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Evolution of commitments under the UNFCCC: Involving newly industrialized economies and developing countries

by

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16. Kurzfassung Diese Studie hat zum Ziel, Hintergrundinformationen zum Thema zukünftiger Verpflichtungen unter der Klimarahmenkonvention (UNFCCC) in übersichtlicher Form bereitzustellen. Insbesondere wird darauf eingegangen, wie Schwellenländer und Entwicklungsländer mit in das Verpflichtungsregime einbezogen werden können. Dazu werden bereits existierende Ansätze zur Einbeziehung von Schwellen- und Entwicklungsländern identifiziert, bewertet und weiterentwickelt.		
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16. Abstract This study has as objective to provide the history and background information on the evolution of commitments under the UNFCCC in a structured manner, where the involvement of newly industrialized economies and developing countries in further commitments under the UNFCCC is of particular concern. For this purpose, existing approaches to further commitments are identified, assessed and further developed.		
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SUMMARY

International negotiations have lead to first steps in combating climate change with the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Under the Protocol, industrialized countries have to reduce their greenhouse gas emissions by around five per cent between 2008 and 2012 compared to 1990 levels. It is however broadly recognized that further steps are necessary to stabilize the climate in the long term.

Therefore, this study has as objective to provide the history and background information on the evolution of commitments under the UNFCCC in a structured manner, where the involvement of newly industrialized economies and developing countries in further commitments under the UNFCCC is of particular concern. For this purpose, existing approaches to further commitments are identified, assessed and further developed.

The starting point is a detailed overview of the current commitments of states under the UNFCCC and the Kyoto Protocol and the relation of these commitments to the reduction necessary to reach a stabilization of the climate. While the reduction of global emissions below 1990 levels within a few decades is necessary to stabilize greenhouse gas concentrations at relatively low levels, most business-as-usual scenarios show increasing emissions, particularly in developing countries.

As a next step, the study includes a discussion of the preconditions and specific difficulties relating to further commitments. These include first the rules of the negotiation process (e.g. that decisions have to be made by consensus) and the history of the negotiations on this topic. Although it was agreed that the negotiations leading to the Kyoto Protocol should only include a discussion on commitments for industrialized countries, some industrialized countries wanted to broaden this mandate, but failed until Kyoto. Also the negotiations after Kyoto on future commitments were always deferred over the question, whether to include commitments for developing countries. Furthermore, the magnitude and scope of the necessary changes necessary to combat climate change, the inertia of the climate system and the scientific uncertainties make it difficult to reach agreement. And lastly, differences in national circumstances and the resulting positions towards commitments are major obstacles.

A separate chapter discusses the equity principles that are embedded in the Convention and that are used in the context of further commitments. We conclude that it is essential that a future approach to commitments satisfies the equity principles '*need*' (allowing economic development to satisfy basic needs), '*responsibility*' (those should act that caused the problem: polluter pays) and '*capability*' (those should act that have the economic capacity: ability to pay).

A survey and literature search of approaches to further commitments reveals that many approaches are available that either describe a particular aspect of commitments (e.g. how to distribute emission rights between a group of countries) or a complete climate commitment regime with all its detail. From this variety of approaches we identified the issues that are relevant in the discussion on further commitments: Should there be a step-by-step approach or a comprehensive approach that is guided by a long-term stabilization target? Should all countries receive the same type of commitment (as e.g. in the Kyoto Protocol) or should several types of commitments exist in parallel (as e.g. the limitation of emissions per gross domestic product for some countries)? Should there be quantified national emission reduction targets or non-quantified targets such as policies and measures? If quantified targets are chosen, what is the stringency of target? What are the consequences if the commitment is not met? Which countries participate and when? How can political agreement be build? All of the above questions have to be answered to describe a complete approach to future commitments.

The study includes also a first snapshot of the views on future commitments among a limited number of delegates to the UNFCCC process. The interviewed delegates see the issue as fundamental, but did not have fully developed opinions or concepts. There is a feeling of need for action on the one hand but mistrust on the other. We conclude that more creative thinking, discussion and education are needed.

The focus of this study is to compare the most prominent approaches to commitments. We selected eight approaches covering a broad range of options not prejudging that there could

be additional options. Where necessary, we extended them into complete global commitment regimes, as to be able to compare them on the same grounds. These illustrative cases include:

- **Continuing Kyoto** assuming that more and more countries join the group countries with binding absolute emission reduction targets.
- **Intensity targets** assuming that all countries reduce their greenhouse gas intensity (greenhouse gas emissions per unit of GDP) at the same rate.
- **Contraction and Convergence** assuming converging per-capita emissions of all countries to equal levels.
- **Global Triptych approach** deriving national targets from bottom-up sectoral targets (CO_2 from energy only).
- **Multi-sector convergence approach** deriving national targets from converging per-capita sectoral targets.
- **Multistage approach (FAIR)** assuming that countries participate in the commitment regime in four stages, 'graduating' from one to the next.
- **Equal mitigation cost** assuming that targets are set distributing the economic burden equally over all countries, base on an agreed model.
- **Coordinated policies and measures** assuming that countries are obliged to implement certain coordinated policies and measures.

After a first consideration of these illustrative cases we included additional new ideas, how some of those proposals could be modified to increase their effectiveness and acceptability. These include:

- **Extended global Triptych** deriving national targets from bottom-up sectoral targets covering all relevant greenhouse gases and sources.
- **New multistage approach** assuming as a first stage to commitments a pledge for sustainable development and as further stages quantitative emission limits.
- **Performance targets** deriving dynamic national targets from dynamic sectoral targets based on emissions per unit of output.

All illustrative cases are described in full detail, including any assumptions. For all approaches, the allowed emissions of all countries are modeled. Subsequently, we assess the approaches with respect to common assessment criteria to test their suitability for the international negotiation process. The criteria include:

Environmental criteria

- **Environmental effectiveness**: Can the approach reach stringent global emission targets to safeguard the fulfilment of the ultimate objective of the Convention?
- **Encouragement of early action**: Are countries that do not yet have binding commitments encouraged to keep emissions as low as possible?

Political criteria

- **Equity principles**: Are the three equity principles *need*, *capability* and *responsibility* covered?
- **Agreement with fundamental positions of all major constituencies**: Could the approach be acceptable for all constituencies given their current positions?

Economic criteria

- **Accounting for structural differences between countries**: Are national circumstances accounted for?

- **Minimizing adverse economical effects**: Does the approach allow distribution of commitments so that the global costs are minimized and gives countries sufficient flexibility to reach their commitments?

Technical criteria

- **Compatibility with the structure of the UNFCCC and the Kyoto Protocol**: Is the approach compatible with the existing international structures of the Convention and the Kyoto Protocol?
- **Moderate political and technical requirements of the negotiation process**: Is the approach simple and requires a low number of separate decisions by international bodies and are all necessary data and tools available and verifiable?

Comparing the different approaches across the different criteria is a subjective task, which depends on the judgment, whether an approach meets the criterion, and the weight given to the individual criteria. The Table S1 below provides an attempt for such a comparison. The eight criteria are evaluated for each approach and rated 'completely not met' (--), 'mainly not met' (-), 'neutral' (0), 'mainly met' (+) and 'completely met' (++). '/' denotes that the criterion may or may not be fulfilled depending on the specific variation of the approach. As an attempt to further condense the assessment, always two criteria are grouped together to four general criteria (environmental, political, economic and technical). The first column of Table S1 provides a possible weighting for these general criteria. A further condensation of the ratings, however, is left to the reader.

Table S1. Indicative assessment matrix for the qualitative comparison of the approaches

Criterion \ Approach	Possible weighting	Continuing Kyoto	Intensity targets	Contraction and convergence	Global Triptych (CO_2 only)	Multi-sector convergence approach	Multistage approach (FAIR)	Equal mitigation cost	Coordinated Policies and measures	Extended global Triptych	New multistage	Performance targets
Environmental criteria	**3**	**+**	**0**	**++**	**+**	**++**	**+**	**0**	**+**	**+**	**++**	**+**
Environmental effectiveness		++	+	++	++	++	++	++	0	++	++	+
Encouragement of early action by Parties that do not yet have binding commitments		-	-	++	0	+	/	--	++	0	+	+
Political criteria	**3**	**0**	**0**	**0**	**+**	**0**	**++**	**0**	**0**	**+**	**++**	**0**
Equity principles		+	0	+	+	+	++	0	-	+	++	+
Agreement with fundamental positions of major constituencies		0	+	-	+	0	+	-	0	+	+	0
Economic criteria	**2**	**0**	**0**	**-**	**+**	**+**	**+**	**++**	**-**	**++**	**+**	**++**
Accounting for structural differences between countries		/	/	--	+	+	+	++	-	++	+	++
Minimizing adverse economic effects		+	+	+	+	+	+	++	-	+	+	+
Technical criteria	**1**	**++**	**0**	**++**	**0**	**0**	**+**	**-**	**0**	**0**	**+**	**0**
Compatibility with UNFCCC and Kyoto Protocol		++	+	+	+	+	+	+	0	+	+	+
Moderate political and technical requirements of the negotiation process		++	-	++	-	-	+	--	-	-	+	-

Note: '--' criterion completely not met, '-' criterion mainly not met, '0' neutral, '/' depends on the specific variation of the approach, '+' criterion mainly met, '++' criterion completely met

From the comparison of the approaches, we draw the following conclusions:

Several approaches are available that would lead to emissions consistent with stringent environmental goals. For all approaches, reductions additional to those in the Kyoto Protocol are necessary.

Significant reductions by industrialized countries are necessary for all these approaches in the order of cutting emissions more than in half by 2050 and continuing to decrease to leave some room for increasing developing country emissions and still to reach stringent environmental goals.

