' emissions (in $MtCO_2$-eq.) in 2000 and 2050 of the IMAGE 2.2 IPCC SRES scenarios of the linear downscaling method used by Höhne and Ullrich (2005), and of the non-linear downscaling method of van Vuuren et al. (2005) used by this study, and its relative difference.

	Emissions – base-year (2000)			**Emissions – 2050**			**Emissions relative to 2000-levels in 2050**		
Country	**Höhne and Ullrich (2005)**	**This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**
Afghanistan	17.0	21.6	-21.2	33.4	41.8	-20.2	2.0	1.9	1.3
Albania	6.4	3.7	74.3	11.3	7.0	60.1	1.8	1.9	-8.1
Algeria	127.4	112.3	13.5	593.5	670.1	-11.4	4.7	6.0	-21.9
Angola	34.7	26.8	29.2	70.1	79.1	-11.4	2.0	3.0	-31.4
Antigua & Barbuda	1.4			2.3			1.7		
Argentina	301.8	290.0	4.1	868.0	901.6	-3.7	2.9	3.1	-7.5
Armenia	7.3	6.7	8.8	11.7	13.1	-10.3	1.6	1.9	-17.6
Australia	511.2	478.2	6.9	557.0	558.1	-0.2	1.1	1.2	-6.6
Austria	81.1	78.0	4.0	95.8	96.1	-0.3	1.2	1.2	-4.1
Azerbaijan	52.0	42.4	22.8	78.6	84.9	-7.4	1.5	2.0	-24.6
Bahamas	0.7	2.0	-65.7	1.9	6.7	-72.3	2.8	3.4	-19.3
Bahrain	16.9	16.6	1.5	81.5	80.4	1.3	4.8	4.8	-0.2
Bangladesh	61.5	122.4	-49.7	228.1	338.5	-32.6	3.7	2.8	34.0
Barbados	4.5	1.6	187.8	10.8	5.2	106.8	2.4	3.4	-28.1
Belarus	85.3	89.7	-4.9	142.9	174.0	-17.9	1.7	1.9	-13.6
Belgium	150.1	151.0	-0.5	166.7	180.0	-7.4	1.1	1.2	-6.9
Belize	7.4	1.3	484.3	19.2	3.9	386.5	2.6	3.1	-16.7

	Emissions – base-year (2000)			Emissions – 2050			Emissions relative to 2000-levels in 2050		
Country	**Höhne and Ullrich (2005)**	**This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**
Benin	46.5	7.7	505.6	263.7	32.5	710.1	5.7	4.2	33.8
Bhutan	1.8	1.8	3.7	4.8	4.8	1.4	2.6	2.7	-2.2
Bolivia	25.1	38.9	-35.5	66.0	101.1	-34.8	2.6	2.6	1.1
Bosnia & Herzegovina	17.3	16.8	2.8	26.5	35.0	-24.3	1.5	2.1	-26.4
Botswana	9.9	15.9	-37.6	37.9	45.1	-16.0	3.8	2.8	34.6
Brazil	723.6	841.7	-14.0	2211.3	2588.5	-14.6	3.1	3.1	-0.6
Brunei	8.2	7.2	13.1	25.8	24.7	4.1	3.2	3.4	-7.9
Bulgaria	64.7	73.4	-11.9	93.2	118.6	-21.5	1.4	1.6	-10.9
Burkina Faso	6.2	21.7	-71.2	33.1	67.9	-51.3	5.3	3.1	69.3
Burundi	2.1	3.2	-35.1	34.4	12.1	183.6	16.4	3.8	337.0
Cambodia	15.5	68.7	-77.5	36.1	128.4	-71.9	2.3	1.9	24.7
Cameroon	22.0	27.4	-19.7	145.9	109.2	33.6	6.6	4.0	66.4
Canada	0.2	0.2	-16.5	1.5	2.2	-30.1	8.6	10.2	-16.3
Cape Verde	735.4	714.1	3.0	758.8	780.4	-2.8	1.0	1.1	-5.6
Central African Republic	10.3	11.9	-14.1	47.2	37.0	27.4	4.6	3.1	48.3
Chad	8.7	18.5	-53.0	40.8	53.7	-24.0	4.7	2.9	61.7
Chile	87.9	76.9	14.3	278.8	277.5	0.5	3.2	3.6	-12.1
China	4589.7	4970.5	-7.7	10480.7	10265.1	2.1	2.3	2.1	10.6
Colombia	152.8	161.1	-5.2	435.9	470.8	-7.4	2.9	2.9	-2.4
Comoros	0.3	0.4	-25.2	2.2	2.7	-18.4	7.3	6.6	9.2
Congo	1.7	5.0	-66.3	15.9	24.7	-35.6	9.4	4.9	91.1
Cook Islands	0.1	0.0	161.2	0.1	0.0	106.2	1.0	1.3	-21.0
Costa Rica	10.3	12.4	-17.5	25.4	34.4	-26.2	2.5	2.8	-10.5
Côte d'Ivoire	32.1	16.6	93.8	316.7	97.8	223.8	9.9	5.9	67.1
Croatia	23.3	26.5	-12.4	37.7	46.9	-19.6	1.6	1.8	-8.2
Cuba	45.5	49.9	-8.8	126.5	149.6	-15.5	2.8	3.0	-7.3
Cyprus	7.3	8.0	-8.7	28.2	33.0	-14.8	3.9	4.1	-6.6
Czech Republic	148.4	143.6	3.4	230.5	262.8	-12.3	1.6	1.8	-15.1
Dem. Republic Congo	45.6	52.7	-13.4	241.8	175.4	37.9	5.3	3.3	59.3
Denmark	68.2	67.2	1.4	70.9	81.6	-13.1	1.0	1.2	-14.2
Djibouti	0.8	1.8	-57.5	11.1	11.4	-1.9	14.7	6.4	130.9
Dominica	0.2	0.2	6.2	0.5	0.5	5.0	2.7	2.8	-1.1
Dominican Republic	27.6	30.2	-8.4	70.6	92.6	-23.7	2.6	3.1	-16.7
Ecuador	44.6	39.8	11.9	146.7	128.1	14.5	3.3	3.2	2.3
Egypt	155.9	178.1	-12.5	959.6	1136.2	-15.5	6.2	6.4	-3.5
El Salvador	13.5	12.1	11.6	33.8	36.3	-7.0	2.5	3.0	-16.7
Equatorial Guinea	0.6	1.3	-53.8	3.1	8.8	-64.3	5.3	6.9	-22.8
Eritrea	5.2	0.6	729.3	197.4	14.2	1286.5	38.2	22.9	67.2
Estonia	19.8	17.7	11.8	25.5	33.6	-24.3	1.3	1.9	-32.3
Ethiopia	55.6	63.4	-12.3	466.3	231.8	101.2	8.4	3.7	129.4
Federated States of Micronesia	0.1			0.2			1.2		
Fiji	2.4	2.8	-14.3	3.4	2.9	16.1	1.4	1.1	35.4
Finland	74.6	68.5	8.9	82.3	81.4	1.1	1.1	1.2	-7.1
France	564.7	502.9	12.3	630.2	605.2	4.1	1.1	1.2	-7.3
FYR Macedonia	14.0	11.2	24.7	18.5	20.8	-11.0	1.3	1.9	-28.6
Gabon	12.1	7.1	70.5	59.3	36.8	61.4	4.9	5.2	-5.3
Gambia	1.1	1.4	-20.9	7.5	5.9	27.8	6.6	4.1	61.5
Georgia	15.7			28.0			1.8		
Germany	996.7	972.3	2.5	1054.9	1169.3	-9.8	1.1	1.2	-12.0
Ghana	15.1	20.7	-27.3	151.0	96.8	56.0	10.0	4.7	114.6
Greece	127.3	116.7	9.1	131.5	143.9	-8.6	1.0	1.2	-16.2
Grenada	1.8	0.1	1355	4.7	0.4	1158	2.6	3.0	-13.6
Guatemala	23.0	21.5	7.1	60.9	61.9	-1.6	2.6	2.9	-8.1
Guinea	9.0	9.5	-4.9	57.3	36.5	56.7	6.3	3.8	64.8
Guinea-Bissau	1.5	2.0	-22.1	9.5	7.5	27.6	6.2	3.8	63.8
Guyana	3.5	3.9	-8.6	9.2	10.8	-14.4	2.6	2.8	-6.3
Haiti	6.5	7.4	-12.3	14.1	17.6	-19.7	2.2	2.4	-8.5
Honduras	12.6	13.5	-6.5	34.3	35.9	-4.6	2.7	2.7	2.1
Hungary	78.1	81.5	-4.1	132.7	141.0	-5.9	1.7	1.7	-1.8
Iceland	2.8	2.8	-1.5	3.1	3.7	-15.2	1.1	1.3	-14.0
India	1803.4	1855.5	-2.8	8670.6	7549.5	14.8	4.8	4.1	18.2
Indonesia	455.0	494.8	-8.1	1369.9	1575.4	-13.0	3.0	3.2	-5.4
Iran	514.1	439.0	17.1	2115.0	1897.1	11.5	4.1	4.3	-4.8