Early involvement of developing countries is needed inducing deviation from current business-as-usual paths. This can be achieved through emission limitation and reduction targets, but also through an enhanced sustainable development approach and through positive spillover of emission reductions from developed countries to developing countries. Not many of the existing approaches encourage early action by countries that are not yet participating.

A good mix of several elements could be a compromise with a higher chance of being accepted since all constituencies find elements of their concern in such mixed approach.

Differentiation not solved: No generally acceptable approach is available how to differentiate targets within a group of countries although many indicators and approaches are available.

Continuing Kyoto without any changes or additions would be an obvious option for future commitments. Stringent environmental goals can, however, only be reached if current Annex I countries decrease their emissions more than for the first commitment period (2008 to 2012) and if developing countries deviate from their business-as-usual paths at an early stage. In this system a method to differentiate the targets for the participating countries is to be found. Taking on absolute emission targets may be difficult for some developing countries due to the uncertainty in the development of the emissions. To help these countries, relatively small additional changes in the rules could be introduced such as 'price caps' (additional permits at a fixed price) or slightly looser compliance mechanisms.

Intensity targets can play a role in future commitments as one form of target for a particular group of countries, possibly in parallel to other types of targets for other countries. If it is applied to all countries, the global emission intensity (Emissions per GDP) has to decrease rapidly (2%-4% per year) in order to reach stringent environmental goals. If equal percentage reductions in emission intensity are agreed for a group of countries, those are in advantage that have higher economic growth. Agreeing on differentiated intensity reductions is more difficult than absolute reductions, since it involves country specific knowledge of the relationship between emissions and GDP, which also may evolve with time.

Contraction and convergence, where per-capita emissions converge, is intriguing due to the simplicity of the approach. Since major reductions in emissions are necessary it is likely, that in the long run under any regime per-capita emissions will converge to a very low level. The question is on which path. The simplicity of the approach is also the major disadvantage: The approach does not account for the structural differences of countries and their ability to decrease their emissions. For stabilization levels of 450 or 550 ppmv CO_2, per-capita emissions have to decrease below the current world average. Also many developing countries would have to decrease emissions below their business as usual path and only a few least developed countries could sell for as short period of time easily earned emission allowances to developed countries.

The Triptych approach has potential as a method to differentiate emission reduction targets between members of a group of countries. The extended version presented here also can accommodate the emission structure of developing countries and includes forestry and non-CO_2 greenhouse gas emissions. Such differentiation approach can produce a starting point for a negotiation between the countries of that group.

Multi-stage approaches will be the future of the climate regime, but there are many possibilities on types of stages and thresholds for moving into a next stage. The current two stages (Annex I and Non Annex I) could be extended. As one promising criteria to move to a further

stage would be the emissions per capita. As a first stage, a well-defined commitment to sustainable development could increase the acceptability for developing countries.

The multi-sector convergence approach is describing a complete set of rules for a future climate regime defining in essence the path on which sectoral per-capita emissions converge. A major downside of the approach is that sectoral activities are not necessarily directly related to the population.

Equal mitigation costs: Setting targets so that mitigation costs are equal for all participating countries (e.g. a percentage share of the GDP) seems to be, from a theoretical point of view, a fair option. In practice, however, it may be impossible to agree on a model or calculation method for calculating the cost of countries. It is therefore not a realistic option.

Policies and measures can also be a part of a mix. Especially for newly entering countries, policies that combine development and environment objectives are very attractive and could form a first stage of commitments.

From the overall report we make the following recommendations:

Start an informal, international dialogue process to educate a discussion and to build trust among delegations outside of the formal negotiations, bringing together scientists and policy makers to discuss the science of climate change (stabilization of greenhouse gas concentrations, range of uncertainties) and possible actions (absolute and intensity targets, form and stringency, sustainable development approach). Such trust building and educating dialogue could help to unblock the official negotiations on future commitments.

Build trust by action: The perception by most developing countries, that Annex I countries do not take sufficient action, blocks the discussion on future commitments. This leads to the (almost trivial) recommendation, that Annex I countries have to build trust by actively reducing emissions, getting involved in the CDM and making available the agreed funds. This also includes working with the USA to find ways of their participation as well as the clear communication of actions taken and results achieved to date. In any case, strong efforts by developed countries are likely to also have reducing effects on developing country emissions (positive spillover).

Stress the need for significant reduction in Annex I countries in the long term: This and other analyses show that in all scenarios that lead to ambitious long-term goals, industrialized countries have to reduce emissions significantly until 2050, otherwise no room is available for moderately increasing developing country emissions. Efforts should focus on actions that reduce emissions not only temporarily in the short-term but sustainably in the long run. A clear statement by developed countries to this effect could be a signal to developing countries.

Build upon existing system, but be creative: Most approaches can be build upon the existing system that is already agreed by the international community: Legally binding emission targets for some countries, inclusion of all greenhouse gases in a basket, commitment periods, emissions trading, limited use of forestry activities, incentives for developing countries to participate e.g. through CDM. The structure allows to build in creative new approaches. E.g. emission intensity targets could be integrated in a further development of the Kyoto Protocol, if so desired.

Support early involvement (not necessarily 'participation') by all countries: Our analysis shows that the way emissions are shared depends to a large extent on the business-as-usual path that is chosen for the analysis. Sustainable development of *all* countries, not including policies aimed directly at the climate, is equally important for low emissions as reductions induced by commitments under the UNFCCC. Unconstrained business-as-usual emissions of Non-Annex I Parties will foreclose certain options for stabilization. All efforts have to be made to enable developing countries to develop in a sustainable way. Further thoughts are necessary how development along such a sustainable path way can be achieved, e.g. use of the currently available tools, such as the financial cooperation, CDM or additional investment programmes. Additionally, initial further commitments for developing countries could take the form of a pledge for enhanced sustainable development or targets that allow economic growth but limit emissions at the same time.

Work together with the Group of 77 and China to break the deadlock: The G77 stands as a group in the international negotiations and is likely to do so in the near future, although the interests of the members of the group are diverse. In the past, efforts by some developing counties to break out of the group to take on commitments have failed, mainly due to the opposition within the G77. Currently, it seems unlikely that only some developing countries take on commitments. One way to overcome this problem could be to agree on a total indicative target for the G77 and let the group decide itself which members have to take which action.

Let countries place themselves in groups: Until the present some industrialized countries stated the general condition of 'meaningful participation of developing countries', but did not differentiate, which of the developing countries are expected to act. Indicators, that would define when a country has to take on climate commitments, are available (greenhouse gas emissions, emissions per GDP, GDP per capita, human development index, vulnerability etc.) but no single one, or combination, is generally acceptable to all countries. Collection of data on such indicators can support a process in which countries are asked to place themselves in one of a number of groups, e.g. 'binding target', 'voluntary, non-binding target', 'No need to act'. Such process would have to take into account the structure of the G77 as explained above. Publicly available indicators and political pressure could move countries to place themselves in a certain group.

Allow diverse forms of targets: Several forms of targets are available. In a diverse world possibly many different approaches need to be available to account for the diverse needs of all countries. One way to accomplish this would be the 'menu approach' to let (newly entering) groups of Parties choose the appropriate form of their target from options such as absolute targets, GDP intensity, certain policies and measures. The form of the target is not significant as long as it is ensured that the targets are stringent enough.

Focus on forms of targets allow developing country economic growth but limit emissions: Absolute targets are seen by developing countries as capping their economic growth. Intensity targets are intending to provide such flexibility but may not do so, if they are set stringently or emission intensive activities increase that do not contribute much to the GDP. 'Performance targets', that are dynamic as intensity targets, but relate to the activity level not the GDP, or the Triptych approach could provide room for economic growth in activities to a greater extent but limit emissions per level of activity. Technology standards also do not limit activities but limit only the specific emissions. Also the pledge for sustainable development focuses on the *development* first and is therefore attractive.

Focus long-term discussion on the lost options: If greenhouse gas concentration levels, for example on 450 or 550 ppmv CO_2, or maximum levels of climate change, such as 2°C temperature rise, cannot be agreed, a discussion could be framed around questions such as 'At what level of global emissions in the year 2020 do we loose the option to stabilize concentrations at 450 ppmv CO_2?'. Answers could lead to the definition of an intermediate global emission target, for e.g. 2020, from which it would still be possible to reach several concentration levels.

Be prepared to evaluate targets of other countries: From the procedural point of view, there are at least two ways to agree on commitments: Countries propose targets for themselves, all evaluate each others proposals and then start to negotiate. Alternatively, a chairman or another person with the political responsibility makes a proposal based on a scientifically credible formula and the following negotiations will provide for the exceptions to particular national circumstances. Countries need to have the analytical capacity to evaluate the proposals by other countries. If a government is supporting the chairman, it must have the capacity to make a scientifically based proposal.

To reach agreement on future commitments in the international climate negotiations will not be an easy task. There are however a large number of approaches available and it seems possible that a mix of several approaches can lead to a compromise. The most important at this moment seems to be to provide information and to stimulate a discussion on the scientific as well as on the policy level. The authors would welcome, if this report would contribute to such a discussion.

ZUSAMMENFASSUNG

In den internationalen Verhandlungen zum Klimawandel hat sich die Staatengemeinschaft mit der Klimarahmenkonvention und mit dem Kyoto-Protokoll auf erste Schritte zur Reduktion von Treibhausgasemissionen geeinigt. Mit dem Kyoto-Protokoll gehen Industrieländer die Verpflichtung ein, ihre absoluten Emissionen um rund fünf Prozent zu senken. Es ist jedoch allgemein anerkannt, dass weitere Verpflichtungen und eine Ausweitung der Gruppe der reduzierenden Staaten nötig sind, um das Klima langfristig zu stabilisieren.

Die vorliegende Studie hat deshalb zum Ziel, Hintergrundinformationen zum Thema zukünftiger Verpflichtungen unter der Klimarahmenkonvention (UNFCCC) in übersichtlicher Form bereitzustellen. Insbesondere wird darauf eingegangen, wie Schwellenländer und Entwicklungsländer mit in das Verpflichtungsregime einbezogen werden können. Dazu werden bereits existierende Ansätze zur Einbeziehung von Schwellen- und Entwicklungsländern identifiziert, bewertet und weiterentwickelt.

Ausgangspunkt ist ein detaillierter Überblick, welche Verpflichtungen für Staaten unter der Klimarahmenkonvention und dem Kyoto Protokoll bereits bestehen und in welchem Verhältnis sie zu den nötigen Reduktionen stehen, die eine Stabilisierung des Klimas gewährleisten würden. Während die Stabilisierung bei niedrigen Treibhausgaskonzentrationen die Reduktion der globalen Treibhausgasemissionen unter das Niveau von 1990 in wenigen Jahrzehnten erfordert, beschreiben die meisten Referenzszenarien stark ansteigende Emissionen, insbesondere in Entwicklungsländern.

Als nächster Schritt werden die Grundvoraussetzungen und spezifischen Schwierigkeiten beschrieben, die im Hinblick auf zukünftige Verpflichtungen zu berücksichtigen sind. Dazu gehören zunächst die Regeln des internationalen Verhandlungsprozesses (z.B. dass Entscheidungen im Konsens gefällt werden müssen) und die Verhandlungsgeschichte. Obwohl in der Vorverhandlung zum Kyoto-Protokoll festgelegt wurde, lediglich neue Verpflichtungen für Industrieländer zu verhandeln, gab es Bestrebungen von Seiten einiger Industrieländer, das Mandat auch auf einige Entwicklungsländer auszuweiten, die jedoch bis Kyoto gescheitert sind. Auch in den folgenden Verhandlungen wurde das Thema der zukünftigen Verpflichtungen immer wieder über die Frage vertagt, ob Entwicklungsländer in Zukunft strengere Verpflichtungen erhalten sollten. Des weiteren tragen auch das Ausmaß und der Umfang der nötigen Maßnahmen zur Reduktion des Klimawandels, die Trägheit des Klimasystems und die wissenschaftliche Unsicherheiten dazu bei, dass sich eine Einigung auf zukünftige Verpflichtungen schwierig gestaltet. Nicht zuletzt sind die unterschiedlichen wirtschaftlichen und sozialen Ausgangssituationen und Interessen der Staaten zu nennen, die zu sehr gegensätzlichen politischen Positionen führen.

Ein separates Kapitel dieser Studie befasst sich mit den Gerechtigkeitsprinzipien, die in der Klimakonvention verankert sind und die im Zusammenhang mit zukünftigen Verpflichtungen genannt werden. Wir kommen zum Schluss, dass ein zukünftiges System von Verpflichtungen mindestens die folgenden drei Gerechtigkeitsprinzipien erfüllen muss: ‚*Bedürfnis*' (Zugeständnis der wirtschaftlichen Entwicklung, um Grundbedürfnisse zu befriedigen), ‚*Verantwortung*' (Derjenige der den Schaden verursacht muss handeln: Das Verursacherprinzip) und ‚*Leistungsfähigkeit*' (Derjenige muss handeln, der dazu wirtschaftlich in der Lage ist: Das Leistungsfähigkeitsprinzip).

Eine Bestandsaufnahme zum Thema der zukünftigen Verpflichtungen ergibt, dass vielfältigste Ansätze vorhanden sind, die entweder Teilaspekte abdecken (z.B. beschreiben wie Emissionsrechte innerhalb einer Gruppe von Staaten verteilt werden könnten) oder ein komplettes Regime beschreiben. Von dieser Vielfältigkeit motiviert werden die Gesichtspunkte herausgearbeitet, die für eine Entscheidung über zukünftige Verpflichtungen relevant sind: Sollte es ein Ansatz sein, der Schritt für Schritt vorgeht oder ein Ansatz, der umfassend und langfristig ausgerichtet ist, in dem er auf ein konkretes Stabilisierungsziel hinarbeitet? Sollten allen Staaten die gleiche Art von Verpflichtungen zugeordnet werden (wie zum Beispiel die des Kyoto Protokolls) oder sollten verschiedene Arten von Verpflichtungen parallel existieren (wie zum Beispiel auch die zusätzliche Begrenzung der Emissionen pro Bruttoinlandsprodukt für einige Länder)? Sollten die Verpflichtung quantifiziert im Sinne von Emissionsreduktionszielen oder nicht quantifiziert im Sinne von spezifischen Klimaschutzmaßnahmen sein? Im Falle von quantifizierten Zielen, wie streng sollten diese Ziele sein? Was passiert wenn die Verpflich-

tungen nicht eingehalten werden? Welche Länder nehmen teil und wann? Wie kann der Prozess der politischen Einigung unterstützt werden? All diese Fragen müssen beantwortet werden, um ein System zukünftiger Verpflichtungen umfassend zu beschreiben.

Als einen weiteren Schritt haben wir eine erste Momentaufnahme der Ansichten von Delegierten der internationalen Klimaverhandlungen zu zukünftigen Verpflichtungen zusammengestellt. Die Befragten schätzten dieses Thema als sehr wichtig ein, hatten aber zumeist noch keine komplette Meinung oder detaillierte Konzepte parat. Auf der einen Seite sprach man sich für rasches Handeln aus, auf der anderen herrschte eine Stimmung des Misstrauens. Dies lässt die Schlussfolgerung zu, dass neue Ideen, Diskussion und Austausch nötig sind.

Der Schwerpunkt dieser Studie ist der Vergleich der wichtigsten Ansätze zu zukünftigen Verpflichtungen, der im folgenden näher beschrieben werden soll. Acht Ansätze wurden ausgewählt, um ein möglichst breites Spektrum abzudecken, ohne sich jedoch auf diese sieben festzulegen. Falls die Ansätze nur Teilaspekte beinhalteten, wurden sie zu umfassenden Verpflichtungsregimen erweitert, um sie verglichen zu können. Diese veranschaulichenden Fälle sind:

- **Weiterführen des Kyoto Protokolls** ohne Änderung der Regeln, so dass mehr und mehr Länder in die Gruppe der reduzierenden Länder aufrücken und absolute Emissionsreduktionsziele erhalten.
- **Begrenzung der Treibhausgasintensität**, alle Länder müssen ihre Treibhausgasintensität (Emissionen pro Bruttoinlandsprodukt) um die gleiche Rate senken.
- **Verringerung und Konvergenz**, Pro-Kopf-Emissionen konvergieren für alle Länder.
- **Globaler Triptych-Ansatz**, nationale Emissionsziele werden aus sektoralen Zielen abgeleitet (nur energiebezogenes CO_2).
- **Multisektorkonvergenz-Ansatz,** nationale Emissionsziele werden aus konvergierenden sektoralen Pro-Kopf-Zielen abgeleitet.
- **Mehrstufen-Ansatz (FAIR)**, vier verschiedene Stufen von Verpflichtungen werden von neu hinzukommenden Ländern nacheinander durchlaufen.
- **Ausgeglichene Vermeidungskosten**, Emissionsreduktionsziele werden mit Hilfe eines allgemein akzeptierten Modells auf die Staaten verteilt, so dass die wirtschaftliche Belastung in jedem Land gleich ist.
- **Koordinierte Maßnahmen**, Staaten müssen bestimmte festgelegte Maßnahmen zu Emissionsreduktion umsetzen.

Nach einer ersten Analyse der obengenannten Fälle wurden neue Ideen hinzugefügt, um die mögliche Akzeptanz und Effektivität der Ansätze zu verbessern:

- **Erweiterter Triptych-Ansatz,** nationale Emissionsziele werden aus sektoralen Zielen abgeleitet, wobei alle relevanten Treibhausgase und Sektoren berücksichtigt werden.
- **Neuer Mehrstufen-Ansatz**, als erste Stufe der Verpflichtungen für neue Staaten steht die Verpflichtung nachhaltige Entwicklung zu betreiben, gefolgt von Stufen der absoluten Emissionsminderung.
- **Leistungsziele**, dynamische Emissionsziele abgeleitet aus dynamischen sektoralen Zielen basierend auf Emissionen pro Produktionseinheit.

Alle Fälle werden im Detail und mit allen Annahmen beschrieben. Wo möglich, werden die Emissionsrechte der einzelnen Länder unter den verschiedenen Fällen berechnet. Anschließend werden die Fälle nach folgenden einheitlichen Kriterien bewertet:

Ökologische Kriterien

- **Sichert positive Umwelteffekte:** Können mit dem Ansatz ehrgeizige globale Ziele erreicht werden, die die Einhaltung des langfristigen Ziels der Klimarahmenkonvention ermöglichen?

- **Anreize für frühzeitige Umsetzung:** Ermutigt der Ansatz Staaten dazu, frühzeitig Emissionen so niedrig wie möglich zu halten?

Politische Kriterien

- **Gerechtigkeitsprinzipien**: Sind die drei Prinzipien *Bedürfnis*, *Verantwortung* und *Leistungsfähigkeit* beachtet worden?
- **Prinzipiell akzeptabel aus Sicht wichtiger Akteure:** Könnte der Ansatz von den wichtigsten Staaten unterstützt werden?

Ökonomische Kriterien

- **Berücksichtigung strukturelle Unterschiede:** Werden die unterschiedlichen nationalen Umstände explizit im Ansatz berücksichtigt?
- **Minimiert nachteilige wirtschaftliche Effekte**: Sind die nötigen Verpflichtungen so verteilt, dass die globalen Kosten minimiert sind und der Ansatz Raum für eine individuelle nationale Umsetzung lässt?