	Emissions – base-year (2000)			Emissions – 2050			Emissions relative to 2000-levels in 2050		
Country	**Höhne and Ullrich (2005)**	**This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**
Iraq	98.7	99.5	-0.8	427.7	416.7	2.6	4.3	4.2	3.5
Ireland	68.1	66.1	3.0	73.4	81.0	-9.4	1.1	1.2	-12.0
Israel	78.7	77.3	1.8	319.6	347.5	-8.0	4.1	4.5	-9.6
Italy	551.3	535.1	3.0	591.5	650.1	-9.0	1.1	1.2	-11.7
Jamaica	125.2	13.0	863.7	192.0	43.8	338.8	1.5	3.4	-54.5
Japan	1352.4	1334.9	1.3	1094.8	1251.9	-12.5	0.8	0.9	-13.7
Jordan	26.2	23.8	10.3	120.2	97.1	23.7	4.6	4.1	12.1
Kazakhstan	161.9	159.1	1.7	288.2	311.6	-7.5	1.8	2.0	-9.1
Kenya	26.7	54.4	-50.9	420.4	313.3	34.2	15.8	5.8	173.4
Kiribati	0.0	0.1	-47.6	0.0	0.1	-48.7	1.1	1.1	-2.1
Korea (North)	203.0	208.7	-2.8	504.3	432.9	16.5	2.5	2.1	19.8
Korea (South)	475.8	525.9	-9.5	1310.0	1353.3	-3.2	2.8	2.6	7.0
Kuwait	71.6	68.9	3.9	335.0	321.1	4.3	4.7	4.7	0.4
Kyrgyzstan	14.5	7.1	102.3	25.4	13.9	82.0	1.8	1.9	-10.0
Laos	10.5	6.7	57.1	22.5	13.8	63.8	2.2	2.1	4.3
Latvia	9.9	10.4	-5.2	20.9	21.0	-0.4	2.1	2.0	5.1
Lebanon	19.9	18.1	9.5	83.8	75.2	11.4	4.2	4.1	1.8
Lesotho	2.0	3.0	-32.0	10.8	6.5	67.3	5.3	2.2	145.9
Liberia	1.9	2.4	-20.8	10.4	9.8	6.5	5.4	4.0	34.5
Libya	56.6	54.5	3.8	313.8	346.3	-9.4	5.5	6.4	-12.7
Liechtenstein	0.2			0.3			1.2		
Lithuania	21.1	21.1	-0.2	34.1	41.8	-18.5	1.6	2.0	-18.3
Luxembourg	6.2	9.2	-33.0	7.4	11.1	-33.3	1.2	1.2	-0.4
Madagascar	30.6	33.0	-7.5	107.6	123.7	-13.0	3.5	3.7	-5.9
Malawi	6.0	6.7	-10.2	19.0	16.5	14.9	3.2	2.5	28.0
Malaysia	142.3	168.1	-15.4	504.4	581.5	-13.3	3.5	3.5	2.5
Maldives	0.3	0.7	-51.2	2.4	3.8	-35.7	7.3	5.6	31.6
Mali	10.1	26.3	-61.5	54.7	80.1	-31.6	5.4	3.0	77.5
Malta	2.4	2.3	3.5	2.2	2.9	-23.2	0.9	1.2	-25.8
Marshall Islands	0.0			0.0					
Mauritania	4.7	14.0	-66.5	31.2	58.4	-46.6	6.7	4.2	59.5
Mauritius	2.4	3.9	-38.1	55.7	63.5	-12.3	22.9	16.2	41.6
Mexico	501.0	511.2	-2.0	1426.8	1704.4	-16.3	2.8	3.3	-14.6
Moldova	8.1	10.9	-25.5	14.6	21.4	-31.6	1.8	2.0	-8.2
Monaco	0.1			0.1			1.2		
Mongolia	30.4	27.6	10.5	48.8	36.5	33.6	1.6	1.3	21.0
Morocco	52.9	59.0	-10.4	307.8	315.7	-2.5	5.8	5.3	8.8
Mozambique	17.6	15.6	12.8	35.1	38.3	-8.4	2.0	2.5	-18.8
Myanmar	70.5	82.5	-14.5	154.7	194.2	-20.3	2.2	2.4	-6.9
Namibia	6.0	10.7	-44.1	26.0	27.1	-4.2	4.4	2.5	71.4
Nauru	0.1	0.2	-29.3	0.1	0.2	-37.6	1.1	1.2	-11.7
Nepal	26.5	31.0	-14.3	53.0	66.6	-20.5	2.0	2.2	-7.2
Netherlands	218.2	218.3	0.0	239.4	266.7	-10.2	1.1	1.2	-10.2
New Zealand	70.7	82.0	-13.9	81.8	85.7	-4.6	1.2	1.0	10.8
Nicaragua	9.8	13.0	-24.2	23.1	32.9	-29.8	2.3	2.5	-7.3
Niger	5.6	12.7	-55.8	32.0	44.7	-28.4	5.7	3.5	61.9
Nigeria	213.2	162.6	31.1	1275.0	857.7	48.7	6.0	5.3	13.4
Niue	5.1			5.0			1.0		
Norway	57.7	50.7	13.8	61.1	64.6	-5.4	1.1	1.3	-16.9
Oman	29.0	29.8	-2.8	134.7	133.3	1.0	4.7	4.5	3.9
Pakistan	280.9	285.6	-1.7	999.3	965.9	3.5	3.6	3.4	5.2
Palau	0.0	0.2	-99.1	0.0	0.3	-99.2	1.1	1.3	-9.8
Panama	13.2	11.7	12.7	34.0	33.6	1.2	2.6	2.9	-10.2
Papua New Guinea	17.0	8.7	96.2	21.1	9.1	131.6	1.2	1.1	18.1
Paraguay	158.3	26.2	505.0	221.6	58.2	280.7	1.4	2.2	-37.1
Peru	74.6	69.9	6.8	254.3	202.2	25.7	3.4	2.9	17.7
Philippines	121.3	131.0	-7.5	385.1	427.2	-9.9	3.2	3.3	-2.6
Poland	385.5	375.6	2.6	556.6	654.0	-14.9	1.4	1.7	-17.1
Portugal	83.6	87.6	-4.6	91.9	106.9	-14.0	1.1	1.2	-9.9
Qatar	41.7	39.7	5.0	203.7	175.9	15.8	4.9	4.4	10.2
Romania	156.1	135.8	14.9	216.5	231.6	-6.5	1.4	1.7	-18.7
Russian Federation	2029.2	1906.5	6.4	3348.5	3805.9	-12.0	1.7	2.0	-17.3
Rwanda	2.5	4.0	-36.5	16.8	20.9	-19.5	6.7	5.3	26.7
Saint Kitts & Nevis	0.2	0.1	84.6	0.5	0.4	41.2	2.7	3.5	-23.5