Technische Kriterien

- **Mit der Klimarahmenkonvention und dem Kyoto-Protokoll vereinbar**: Ist der Ansatz kompatibel mit den existierenden internationalen Strukturen der Klimarahmenkonvention und des Kyoto-Protokolls?
- **Moderate politische und technische Anforderungen im Verhandlungsprozesses:** Ist der Ansatz einfach, sind nur eine begrenzte Anzahl von Entscheidungen der verhandelnden Parteien nötig und sind alle nötigen Daten und Berechnungsmethoden verfügbar und überprüfbar?

Ein Vergleich der Ansätze über die Bewertungskriterien birgt subjektive Entscheidungen auf

Tabelle S1: Bewertungsmatrix für den qualitativen Vergleich der Ansätze

Kriterium / Ansatz	Mögliche Wichtung	Weiterführen des Kyoto Protokolls	Begrenzung der Treibhausgasintensität	Verringerung und Konvergenz	Globaler Triptych Ansatz (nur CO_2)	Multisektorkonvergenz-Ansatz	Mehrstufen-Ansatz (FAIR)	Ausgeglichene Vermeidungskosten	Koordinierte Maßnahmen	Erweiterter Triptych Ansatz	Neuer Mehrstufen Ansatz	Leistungsziele
Ökologische Kriterien	**3**	**+**	**0**	**++**	**+**	**++**	**+**	**0**	**+**	**+**	**++**	**+**
Sichert positive Umwelteffekte		++	+	++	++	++	++	++	0	++	++	+
Anreize für frühzeitige Umsetzung		-	-	++	0	+	/	--	++	0	+	+
Politische Kriterien	**3**	**0**	**0**	**0**	**+**	**0**	**++**	**0**	**0**	**+**	**++**	**0**
Gerechtigkeitsprinzipien		+	0	+	+	+	++	0	-	+	++	+
Prinzipiell akzeptabel aus der Sicht wichtiger Akteure		0	+	-	+	0	+	-	0	+	+	0
Ökonomische Kriterien	**2**	**0**	**0**	**-**	**+**	**+**	**+**	**++**	**-**	**++**	**+**	**++**
Berücksichtigung struktureller Unterschiede		/	/	--	+	+	+	++	-	++	+	++
Minimiert nachteilige wirtschaftliche Effekte		+	+	+	+	+	+	++	-	+	+	+
Technische Kriterien	**1**	**++**	**0**	**++**	**0**	**0**	**+**	**-**	**0**	**0**	**+**	**0**
Mit Klimarahmenkonvention und Kyoto Protokoll vereinbar		++	+	+	+	+	+	+	0	+	+	+
Moderate politische und technische Anforderungen im Verhandlungsprozess		++	-	++	-	-	+	--	-	-	+	-

Bemerkung: '--' Kriterium vollständig nicht erfüllt, '-' Kriterium nicht erfüllt, '0' neutral, '/' von der Ausgestaltung des Ansatzes abhängig, '+' Kriterium erfüllt, '++' Kriterium vollständig erfüllt

zwei Ebenen: Die Entscheidung, ob ein Kriterium für einen Ansatz zutrifft, und das Gewicht, das jedem einzelnen Kriterium zugeordnet wird. In Tabelle S1 wird ein solcher Versuch unternommen. Die acht Kriterien wurden für alle Ansätze mit ‚vollständig nicht erfüllt' (--), ‚nicht erfüllt' (-), ‚neutral' (0), erfüllt' (+) oder ‚vollständig erfüllt' (++) bewertet. Das Zeichen ‚/' zeigt an, dass eine Bewertung davon abhängt, wie der Ansatz im Detail ausgestaltet ist. Um die Bewertung zu verdichten, werden jeweils zwei Kriterien zu vier allgemeinen Kriterien zusammengefasst (ökologisch, politisch, ökonomisch und technisch). Die erste Spalte enthält zudem eine mögliche Wichtung der allgemeinen Kriterien. Eine weitere Verdichtung und Bewertung bleibt dem Leser überlassen.

Folgende Schlussfolgerungen werden aus dem Vergleich gezogen:

Mehrere Ansätze stehen zur Verfügung, die Emissionen minimieren könnten, um ehrgeizige langfristige Ziele zu erreichen. Unter allen Ansätzen sind Reduktionen zusätzlich zu den im Kyoto-Protokoll festgeschriebenen nötig.

Erhebliche Reduktionen in Industrieländern sind nötig, mindestens eine Halbierung der Emissionen bis 2050 und nachfolgend eine weitere Reduzierung, um ausreichend Raum für leicht ansteigende Emissionen für Entwicklungsländer zu lassen und gleichzeitig ehrgeizige langfristige Ziele zu erreichen.

Frühzeitige Einbindung von Entwicklungsländern ist nötig, um Emissionen unter die heute angenommenen zukünftigen Werte zu senken. Dies kann durch Emissionsminderungsziele erreicht werden, aber auch durch einen Ansatz, der verstärkt auf nachhaltige Entwicklung setzt, oder durch den positiven Einfluss von Emissionsreduktionen in Industrieländern auf Emissionen in Entwicklungsländern. Nur wenige der hier betrachteten Ansätze motivieren zu frühzeitigem Handeln in Abwesenheit von Reduktionszielen.

Eine gute Mischung von wichtigen Elementen verschiedener Ansätze könnte der Weg zu einer Lösung sein, da sich viele Teilnehmer in einem solchen gemischten Ansatz wiederfinden können.

Das Problem der Staffelung von Emissionsminderungszielen ist nicht gelöst. Mehrere Methoden und Indikatoren stehen zur Verfügung, Emissionsminderungsziele zwischen Ländern innerhalb einer Gruppe zu bestimmen. Keine Methode ist jedoch generell akzeptiert.

Eine Weiterführung des Kyoto-Protokolls ohne eine Änderung der Regeln wäre das offensichtliche Instrument zu zukünftigen Verpflichtungen. Ehrgeizige langfristige Ziele können erreicht werden, aber nur wenn Industrieländer erheblich striktere Ziele nach 2012 erhalten und Entwicklungsländer frühzeitig Emissionen unter die heute angenommenen zukünftigen Werte zu senken. Eine Methode, Emissionsreduktionsziele zwischen Ländern zu staffeln muss noch entwickelt werden. Die Unsicherheiten in der Hochrechnung der zukünftigen Emissionen könnten ein Hindernis für Entwicklungsländer sein, absolute Emissionsreduktionsziele zu akzeptieren. Um diesen Ländern entgegenzukommen, könnten relativ kleine Änderungen wie ein Preislimit für Emissionsrechte oder etwas gelockerte Regeln im Falle der Nicht-Erfüllung eingeführt werden.

Limitierung der Treibhausgasintensität kann als eine besondere Art von Emissionsreduktionszielen, möglicherweise zusammen mit absoluten Zielen, eine Rolle spielen. Für den Fall, das solche Ziele für alle Staaten angewandt werden, müsste die globale Emissionsintensität (Emissionen pro Bruttoinlandsprodukt) stark zurückgehen (2%-4% pro Jahr), um ehrgeizige langfristige Ziele zu erreichen. Wenn Reduktionen der Emissionsintensität für alle Länder um dieselbe Prozentzahl vorgeschrieben werden, profitieren die Länder, die ein überdurchschnittlich hohes Wirtschaftswachstum erreichen. Einigung über Intensitätsziele könnte schwieriger sein als bei absoluten Zielen, da Kenntnis der länderspezifischen Beziehung zwischen Emissionen und Bruttoinlandsprodukt notwendig ist.

Verringerung und Konvergenz (konvergierende Pro-Kopf-Emissionen) ist ein faszinierender Ansatz, hauptsächlich durch seine Einfachheit. Unter jeglichem Ansatz werden auf lange Sicht Pro-Kopf-Emissionen auf einem sehr niedrigen Niveau konvergieren. Die entscheidende Frage ist aber auf welchem Pfad. Die Schlichtheit des Ansatzes ist jedoch auch sein größter Nachteil: Strukturelle Unterschiede zwischen Staaten können nicht berücksichtigt werden. Um die Stabilisierung der CO_2-Konzentration bei 450 oder 550 ppmv zu erreichen, müssen die Pro-Kopf-Emissionen auf ein Niveau unter dem jetzigen Weltmittel sinken. Zudem müssten

viele Entwicklungsländer Ihre Emissionen unter den vorhergesagten Werten halten. Nur die kleine Gruppe der am wenigsten entwickelten Länder könnte für kurze Zeit relativ einfach verdiente Emissionsrechte verkaufen.

Der Triptych-Ansatz ist eine sehr leistungsfähige Methode, in einer objektiven Weise Emissionsreduktionsziele auf Länder einer Gruppe aufzuteilen. Die erweiterte Version, die hier vorgestellt wurde, beinhaltet nun auch die Emissionssektoren, die insbesondere für Entwicklungsländer relevant sind. Ergebnisse eines solchen Ansatzes können Ausgangspunkt für politische Verhandlungen sein.

Der Mehrstufen-Ansatz beschreibt einen generellen Rahmen der die Grundlage für ein zukünftiges Klimaregime bilden könnte. Die Einzelheiten können jedoch vielfältig ausgestaltet werden. Die jetzigen zwei Stufen (Annex I und Nicht-Annex I) könnten erweitert werden. Ein Grenzwert für Pro-Kopf-Emissionen empfiehlt sich als ein Kriterium, um auf eine nächste Stufe zu rücken. Die Akzeptanz von Entwicklungsländern könnte erhöht werden, wenn als ersten Stufe eine wohldefinierte Verpflichtung zur nachhaltige Entwicklung gewählt würde.

Der Multisektorkonvergenz-Ansatz beschreibt eine komplettes Regelwerk für ein Klimaregime, in dem Pro-Kopfemissionen auf einem bestimmten Pfad konvergieren. Als Nachteil ist zu werten, dass Emissionen bestimmter Sektoren nicht unbedingt mit der Bevölkerungszahl korrelieren.

Ausgeglichene Vermeidungskosten als Methode, um Emissionsreduktionsziele auf Länder aufzuteilen, ist auf den ersten Blick eine faire Lösung. Die technische Umsetzung über ein allgemein anerkanntes Modell scheint jedoch unrealistisch.

Koordinierte Maßnahmen können Teil eines gemischten Ansatzes sein. Speziell für neu hinzukommende Länder ist es attraktiv, entwicklungspolitische Maßnahmen mit Klimaschutzmaßnahmen zu verbinden.

Aus den hier angestellten Überlegungen geben wir die folgenden Empfehlungen:

Ein internationaler, inoffizieller Dialog könnte neue Informationen in die Diskussion tragen und Vertrauen unter den Delegierten fördern. Ein solcher Dialog würde Wissenschaftler sowie politische Entscheidungsträger an einem Tisch versammeln, um die wissenschaftlichen Grundlagen (Stabilisierung der Treibhausgaskonzentrationen und Unsicherheiten) und mögliche Ansätze (absolute Ziele, Emissionsintensität, Ansatz der nachhaltigen Entwicklung) zu diskutieren. Ein solch informierender und vertrauenbildender Dialog könnte Schwung in die festgefahrenen offiziellen Verhandlungen bringen.

Vertrauen bilden durch Handeln: Die Ansicht der meisten Entwicklungsländer, dass Annex-I-Länder (Industrieländer) ihre Emissionen nicht ausreichend reduzieren, blockiert die Diskussion über zukünftige Verpflichtungen. Dies führt zu der (fast trivialen) Empfehlung, dass Annex-I-Länder dieses Vertrauen zurückgewinnen können, in dem sie aktiv Emissionen mindern, aktiv am Clean Development Mechanism (CDM) teilnehmen und die vereinbarten Gelder bereitstellen. Dazu gehört auch, sich gegenüber den USA für eine Umsetzung von Klimaschutzmaßnahmen einzusetzen sowie die national umgesetzten Maßnahmen und Erfolge klar zu kommunizieren. Es scheint sicher, das Emissionsreduktionen in Industrieländern langfristig auch zu niedrigeren Emissionen in Entwicklungsländern führen wird.

Betonung der Notwendigkeit signifikanter Emissionsreduktionen in Industrieländern auf lange Sicht: Wie bereits andere Studien zeigt auch diese, dass unter allen Szenarien die Industrieländer ihre Emissionen bis 2050 signifikant reduzieren müssen, um Raum für wachsende Emissionen von Entwicklungsländern zu lassen und um gleichzeitig ehrgeizige umweltpolitische Ziel zu erreichen. Anstrengungen müssen unternommen werden, Emissionen langfristig nachhaltig zu senken. Eine klare Äußerung der Industrieländer dahingehend wäre ein Signal für Entwicklungsländer.

Kreativ auf dem existierenden System aufbauen: Die meisten Ansätze können in das existierende System des Kyoto Protokolls eingebettet werden: Bindende Emissionsreduktionsziele, bezogen auf eine Gruppe von Gasen, Verpflichtungsperioden, Emissionshandel, begrenzte Nutzung natürlicher Senken, Anreize für Entwicklungsländer durch z.B. CDM. Die Struktur ist flexibel, kreative neue Vorschläge aufzunehmen. Intensitäts-Ziele, zum Beispiel, könnten integriert werden, falls erwünscht.

Unterstützung frühzeitiger Einbeziehung (nicht unbedingt „participation“) aller Länder: Die Ergebnisse dieser Studie zeigen, dass die Art und Weise, wie Emissionsrechte verteilt werden, sehr stark von den Annahmen des Referenzszenarios abhängen. Nachhaltige Entwicklung für alle Länder, direkte Maßnahmen zum Klimaschutz ausgenommen, ist ebenso wichtig für niedrige Emissionen wie Emissionsreduktionen, die durch Verpflichtungen unter der Klimarahmenkonvention hervorgerufen werden. Uneingeschränkter Emissionszuwachs von Entwicklungsländern würde gewisse Stabilisierungsziele unerreichbar machen. Alle Anstrengungen müssen unternommen werden, Entwicklungsländern zu ermöglichen, sich nachhaltig zu entwickeln. Mehr Analyse ist notwendig, wie solch ein nachhaltiger Entwicklungspfad beschritten werden kann, zum Beispiel durch die existierenden Kanäle der technischen Zusammenarbeit und des Clean Development Mechanisms (CDM) oder durch zusätzliche Investitionsprogramme. Zusätzlich könnten Entwicklungsländer als ersten Schritt sich zu nachhaltiger Entwicklung verpflichten oder Emissionsreduktionsziele annehmen, die gleichzeitig Emissionen begrenzen und wirtschaftliche Entwicklung erlauben.

Zusammenarbeit mit der Gruppe der 77 und China: Die Entwicklungsländer haben sich in den internationalen Verhandlungen zu einer festen Gruppe, die G77, zusammengeschlossen, obwohl die Interessen der einzelnen Mitglieder der Gruppe sehr unterschiedlich sind. Staaten der G77, die in der Vergangenheit versucht hatten, freiwillig Verpflichtungen zu übernehmen, sind gescheitert, meist an der Opposition innerhalb der G77. Es erscheint daher unwahrscheinlich, dass *einzelne* Staaten der G77 Verpflichtungen übernehmen würden. Eine mögliche Lösung wäre es, der G77 ein Gesamtziel zu übertragen, dass dann innerhalb der Gruppe aufgeteilt wird.

Einteilung in Gruppen von Staaten selbst: In der Vergangenheit wurde oft von Seiten der Industrieländer der Ruf nach „wirksamer Beteiligung“ von Entwicklungsländern laut, ohne dass differenziert wurde, genau welche Länder handeln sollten. Indikatoren, die anzeigen würden, welche Länder Verpflichtungen übernehmen sollten, sind vorhanden (Emissionen, Emissionen pro BIP, BIP pro Kopf, Entwicklungsindices etc.), aber kein einzelner oder keine Kombination der Indices ist allgemein akzeptiert. Vergleichbare Daten könnten einen Prozess unterstützen in dem sich Staaten selbst in Gruppen einteilen, wie zum Beispiel „Bindende Ziele“, „Freiwillige nichtbindende Ziele“ und „Keine Ziele“. Ein solcher Prozess müsste die Struktur der G77 berücksichtigen. Annerkannte, öffentliche, vergleichbare Daten und politischer Druck könnten Länder dazu bewegen sich einer bestimmten Gruppe zuzuordnen.

Zulassen verschiedener Arten von Zielen: Viele verschiedenen Arten von Zielen stehen zu Verfügung. Unter 180 Staaten könnte es von Nöten sein, verschiedene Arten von Zielen zuzulassen, um die nationalen Gegebenheiten der einzelnen Staaten berücksichtigen zu können. Es wäre zum Beispiel möglich, dass in einem „Menu Ansatz“ (neu hinzukommende) Staaten sich eine Art von Ziel von einer Liste möglicher Ziele aussuchen könnten (z.B. absolute Emissionsreduktionsziele, Intensitätsziele, bestimmte Klimaschutzmassnahmen). Die *Art* der Verpflichtung ist nicht ausschlaggebend, solange die *Strenge* ausreichend ist.

Konzentration auf Ziele, die Emissionen begrenzen und Entwicklung begünstigen: Absolute Emissionsziele werden von Entwicklungsländern oft als eine Begrenzung des Wirtschaftswachstums angesehen. Intensitätsziele sollten eine solche Flexibilität erlauben, können aber ebenso strikt sein, wenn sie sehr hohe Reduktionen verlangen oder wenn Emissionen in Bereichen steigen, die wenig zum BIP beitragen. „Leistungsziele“, die dynamisch sind wie Intensitätsziele, werden aber auf Aktivitätsdaten und nicht auf das BIP bezogen. Der Triptych-Ansatz erlaubt Wachstum in der Produktion, und limitiert Emissionen pro Produktionseinheit. Technologiestandards begrenzen ebenfalls nur spezifische Emissionen. Des weiteren konzentriert sich der Ansatz der nachhaltigen Entwicklung zunächst auf *Entwicklung* und nicht in erster Linie auf Klimaschutz und ist deshalb attraktiv.

Diskussion möglicher entgangener Stabilisierungsoptionen: Falls maximale Konzentrationsniveaus wie 450 oder 550 ppmv CO_2 oder Maximalwerte für Klimaänderungen, wie 2°C Erderwärmung, nicht abgestimmt werden können, so könnte man eine Diskussion um das Thema führen: „Bei welchem Niveau globaler Emissionen in 2020 ist die Option bei 450 ppmv zu stabilisieren außer Reichweite?“. Antworten auf diese Frage könnten zu einem mittelfristigen Zwischenziel für globale Emissionen führen, von dem aus verschiedene Konzentrationsniveaus erreicht werden können.

Ziele anderer Staaten beurteilen können: Formal könnten zukünftige Verpflichtungen auf mindestens zwei Arten zustande kommen: Staaten tragen konkrete Ziele vor, alle Staaten beurteilen die Ziele der anderen und starten Verhandlungen. Als Alternative könnte ein(e) Vorsitzende(r) Ziele für die einzelnen Staaten vorschlagen, basierend auf einem wissenschaftlichen, transparenten System. Dieser Vorschlag würde in den anschließenden Verhandlungen den einzelnen nationalen Unterschieden angepasst. In beiden Fällen müssen Länder die Ziele anderer Länder beurteilen können. Regierungen, die die Vorsitzende / den Vorsitzenden stellen, müssen in der Lage sein einen solchen wissenschaftliche transparenten Vorschlag zu machen.