	Emissions – base-year (2000)			Emissions – 2050			Emissions relative to 2000-levels in 2050		
Country	**Höhne and Ullrich (2005)**	**This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**	**Linear downscaling method- Höhne and Ullrich (2005)**	**Non-linear downscaling of This study**	**Difference (%)**
Saint Lucia	1.0	0.6	79.9	2.7	1.9	44.1	2.6	3.2	-19.9
Saint Vincent & Grenadines	0.4	0.2	79.5	0.9	0.7	14.5	1.9	3.0	-36.2
Samoa	0.8	0.1	450.8	1.2	0.2	569.7	1.5	1.3	21.6
San Marino	0.0			0.0			1.1		
Sao Tome & Principe	0.1	0.1	-5.7	0.9	1.0	-11.7	9.6	10.3	-6.4
Saudi Arabia	347.8	330.0	5.4	1524.8	1530.3	-0.4	4.4	4.6	-5.5
Senegal	15.4	18.9	-18.8	152.2	80.9	88.1	9.9	4.3	131.6
Serbia & Montenegro	56.4	60.8	-7.3	81.3	115.0	-29.3	1.4	1.9	-23.7
Seychelles	0.3	0.3	12.2	5.6	5.1	10.3	18.7	19.0	-1.7
Sierra Leone	3.2	4.1	-23.4	16.2	15.9	1.5	5.1	3.9	32.6
Singapore	33.3	64.2	-48.2	120.9	250.6	-51.8	3.6	3.9	-6.9
Slovakia	47.3	44.6	5.9	86.3	82.5	4.6	1.8	1.8	-1.2
Slovenia	21.4	19.8	7.8	35.7	37.6	-5.2	1.7	1.9	-12.1
Solomon Islands	0.5	0.4	7.2	0.5	0.5	7.7	1.1	1.1	0.4
South Africa	361.8	413.4	-12.5	1243.2	2127.1	-41.6	3.4	5.1	-33.2
Spain	387.0	382.2	1.2	419.4	470.1	-10.8	1.1	1.2	-11.9
Sri Lanka	39.6	27.4	44.4	171.4	95.5	79.5	4.3	3.5	24.3
Sudan	90.9	99.7	-8.8	383.9	329.4	16.6	4.2	3.3	27.8
Suriname	2.5	3.5	-29.0	5.8	11.7	-50.2	2.4	3.4	-29.8
Swaziland	3.1	2.7	14.0	13.8	6.8	103.8	4.5	2.5	78.8
Sweden	69.7	63.7	9.6	79.8	77.7	2.6	1.1	1.2	-6.3
Switzerland	52.9	51.1	3.5	61.9	62.7	-1.2	1.2	1.2	-4.6
Syria	74.3	70.6	5.2	281.6	290.7	-3.1	3.8	4.1	-7.9
Taiwan	225.3	230.6	-2.3	625.5	578.4	8.1	2.8	2.5	10.7
Tajikistan	4.0	8.2	-51.7	8.2	30.4	-73.0	2.1	3.7	-44.0
Tanzania	57.1	61.5	-7.1	179.1	133.4	34.2	3.1	2.2	44.6
Thailand	275.3	261.5	5.3	853.1	822.3	3.7	3.1	3.1	-1.5
Timor-Leste (East Timor)	0.1			0.5			3.8		
Togo	8.3	6.0	37.1	85.9	27.2	216.1	10.4	4.5	130.6
Tonga	0.1	0.3	-54.0	0.1	0.3	-46.5	1.2	1.1	16.4
Trinidad & Tobago	24.4	21.5	13.4	79.8	69.9	14.2	3.3	3.3	0.6
Tunisia	31.6	30.2	4.7	179.7	179.0	0.4	5.7	5.9	-4.1
Turkey	304.9	362.6	-15.9	1201.7	1425.4	-15.7	3.9	3.9	0.3
Turkmenistan	47.4	62.3	-23.9	83.3	121.8	-31.6	1.8	2.0	-10.2
Tuvalu	0.0			0.0	0.0		0.9		
Uganda	53.0	26.8	97.9	523.4	87.1	500.9	9.9	3.3	203.7
Ukraine	446.6	522.6	-14.6	787.4	1018.9	-22.7	1.8	1.9	-9.5
United Arab Emirates	105.4	107.9	-2.3	515.7	539.4	-4.4	4.9	5.0	-2.1
United Kingdom	650.5	662.1	-1.8	693.6	798.3	-13.1	1.1	1.2	-11.6
United States of America	7079.6	6936.6	2.1	7107.9	7383.5	-3.7	1.0	1.1	-5.7
Uruguay	33.2	25.5	30.2	62.2	63.3	-1.8	1.9	2.5	-24.5
Uzbekistan	196.6	181.0	8.6	363.4	357.1	1.8	1.8	2.0	-6.3
Vanuatu	1.2	0.9	31.8	1.3	0.9	47.7	1.1	1.0	12.0
Venezuela	244.1	240.7	1.4	1093.0	883.4	23.7	4.5	3.7	22.0
Vietnam	115.2	128.6	-10.4	293.0	341.9	-14.3	2.5	2.7	-4.3
Yemen	20.2	24.7	-18.4	70.1	97.5	-28.2	3.5	3.9	-12.0
Zambia	22.5	18.6	21.1	45.3	45.4	-0.4	2.0	2.4	-17.7
Zimbabwe	26.6	33.8	-21.4	123.1	116.7	5.5	4.6	3.5	34.2
average difference*			50.2			55.5			26.2
OECD90	13963	13634	2.4	14252	15013	-5.1	1.0	1.1	-7.3
E. Europe and FSU	4138	4039	2.4	6787	7820	-13.2	1.6	1.9	-15.3
Asia	9030	9736	-7.3	26590	27467	-3.2	2.9	2.8	4.4
ALM	6156	6043	1.9	24839	24936	-0.4	4.0	4.1	-2.2
Annex I	17497	17100	2.3	20458	21688	-5.7	1.2	1.3	-7.8
non-Annex I	15485	15989	-3.2	51269	53376	-3.9	3.3	3.3	-0.8
Global	33286	33452	-0.5	71782	80174	-10.5	2.2	2.4	-10.0