Eine Einigung auf zukünftige Verpflichtungen in den internationalen Klimaverhandlungen ist keine einfache Aufgabe. Es liegen jedoch mehrere potenzielle Ansätze vor und es scheint möglich, aus einer Mischung verschiedener Ansätze einen Kompromiss zu bilden. Zum jetzigen Zeitpunkt besteht jedoch zunächst ein großer Informations- und Diskussionsbedarf auf der wissenschaftlichen wie auch auf der politischen Ebene. Es ist im Sinne der Autoren wenn diese Studie zu einer solchen Diskussion beiträgt.

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1. INTRODUCTION

The objective of this report is to provide the history and background information on evolution of commitments under the United Nations Framework Convention on Climate Change (UNFCCC), in particular involving newly industrialized economies and developing countries in further commitments under the UNFCCC as well as to further analyze existing approaches, develop new approaches and to make recommendations on future steps. It intends to help shape a German position in the international negotiations on this issue.

The reader should bear in mind that this work intends to provide useful background information for the negotiations. The analysis can provide helpful insights on targets, for example, whether to use absolute emission targets or dynamic ones and possible levels. The elaboration of such theoretical approaches may however not be capable to replace entirely the "real negotiations" on the targets that will take place on the international level.

There were two occasions during the international negotiations on climate change where quantitative commitments were agreed: The commitments by countries as inscribed in Annex B to the Kyoto Protocol are a result of the negotiations before and in Kyoto 1997. During the negotiations the *form* of the targets was agreed (binding emission limits), but the *stringency* of the target was based partly on Parties' choices. At a late point in the negotiations in Kyoto, Parties were asked to provide proposals for their individual targets. These targets were finally adopted with only minor changes (see UNFCCC 2000). Similarly, four years later, Parties were asked to provide their country specific limits for the use of forest management activities in official submissions. For most Parties, these levels were accepted with a package of agreements in Bonn 2001.

This project, of which this is the final report, was initiated October 2001. It produced an interim report in April 2002 and was finalized in December 2002.

This final report is structured as follows: Chapter 2 provides a discussion why further commitments under the UNFCCC are necessary. The current commitments are compared to emission limits needed to reach the stabilization of greenhouse gas concentrations. In chapter 3, the specific difficulties in agreeing further commitments are discussed. In chapter 4, the equity principles are discussed that are embedded in the Convention and that are used in the discussion on further commitments. Chapter 5 provides an overview of the approaches to further commitments that have been proposed in the past and lists the issues that are relevant in the discussion on further commitments. Chapter 6 elaborates on, and assesses, a limited but representative number of approaches. Chapter 7 provides ideas for new approaches or refines existing ones. Chapter 8 provides conclusions on all the considered approaches. Chapter 9 provides a discussion of some selected views of delegates to the climate negotiations on the topic of future commitment. Finally, chapter 10 provides some recommendations for the future.

2. THE NEED FOR THE EVOLUTION OF COMMITMENTS

This chapter provides an overview of the commitments of countries under the UNFCCC and the Kyoto Protocol. The expected development of emissions under these commitments is compared to emissions paths, that could successfully prevent dangerous interference with the climate system.

"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

Box 1. Article 2 of the UNFCCC

2.1 CURRENT COMMITMENTS UNDER THE UNFCCC AND THE KYOTO PROTOCOL

The United Nations Framework Convention on Climate Change (UNFCCC) has the ultimate objective to stabilize greenhouse gas concentration at a level that would prevent dangerous anthropogenic interference with the climate system (see Box 1).

To reach this goal, the UNFCCC builds upon the principle of common but differentiated responsibilities and capabilities of Parties. Accordingly, for the purpose of differentiating the obligations or commitments under the Conventions (and later the Kyoto Protocol), countries are

Table 1. Members of Annex I and their commitment under the Kyoto Protocol

Country	Member of Annex I	Member of Annex II	Economy in transition	Commitment inscribed in Annex B (in the EU burden sharing agreement)
Australia	X	X		108
Austria	X	X		92 (87)
Belarus	X		X	****
Belgium	X	X		92 (92.5)
Bulgaria	X		X	92
Canada	X	X		94
Croatia	X*		X	95
Czech Republic	X*		X	92
Denmark	X	X		92 (79)
Estonia	X		X	92
European Community	X	X		92
Finland	X	X		92 (100)
France	X	X		92 (100)
Germany	X	X		92 (79)
Greece	X	X		92 (125)
Hungary	X		X	94
Iceland	X	X		110
Ireland	X	X		92 (113)
Italy	X	X		92 (93.5)
Japan	X	X		94
Kazakhstan	X**		X	To be negotiated
Latvia	X		X	92
Liechtenstein	X*			92
Lithuania	X		X	92
Luxembourg	X	X		92 (72)
Monaco	X*			92
Netherlands	X	X		92 (94)
New Zealand	X	X		100
Norway	X	X		101
Poland	X		X	94
Portugal	X	X		92 (127)
Romania	X		X	92
Russian Federation	X		X	100
Slovakia	X*		X	92
Slovenia	X*		X	92
Spain	X	X		92 (115)
Sweden	X	X		92 (104)
Switzerland	X	X		92
Turkey	X	***		****
Ukraine	X		X	100
United Kingdom	X	X		92 (87.5)
United States of America	X	X		93

*: Added to Annex I at the third conference of the Parties in Kyoto 1997 (COP 3)
**: Added at COP7 only for the purpose of the Kyoto Protocol (see FCCC/CP/2001/13/Add.4, section V.C)
***: Deleted from Annex II by decision 26/CP.7
****: No limit specified. Country had not ratified the Convention when Kyoto Protocol was adopted

divided into three groups (see also Table 1 and Figure 1):

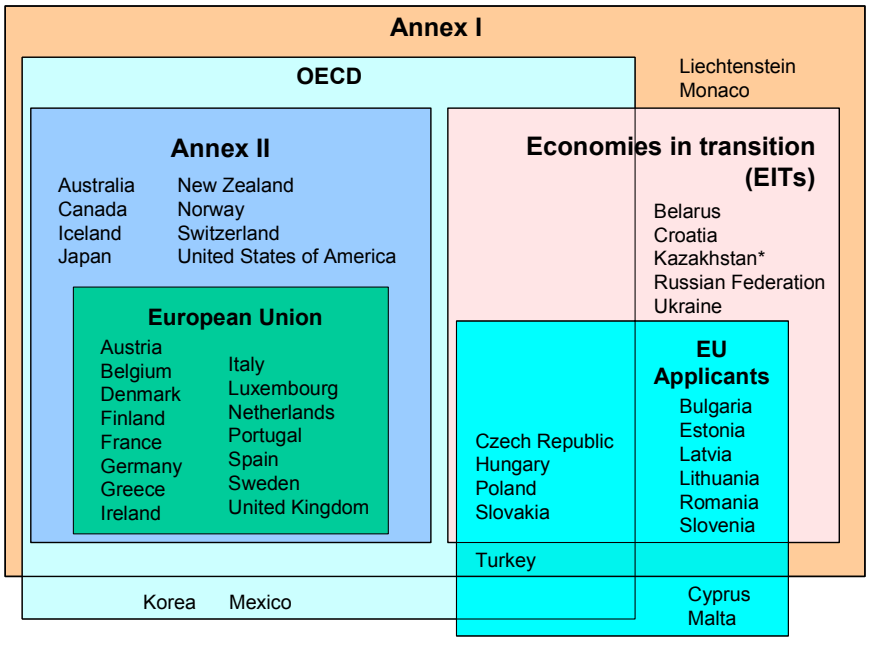
- *Parties included in Annex II to the Convention* encompass the countries that were members of the Organization for Economic Co-operation and Development (OECD) in 1992.
- *Parties included in Annex I to the Convention (Annex I Parties)* encompass both the countries that were members of the Organization for Economic Co-operation and Development (OECD) in 1992, and countries with "economies in transition" (EITs), that is, the Russian Federation and several other Central and Eastern European countries.
- *Parties not included in Annex I to the Convention (Non-Annex I Parties)* encompass those countries that are not member of Annex I, including all newly industrialized countries and developing countries.

Under the Convention, *all* Parties have certain general commitments (Article 4.1, UNFCCC):

- To prepare national inventories of greenhouse gas emissions
- To implement measures to mitigate climate change
- To promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that reduce greenhouse gas emissions
- To preserve sinks and reservoirs of greenhouse gases
- To cooperate in preparing for adaptation to the impacts of climate change
- To promote and cooperate in research on climate change
- To exchange information related to climate change
- To promote and cooperate in education, training and public awareness related to climate change
- To report information related to the above in “national communications”

In addition to those general commitments, certain groups of countries have additional obligations or rights:

- Annex I Parties are to take the lead in modifying longer-term trends in emissions by adopting national policies and measures with the non-legally binding aim of returning their greenhouse gas emissions individually or jointly to 1990 levels by the year 2000 (Article 4.2, UNFCCC).
- The Parties included in Annex II have the further commitment to provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations (Article 4.3, 4.4, 4.5, UNFCCC).



*: Added to Annex I only for the purpose of the Kyoto Protocol at COP7

Figure 1. Country groups

- Economies in transition are allowed a certain degree of flexibility in implementing their commitments (Article 4.6, UNFCCC). For example, several of those countries have chosen a base year other than 1990.
- Parties not included in Annex I are eligible for funding for the implementation of their general commitments (Article 11, UNFCCC). The general commitments as described above are interpreted weaker than for Annex I Parties. For example, the required content of the regular reports ('national communications') is less stringent and its submission is less frequent. The guidelines for the preparation of national communications for Non-Annex I Parties do not speak of 'policies and measures' but of 'steps taken or envisaged to implement the Convention'.