***** Defined as the sum of the absolute differences of the countries included (only those where data was available for both studies) divided by the number of countries.

* Note: the absolute numbers here represent the median over the six scenarios.

Source: FAIR 2.1 world model

Appendix B Regions and countries used for the costs calculations

Table B.1 Regions and countries used for the abatement cost calculations within the FAIR 2.1 world model

Region	Countries included		
01 Canada	Canada		
02 USA	United States of America		
03 Mexico	Mexico		
04 Rest of Central America	Antigua & Barbuda Bahamas Barbados Belize Costa Rica Cuba Dominica	Dominican Republic El Salvador Grenada Guatemala Haiti Honduras Jamaica	Nicaragua Panama Saint Kitts & Nevis Saint Lucia St Vincent & Gren. Trinidad & Tobago
05 Argentina	Argentina		
06 Brazil	Brazil		
07 Venezuela	Venezuela		
08 Rest of South America	Bolivia Chile Colombia	Ecuador Guyana Paraguay	Peru Suriname Uruguay
09 Egypt	Egypt		
10 Northern Africa	Algeria Libya	Morocco Tunisia	
11 Nigeria	Nigeria		
12 Rest of Western Africa	Benin Burkina Faso Cameroon Cape Verde Central African Republic Chad Congo Congo Dem. Rep.	Côte d'Ivoire Equatorial Guinea Gabon Gambia Ghana Guinea Guinea-Bissau Liberia	Mali Mauritania Niger Sao Tome & Principe Senegal Sierra Leone Togo
13 Eastern Africa	Burundi Comoros Djibouti Eritrea	Ethiopia Kenya Madagascar Mauritius	Rwanda Seychelles Sudan Uganda
14 South Africa	South Africa		
15 Rest of Southern Africa	Angola Botswana Lesotho Malawi	Mozambique Namibia Swaziland	Tanzania Zambia Zimbabwe
16 France	France		
17 Germany	Germany		
18 Italy	Italy		
19 the Netherlands	Netherlands		
20 Spain	Spain		
21 United Kingdom	United Kingdom		
22 Rest of EU-15 Northern countries	Belgium Denmark	Finland Luxembourg	Sweden
23 Rest of EU-15 Northern countries	Greece	Portugal	
24 Rest of OECD Europe	Austria Iceland Liechtenstein	Ireland Malta Monaco	Norway San Marino Switzerland

25 Czech Republic	Czech Republic		
26 Hungary	Hungary		
27 Poland	Poland		
28 Rest of New member States	Bulgaria Belarus	Estonia Slovakia	Latvia
29 Rest of Eastern Europe	Albania Bosnia & Herzegovina	Croatia Macedonia, FYR	Romania Serbia & Montenegro Slovenia
30 Kazakhstan	Kazakhstan		
31 Russian Federation	Russian Federation		
32 Ukraine	Ukraine		
33 Former USSR	Armenia Azerbaijan Georgia	Kyrgyzstan Lithuania Moldova	Tajikistan Turkmenistan Uzbekistan
34 Iran	Iran		
35 Saudi Arabia	Saudi Arabia		
36 Rest of Middle East	Bahrain Cyprus Iraq Israel	Jordan Kuwait Lebanon Oman Qatar	Syria Turkey UAE Yemen
37 India	India		
38 Pakistan	Pakistan		
39 Rest of South Asia	Afghanistan Bangladesh	Bhutan Maldives	Sri Lanka Nepal
40 China	China		
41 Korea (South)	Korea (South)		
42 Korea (North)	Korea (North)		
43 Rest of East Asia	Mongolia	Taiwan	
44 Indonesia	Indonesia		
45 Malaysia	Malaysia		
46 Singapore	Singapore		
47 Rest of South East Asia	Brunei Cambodia Laos	Myanmar Philippines	Thailand East Timor Vietnam
48 Australia	Australia		
49 New Zealand	New Zealand		
50 Rest of Oceania	Cook Islands Fiji Kiribati Marshall Islands Micronesia, Fed. St	Nauru Niue Palau Papua New Guinea	Samoa Solomon Islands Tonga Tuvalu Vanuatu
51 Japan	Japan		

Appendix C Indexing countries

This appendix gives the indexing for the different countries for this study using the default data for excluding LDCs (default, Table C.1) and including LDCs (Table C.2).