The Kyoto Protocol, adopted 1997, adds new commitments for Annex I Parties and confirms the general commitments from the Convention for Non-Annex I Parties without modifying them.

With the Kyoto Protocol, Annex I Parties agreed to reduce aggregated emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6) jointly by at least 5 per cent in the period 2008 to 2012 relative to 1990 levels. Individual developed nations have individual limitation or reduction targets as provided in Table 1.

To a certain extent, countries can reach their targets by trading emissions with other countries or by implementing emission reduction projects in other Annex I countries (Joint Implementation) or in developing countries (Clean Development Mechanism), which do not have quantified targets themselves.

Countries may also choose to implement the commitments jointly as a group. The European Union has chosen to do so and has internally negotiated other national targets (see Table 1) that will be the basis for the assessment of their individual compliance with the Kyoto Protocol.

While the "Annex I" was used in the Convention as a vehicle to differentiate the commitments related to only one Article, the division between Annex I and Non Annex I Parties has developed since into a very rigid divide (see also chapter 3.1.3). With the Kyoto Protocol, this division has been further manifested. The Kyoto Protocol did not define a new group of countries (sometimes referred to as "Annex B Parties"), it rather updated Annex I by adding those countries that applied to be included and those whose geographical borders changed as well as deleting those that had not ratified the Convention at the time of adoption of the Kyoto Protocol.

The term "commitments" is often used as referring only to the quantified emission limitation commitments inscribed in the Kyoto Protocol for Annex I Parties. While developing countries do not have quantified emission limitation commitments, these countries are nevertheless an integral part of the commitment regime under the UNFCCC and the Kyoto Protocol in many ways (see also Grubb et al. 2001):

First, developing countries have commitments, e.g. related to the implementation of policies and measures and regular reporting (see above). Several developing countries report major efforts to reduce their emissions (UNFCCC 2001). For example, the CO_2 emissions per unit of Gross Domestic Product (carbon intensity) in China has decreased substantially during the last decade as described in NRDC (2001) and Müller (2002) and as can be seen in Figure 2.[1]

Second, the Kyoto Protocol provides with the Clean Development Mechanism (CDM) an incentive for developing countries to be active in the implementation of climate friendly projects.

Third, the Marrakech accords include a series of decisions aimed at the involvement of developing countries. A framework on capacity building in developing countries sets out the scope of, and provides the basis for action on, capacity building related to the implementation of the

[1] Part of the decrease is due to growth in the emission-extensive services sector. In addition, questions have been raised about the calculation of the emissions and the GDP. A substantial decrease in carbon intensity is however very likely.

Convention. A framework on transfer of technology has been adopted to develop meaningful and effective actions to increase and improve the transfer of and access to environmentally sound technologies and know-how. A new special climate change fund, a least developed country fund and an adaptation fund have been established to mobilize additional resources for the involvement of developing countries.

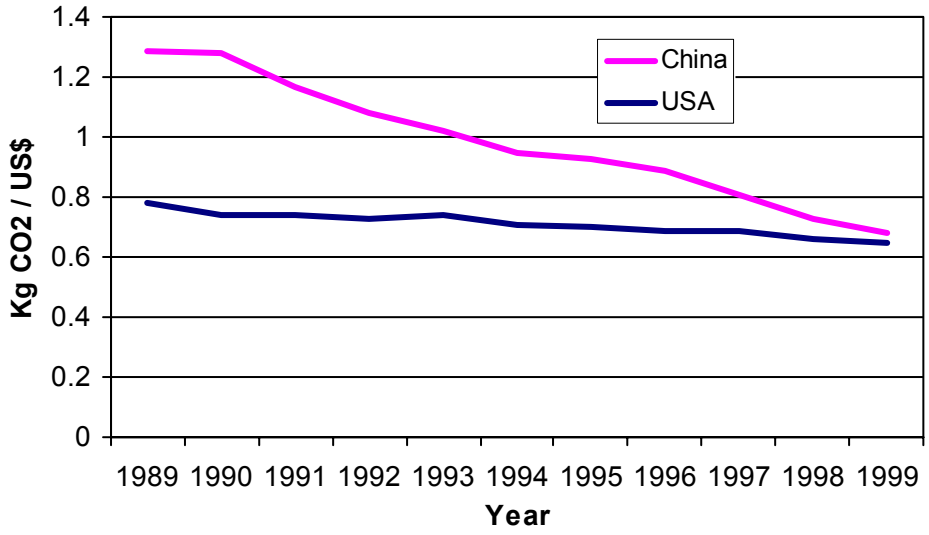


Figure 2. Emission intensity of the USA and China in kg of CO_2 from fossil fuel burning per US$ using 1995 prices and purchasing power parities (Source IEA 2001)

2.2 SCIENCE DEMANDS EMISSION REDUCTIONS

The previous chapter 2.1 provided an overview of the current commitments by Parties. The following chapter considers the question whether these are sufficient to reach the ultimate objective of the Convention.

The UNFCCC has the ultimate objective to stabilize greenhouse gas concentration at a level that would prevent dangerous anthropogenic interference with the climate system (see also Box 1). Two aspects are important: the *stabilization* of greenhouse gas concentrations and the prevention of *dangerous* interference.

First we consider how emissions and the climate would develop without further climate commitments and how that relates to the ultimate objective of the Convention. The intergovernmental Panel on Climate Change (IPCC) in its Third Assessment Report and in its Special Report on Emissions Scenarios (SRES, 2001) has laid out possible future emissions paths and their resulting effects on the climate under the assumption that no additional measures specifically targeted to climate change would be implemented. As shown in Figure 3, under all considered scenarios, global emissions rise at least until the middle of the this century. Resulting concentrations of the major greenhouse gas carbon dioxide (CO_2) do not stabilize within the next century. CO_2 concentrations in 2100 are estimated to range from 500 to 900 ppmv. The resulting increase in the global average surface air temperature by the end of the next century is estimated to be between 1.4°C and 5.8°C, depending on the emission scenario and the climate model used.

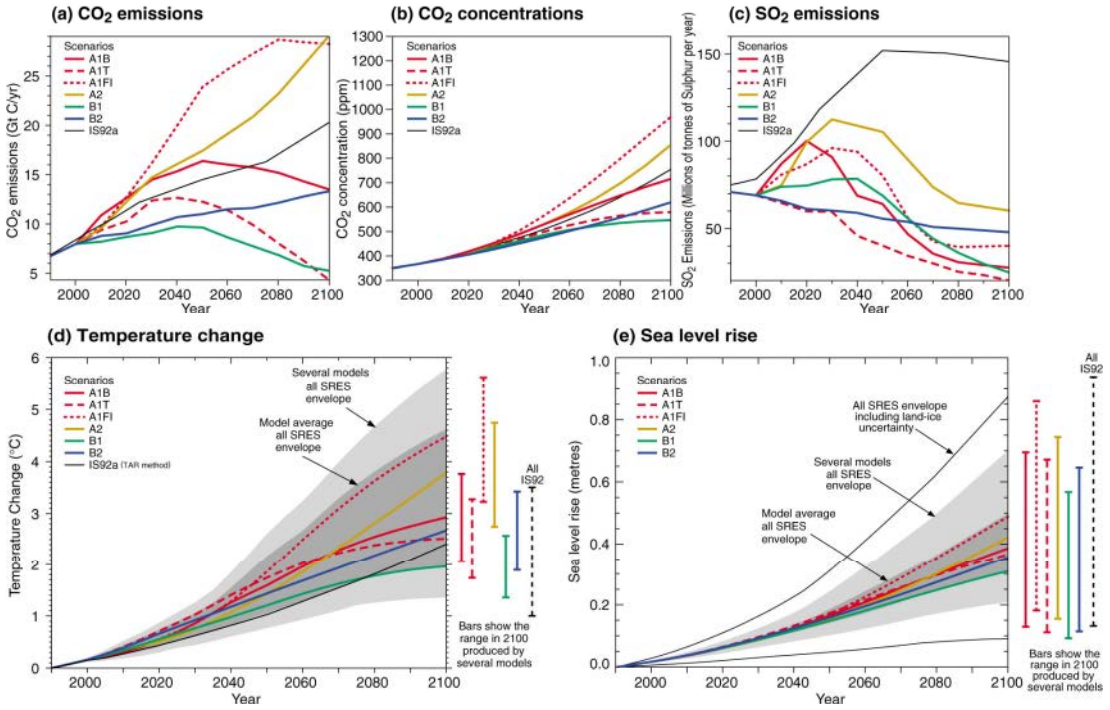


Figure 3. Possible future emissions, concentrations, temperature change and sea level rise (IPCC 2001a)

The IPCC refrains from making judgements about what constitutes "dangerous" interference since such advice could not be based exclusively on objective science. The IPCC however made a general statement about the timing of the stabilization of greenhouse gas concentrations: "Stabilization of atmospheric CO_2 concentrations at 450, 650 or 1000 ppmv would require global anthropogenic CO_2 emissions to drop below 1990 levels within a few decades, about a century or about two centuries, respectively and continue to decrease steadily thereafter."

For any stabilization level, global emissions of CO_2 have to be reduced below 1990 levels in the order of 50% and ultimately drop to very low levels since the carbon is circulated between the air, biomass and oceans. It is the cumulative emissions that ultimately determine the concentration level. Table 2 provides some examples of stabilization paths from the IPCC Third Assessment Report.