Table C.1. Results of indexing for 2000 (default calculations). LDCs (in bold) and some NICs or Other DCs (in italics) are excluded from the indexing

Country	**Income (in PPP $)**	**Population**	**Potential to mitigate – Energy CO_2 per GDP (weight: 1/6)**	**Potential to mitigate – All GHG per capita (weight: 1/6)**	**Responsibility – Cumulative average energy CO_2 per capita from 1990 (weight: 1/3)**	**Capability – Income (in PPP$)/cap (weight 1/3)**	**Aggregated index weighted**	**Resulting stage**	**Original SN proposal**
Units	**Billion US$**	**Million**	**Index**	**Index**	**Index**	**Index**	**Index**	**-**	**-**
Afghanistan	9.3	21.4	2	7	1	1	2	1	1
Albania	11.6	3.1	6	8	9	11	9	**2**	**2**
Algeria	150.6	30.2	14	25	23	15	19	3	3
Angola	22.2	12.4	7	15	4	5	7	**1**	**1**
Antigua & Barbuda	0.0	1.0	0	0	3	0	1	3	3
Argentina	412.7	37.1	8	52	29	34	31	3	3
Armenia	6.9	3.1	15	14	14	7	12	**2**	**2**
Azerbaijan	19.2	8.2	43	35	43	7	30	3	2
Bahamas	4.6	0.3	8	44	48	47	40	4	3
Bahrain	9.7	0.7	38	*165*	172	44	106	4	4
Bangladesh	196.8	138.0	4	6	1	4	4	1	1
Barbados	3.8	0.3	8	39	31	43	33	3	3
Belize	1.2	0.2	15	36	16	16	19	3	3
Benin	5.6	6.2	7	8	1	3	4	1	1
Bhutan	5.0	2.1	2	6	1	7	4	1	1
Bolivia	18.2	8.3	16	31	9	7	13	**2**	**2**
Bosnia & Herzegovina	15.4	4.0	22	28	24	12	20	3	3
Botswana	11.9	1.7	9	62	18	21	25	3	3
Brazil	1164.9	171.8	7	33	13	21	18	3	3
Brunei	8.2	0.3	19	*145*	162	75	107	4	4
Burkina Faso	11.1	11.9	2	12	1	3	4	1	1
Burundi	3.5	6.3	2	3	0	2	1	1	1
Cambodia	22.1	13.1	1	35	0	5	8	**1**	**1**
Cameroon	26.0	15.1	4	12	2	5	5	2	2
Cape Verde	1.9	0.4	3	3	2	13	6	1	1
Central African Republic	4.0	3.7	2	22	1	3	5	1	1
Chad	6.3	7.9	0	16	0	2	4	1	1
Chile	128.1	15.2	10	34	23	26	24	3	3
China	4523.7	1275.2	19	26	21	11	18	3	3
Colombia	236.6	42.1	7	26	13	17	16	3	3
Comoros	1.1	0.7	2	4	1	5	3	1	1
Congo	3.0	3.4	18	10	6	3	7	**2**	**2**
Cook Islands	0.1	0.0	12	12	11	11	11	**2**	**2**
Costa Rica	32.1	3.9	4	21	10	25	16	3	3
Côte d'Ivoire	23.0	15.8	7	7	2	4	5	2	2
Cuba	31.0	11.2	24	30	22	8	19	3	4
Cyprus	12.3	0.8	13	68	60	48	50	4	3
Dem. Republic Congo	31.0	48.6	2	7	1	2	2	1	1
Djibouti	1.2	0.7	7	18	5	5	8	**1**	**1**
Dominica	0.4	0.1	4	15	8	17	11	3	2
Dominican Republic	47.1	8.4	10	24	14	17	16	3	3
Ecuador	38.3	12.4	13	22	12	9	13	2	2
Egypt	220.5	67.8	14	18	13	10	13	2	2
El Salvador	26.7	6.2	6	13	7	13	10	3	3
Equatorial Guinea	7.1	0.5	2	19	5	48	21	3	1
Eritrea	2.8	3.7	5	1	1	2	2	1	1
Ethiopia	42.5	65.6	2	6	0	2	2	1	1
Federated States of Micronesia	0.2	0.1	0	0	0	5	2	2	2
Fiji	3.6	0.8	4	23	8	14	12	3	3
FYR Macedonia	12.2	2.0	17	37	38	18	28	3	2

Country	Income (in PPP $)	Population	Potential to mitigate – Energy CO_2 per GDP (weight: 1/6)	Potential to mitigate – All GHG per capita (weight: 1/6)	Responsibility – Cumulative average energy CO_2 per capita from 1990 (weight: 1/3)	Capability – Income (in PPP$)/cap (weight 1/3)	Aggregated index weighted	Resulting stage	Original SN proposal
Units	**Billion US$**	**Million**	**Index**	**Index**	**Index**	**Index**	**Index**	**-**	**-**
Gabon	7.1	1.3	12	38	24	17	22	3	2
Gambia	2.0	1.3	3	7	1	5	4	1	1
Georgia	0.0	1.0	0	0	42	0	14	**2**	**2**
Ghana	35.3	19.6	4	7	2	6	4	2	2
Grenada	0.6	0.1	3	10	14	21	14	3	3
Guatemala	41.5	11.4	6	13	5	11	8	**2**	**2**
Guinea	14.7	8.1	2	8	1	6	4	1	1
Guinea-Bissau	1.0	1.4	7	10	1	2	4	1	1
Guyana	2.8	0.8	13	34	15	11	17	3	3
Haiti	12.1	8.0	3	6	1	5	3	1	1
Honduras	14.9	6.5	8	14	5	7	8	**2**	**2**
India	2257.9	1016.9	11	12	7	7	8	**2**	**2**
Indonesia	593.9	211.6	13	16	11	9	11	**2**	**2**
Iran	362.8	66.4	22	44	38	17	29	3	3
Iraq	28.7	23.2	65	29	27	4	26	**2**	**2**
Israel	114.2	6.0	13	86	70	58	59	4	4
Jamaica	8.7	2.6	27	34	28	10	23	**2**	**2**
Jordan	18.1	5.0	20	32	23	11	20	3	3
Kazakhstan	65.9	15.6	47	68	100	13	57	4	4
Kenya	28.2	30.5	8	12	2	3	5	2	2
Kiribati	0.1	0.1	11	4	2	2	4	3	1
Korea (North)	31.7	22.3	122	63	140	4	79	4	4
Korea (South)	653.7	46.8	17	75	34	43	41	4	2
Kuwait	32.5	2.2	47	*206*	168	44	113	4	4
Kyrgyzstan	7.0	4.9	16	10	11	4	9	**2**	**2**
Laos	7.5	5.3	1	8	0	4	3	1	1
Lebanon	13.4	3.5	26	35	30	12	24	3	3
Lesotho	3.6	1.8	1	11	1	6	4	1	1
Liberia	1.7	2.9	6	6	1	2	3	1	1
Libya	61.2	5.2	19	70	73	36	51	4	2
Madagascar	12.1	16.0	5	14	1	2	4	1	1
Malawi	6.3	11.4	3	4	1	2	2	1	1
Malaysia	189.0	23.0	16	49	37	25	32	3	3
Maldives	2.9	0.3	5	16	9	30	17	1	1
Mali	8.1	11.9	2	15	0	2	4	1	1
Malta	6.4	0.4	8	40	45	50	40	4	3
Marshall Islands	0.1	0.1	0	0	0	5	2	2	2
Mauritania	4.5	2.6	16	35	9	5	13	**1**	**1**
Mauritius	10.5	1.2	7	22	15	27	19	3	3
Mexico	809.5	98.9	11	35	30	25	26	3	3
Moldova	5.1	4.3	34	17	25	4	18	**2**	**2**
Mongolia	3.7	2.5	44	74	27	5	30	3	2
Morocco	93.0	29.1	8	14	8	10	10	**2**	**2**
Mozambique	14.4	17.9	2	6	1	2	2	1	1
Myanmar	65.7	47.5	3	12	1	4	4	1	1
Namibia	10.1	1.9	4	38	6	16	15	3	2
Nauru	0.03	0.0	115	83	91	7	66	2	2
Nepal	28.6	23.5	3	9	1	4	3	1	1
Nicaragua	11.6	5.1	7	17	5	7	8	2	2
Niger	7.4	10.7	4	8	1	2	3	1	1
Nigeria	92.8	114.7	17	10	5	2	7	**2**	**2**
Niue	0.0	0.0	17	12	15	7	12	2	2
Oman	30.0	2.6	21	77	63	35	49	4	3
Pakistan	249.7	142.7	10	13	5	5	8	**2**	**2**
Palau	0.1	0.0	50	85	101	18	62	4	2
Panama	17.0	2.9	8	27	12	18	16	3	3
Papua New Guinea	11.7	5.3	5	11	4	7	6	2	2
Paraguay	23.0	5.5	4	32	5	13	12	3	2
Peru	113.0	26.0	6	18	8	13	11	3	3
Philippines	277.7	75.7	6	12	7	11	9	3	3
Qatar	21.5	0.6	41	*459*	424	113	262	4	4
Rwanda	7.9	7.7	2	3	1	3	2	1	1
Saint Kitts & Nevis	0.4	0.0	5	16	17	32	20	3	3
Saint Lucia	0.7	0.1	14	26	17	16	18	3	3

Country	**Income (in PPP $)**	**Population**	**Potential to mitigate – Energy CO_2 per GDP (weight: 1/6)**	**Potential to mitigate – All GHG per capita (weight: 1/6)**	**Responsibility – Cumulative average energy CO_2 per capita from 1990 (weight: 1/3)**	**Capability – Income (in PPP$)/cap (weight 1/3)**	**Aggregated index weighted**	**Resulting stage**	**Original SN proposal**
Units	**Billion US$**	**Million**	**Index**	**Index**	**Index**	**Index**	**Index**	**-**	**-**
Saint Vincent & Grenadines	0.6	0.1	7	14	9	15	11	3	3
Samoa	0.8	0.2	4	6	6	14	9	3	1
San Marino	0.7	0.0	0	0	0	80	27	3	2
Sao Tome & Principe	0.2	0.1	15	5	4	3	6	1	1
Saudi Arabia	255.6	22.1	28	100	96	35	65	4	4
Senegal	12.8	9.4	8	14	3	4	6	1	1
Serbia & Montenegro	32.8	10.6	32	39	39	10	28	3	2
Seychelles	2.6	0.1	2	23	18	100	43	3	2
Sierra Leone	1.9	4.4	7	6	1	1	3	1	1
Singapore	87.7	4.0	16	107	101	67	77	4	4
Solomon Islands	0.8	0.4	5	7	3	5	5	1	1
South Africa	381.3	44.0	22	63	65	27	44	4	3
Sri Lanka	59.2	18.6	4	10	3	10	7	**2**	**2**
Sudan	47.5	31.4	3	21	1	5	6	1	1
Suriname	1.2	0.4	44	55	41	8	33	3	4
Swaziland	4.2	1.0	3	17	4	12	9	3	2
Syria	50.8	16.6	25	29	22	9	19	**2**	**2**
Taiwan	724.5	22.2	7	70	64	100	67	4	2
Tajikistan	4.5	6.1	23	9	10	2	9	**2**	**2**
Tanzania	16.6	34.8	4	12	1	1	3	1	1
Thailand	356.2	60.9	11	29	20	18	19	3	3
Timor-Leste (East Timor)	0.3	0.7	0	0	0	1	0	2	2
Togo	6.0	4.6	6	9	2	4	4	1	1
Tonga	0.6	0.1	5	17	9	18	13	3	2
Trinidad & Tobago	10.6	1.3	44	112	101	25	68	4	4
Tunisia	54.8	9.5	9	21	16	18	16	3	3
Turkmenistan	15.0	4.6	87	90	104	10	68	4	4
Tuvalu	0.0	0.0	0	0	0	7	2	1	1
Uganda	27.3	23.5	1	8	0	4	3	1	1
United Arab Emirates	100.0	2.8	24	*257*	268	109	172	4	4
Uruguay	27.2	3.3	5	51	13	25	22	3	3
Uzbekistan	35.1	24.9	100	49	49	4	43	3	4
Vanuatu	0.6	0.2	4	30	3	9	10	**1**	**1**
Venezuela	125.6	24.3	32	67	54	16	40	4	2
Vietnam	144.9	78.1	8	11	3	6	6	2	2
Yemen	13.7	18.0	22	9	5	2	8	**1**	**1**
Zambia	7.5	10.4	6	12	2	2	4	1	1

Data sources: GDP: base year data from Word Bank (2004) and UNSTAT (2005); Population (UN, 2004a) and GHG emissions (CAIT: http://cait.wri.org)
Note: same as Table 3, but first column in alphabetical order.
Source: FAIR 2.1 world model

Appendix D Emission allowances under the 400 and 450 CO_2-only ppm scenario

This appendix compares the results of the 400 and 450 ppm CO_2-only concentration stabilisation scenarios with those of Höhne and Ullrich (2005). Höhne and Ullrich used their model to tune parameters in such a way that the reductions required of different country groups would lead to a CO_2 concentration stabilisation at 400 and 450 ppm CO_2 only, respectively. More specifically, the reduction percentages in Table D.1 are chosen such that the median of the global emission level over the six cases for the different SRES scenarios reaches the prescribed global total CO_2-only emissions of 10% and 30% above 1990 level in 2020, and 60% and 35% below 1990 level in 2050. This is valid for the 400 ppm and 450 ppm CO_2-only scenario, respectively. Höhne and Ullrich have chosen absolute limitation targets for NICs, not reductions relative to baseline emissions, as there is no methodology defined for countries to move from NIC to Annex I. In this method NICs are treated similarly to Annex I countries after 2020.

Table D.1. Configuration for the 400 and 450 ppm CO_2-only ppm scenario of Höhne and Ullrich (2005)

Region	Configuration	Year	400 ppm	450 ppm
Annex II	EU-25: reduce below 1990 level	in 2020	58%	40%
	Others: reduce below 1990 level	in 2020	50%	33%
	Reduction after 2020	per decade	42%	28%
Annex I but not Annex II	Reduce below 1990 level	in 2020	47%	28%
	Reduction after 2020	per decade	39%	25%
Newly industrialised countries (NIC)	Increase above 2000 level	in 2020	14%	39%
	Reduce below baseline emissions	in 2020		
	Reduction after 2020	per decade	37%	22%
	Reduce threshold NIC-RIDC	per decade after 2020	20%	20%
Rapidly industrialising countries (RIDC)	Reduce below baseline emissions	in 2020	30%	16%
	Reduction below baseline emissions	after 2020	40%	24%
	Reduce threshold RIDC-Other DC	per decade after 2020	20%	20%
Other developing countries (Other DCs)	Follow baseline emissions			
Least developed countries (LDCs)	Follow baseline emissions			

* Up to 2020, the assumptions were the same as in the political willingness scenario.

The calculations using the reduction parameters of the 400 ppm and 450 ppm CO_2-only scenario leads to lower emissions in 2020 as a result of the differences in the base-year data and downscaling methodology. The global emissions for the 400 ppm CO_2-only scenario are now just above 1990 levels in 2020, whereas in Höhne and Ullrich's calculations, these come up to a level of 20% above 1990 levels. For the 450 ppm CO_2-only scenario the difference is less, about +20% here vs. +30% by Höhne and Ullrich. However, in the long-term the emission reduction levels presented here are lower. The 400 ppm (450 ppm) CO_2-only scenario now only leads to global emissions of about 45% (15%) below 1990 levels, compared to 60% (35%) in Höhne and Ullrich.

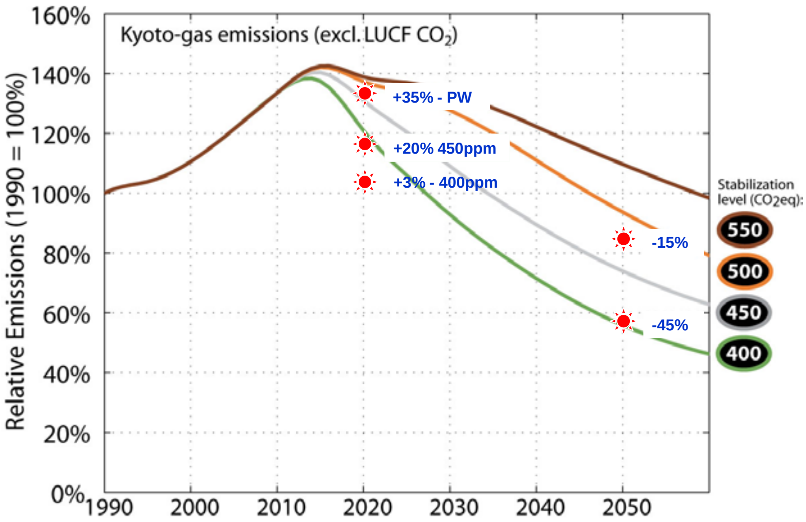


Figure D.1. The global emission reduction targets (small circles) of the 400 and 450 ppm CO_2-only scenario (for 2020 for the political willingness scenario) (see Figure D.2) compared with the multi-gas emission pathways (vertical lines) at 550, 500, 450 and 400 ppm CO_2-equivalent concentrations for the CPI+tech scenario (Figure 2).

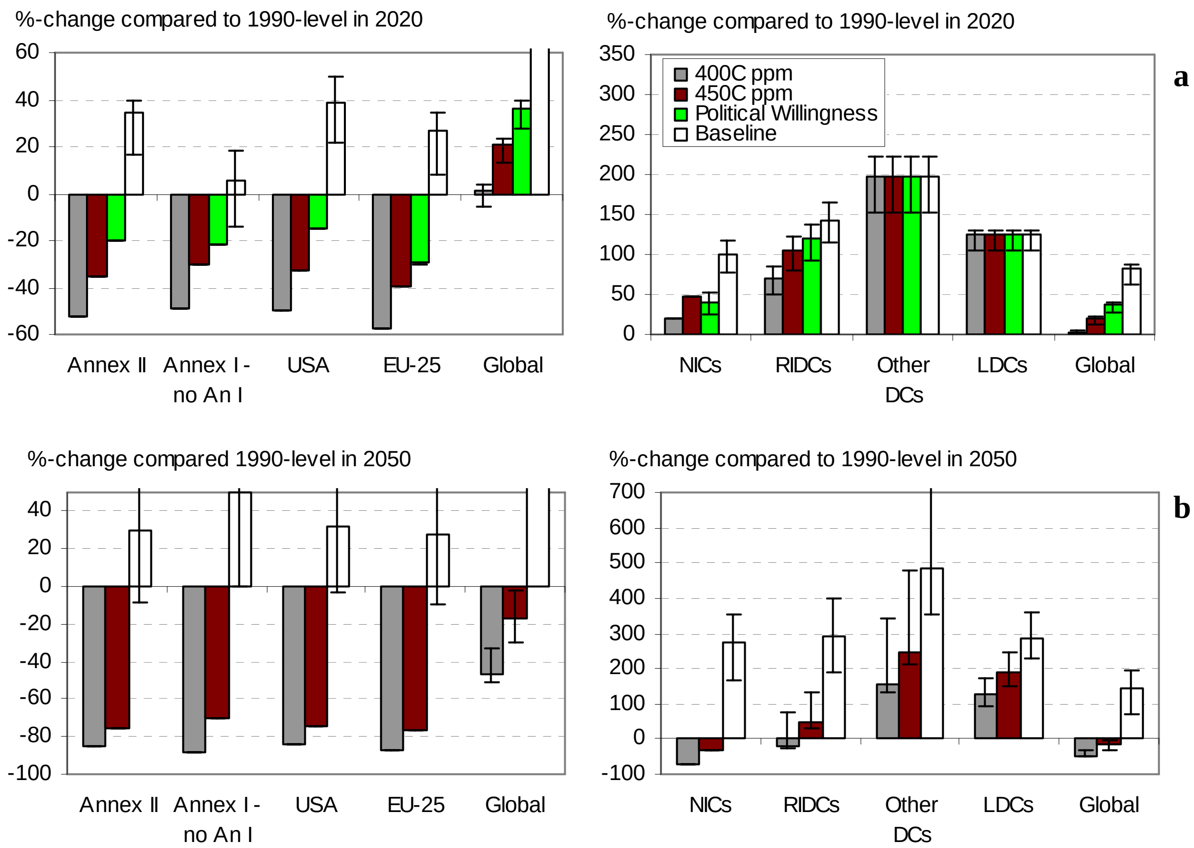


Figure D.2. Change in emission allowances compared to 1990 levels in 2020 (a) and 2050 (b) under the 400 and 450 CO_2-only ppm scenario compared to the baseline. The results of the "political willingness" are also given for 2020. The bars show the median over the six IMAGE IPCC SRES scenarios, with error bars covering the full range of the six scenarios.

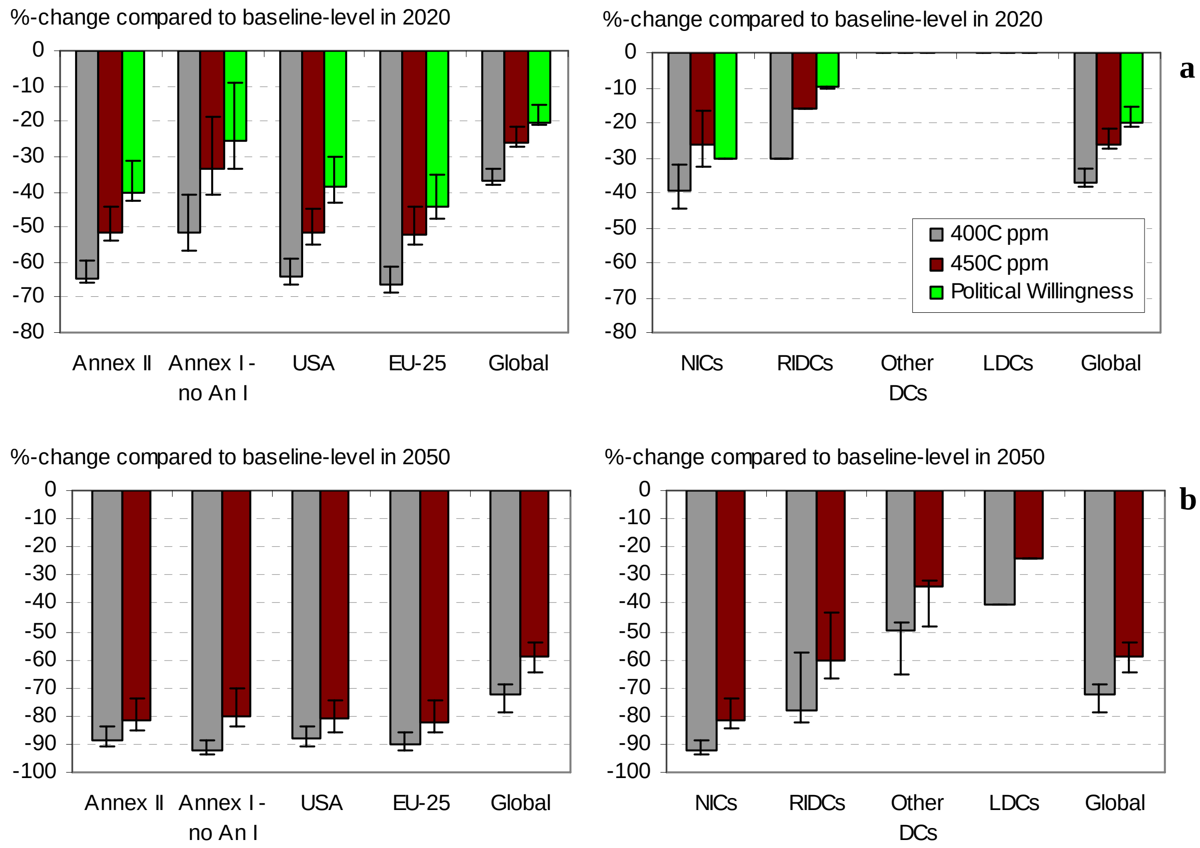


Figure D.3. Same as Figure D.2, but now compared to the baseline emissions.

The 450 ppm CO_2-only scenario leads to global CO_2-equivalent emissions of around 20% above 1990 levels in 2020 (Figure D.1), which corresponds with the 2020 target of the 400 ppm CO_2-equivalent multi-gas emission pathway of this study. The 400 ppm CO_2-only scenario leads to global CO_2-equivalent emissions much below the emission pathways (Figure 2). The main reason for the more stringent emission targets in the pathways in Höhne and Ullrich (2005) is that their emission pathways do not include a temporarily overshoot of the final stabilisation levels, as allowed in the multi-gas pathways, but already mentioned in section 1. Their more stringent global emission targets (in particular for the 400 ppm scenario) leads to very high, and maybe "unrealistic" fast and deep emission reduction commitments, in particular, for the EU-25 and the rest of Annex I in the short term (2020-2025) (see Figure D.2). This becomes very clear in comparing the emission reductions to the baseline emissions, as given in Figure D.3. For the 400 ppm CO_2-only scenario the EU-25 reductions compared to the baseline emissions rise as high as 70%. Such stringent reductions would seem politically, technically and economically unfeasible.
The short-term global CO_2-equivalent emission targets are less stringent in this study (Section 3). For example, the global emissions target for 2020 for the most stringent concentration target (400 ppm CO_2-eq) here corresponds with Höhne and Ullrich's 450 ppm CO_2-only target (about 500-525 ppm CO_2-eq). For this reason, the 2020 reduction settings (i.e. the values of the 2020 reduction and limitation targets) of the 450 ppm CO_2-only scenario are used as the basis for developing the 400 ppm CO_2-equivalent scenario of this study. Nevertheless, after 2020 the reductions will need to be enhanced to meet the global emissions target of 45% below 1990 levels in 2050. Finally, the reductions relative to baseline emissions for NICs for 2020 have been adopted here, and not the absolute limitation target, considering that an absolute target will lead to even higher emissions

(compare the NICs emission allowances of the political willingness scenario with the 450 ppm scenario).