Stabilization of greenhouse gas concentrations includes both, the stabilization of CO_2 concentration and the stabilization of the concentration of other greenhouse gases. Historic emissions have increased the CO_2 concentration from 280 ppmv to currently 360 ppmv. CO_2, CH_4 and N_2O together produce today an amount of radiative forcing that is equivalent to the forcing of CO_2 alone at roughly 400 ppmv (400 ppmv CO_2eq.). Stabilizing the CO_2 concentrations at 450 ppmv and concentrations of the other gases at similar levels would lead to a radiative forcing equivalent to a concentration 550ppmv of CO_2 alone (550 CO_2eq ppmv).

Table 2. Level and timing of required global emission reductions (Source: IPCC 2001d, table 6-1)

WRE CO_2 stabilization profiles	Accumulated CO_2 emissions 2001 to 2100 (GtC)	Year in which global emissions peak	Year in which global emissions fall below 1990 level
450	365-735	2005-2015	<2000-2040
550	590-1135	2020-2030	2030-2100
650	735-1370	2030-2045	2055-2145
750	820-1500	2040-2060	2080-2180
1000	905-1620	2065-2090	2135-2270

The Council of Ministers of the European Union made a political judgment on what constitutes "dangerous" interference: It agreed that "global average temperatures should not exceed 2 degrees Celsius above pre-industrial level and that therefore concentration levels lower than 550 ppm CO_2 should guide global limitation and reduction efforts"[2] (EC 1996). Substantial emission reductions are necessary to reach this stabilization level.

In addition to the absolute level of concentrations, also the *rate* of change is important. Many ecosystems can adapt to changes in climate. In the past, species always migrated or adapted to new circumstances. Such adaptation however, can only occur at a certain rate of change. The effect of rates of change on impacts a matter of active research. Early results have suggested that rates of change exceeding the ability of ecosystems to migrate would be particularly damaging (see IPCC 2001b, chapters 5 and 19).

At present, there is no common perception of the long-term goals of climate policy and which aspects (concentrations, temperature change, rate of change, other impacts) are relevant for the definition of a long-term target and how dangerous interference with the climate system should be avoided (see also O'Neill & Oppenheimer 2002).

As a next step we consider, where greenhouse gas emissions originate historically and how they will be distributed in the future:

Figure 4a shows the historic emissions from Annex I and Non-Annex I Parties of the CO_2, CH_4 and N_2O in CO_2 equivalents.[3] Figure 4b shows in addition to the historic emissions also the expected future emissions according to the A1B scenario of the IPCC SRES (one scenario in the middle of the range with a decline in emissions after 2050).

Within the margins of uncertainty, the following conclusions can be drawn from that data:

- Annex I countries are responsible for 80% of the cumulative CO_2 emissions for fossil fuels from 1900.
- The sum of Annex I countries' emissions is stable over the last 10 year, an increase by some OECD countries is compensated by decrease in the economies in transition. No extreme growth in emissions is expected in the future.
- Emissions of Non-Annex I Parties are increasing rapidly. CO_2 emissions from fossil fuels are expected to supercede those of Annex I in the next decades.
- Deforestation activities have contributed largely to the CO_2 emissions of developing countries. (Values shown here are considered to be at the high end of the possible range.)
- Non-Annex I countries have a higher share of emissions from CH_4 and N_2O than Annex I Parties. Emissions of those gases are largely due to agricultural activities.

Currently only Annex I Parties have binding emission limitations and major growth in emissions is expected in Non-Annex I countries. Considering possible future emission paths, it can be concluded that the current commitments in the UNFCCC and the Kyoto Protocol will not be sufficient to reach ambitious long-term targets such as stabilization at 450 or 550 ppmv CO_2eq concentrations. The Kyoto Protocol is only a first step towards the ultimate objective of the Convention. Eventually participation of all major countries will be required. The question is when and how.

Industrialized countries are on the one hand responsible for most of the problem should take the first step in reducing emissions. On the other hand, their efforts can only be effective, if also developing countries' emissions do not grow indefinitely.

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[2] Technical note: Climate models, which take into account greenhouse gases other than CO_2 and use an average climate sensitivity, may predict a temperature increase higher than 2°C for a stabilization of CO_2 concentrations at 550 ppmv, see also figure 5.

[3] Fossil and industrial CO_2 from Marland et al. (2001), Land-use change from and Houghton (1999), CH_4 and N_2O from EDGAR (2001), scaled from HYDE (1999) for the years 1890 to 1975, fluorinated gases are own estimates.

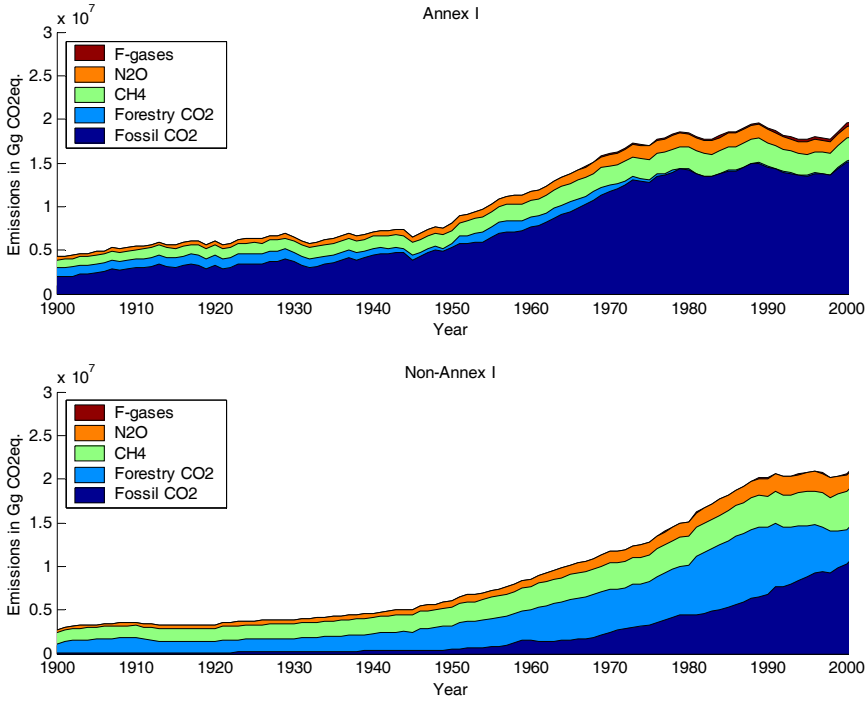

Figure 4a. Historic emissions of Annex I and Non-Annex I Parties (Source: see text)

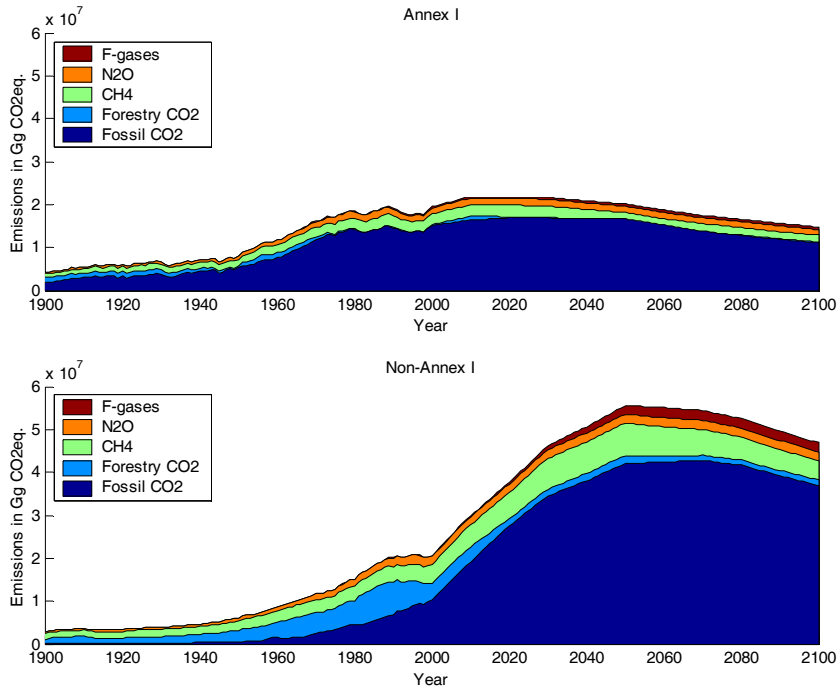

Figure 4b. Historic and future emission of Annex I and Non-Annex I Parties under the IPCC SRES A1B scenario

Developing countries object to restrictions to their economic growth, since they are only to a relatively small part responsible for the problem. On the other hand, reaching the ultimate objective of the convention is only possible developing countries 'get it right the first place', meaning that these countries do not first become large polluters and then reduce emissions.

Keeping emissions of Non-Annex I countries at a low level does not necessarily have to be ensured by assigning emission limitation targets to developing countries. Emission reduction efforts by developed countries will have an effect on emissions of developing countries (spill-over). In the past mainly the negative 'leakage' was considered, that is that emission intensive activities would migrate from industrialized countries (with emission limits) to developing countries (without emission limits). But there is currently an ongoing scientific debate whether the positive effects would outweigh the negative by far, in that innovative technologies and policies are developed, introduced and used in developing countries, decreasing their emissions (Grubb et al. 2002).

The report of the global dialogue "Climate OptiOns for the Long term" (COOL) organized by the RIVM in the Netherlands (Berk et al. 2001) argues that the long term options have to be kept within reach. Under the uncertainty of climate change, actions have to be implemented today, so that lower stabilization targets are still reachable. "In order to keep the option of stabilizing CO_2 concentrations at 450 ppmv open, major developing countries (like China and India) will need to start participating in global greenhouse gas emission control at much lower levels of income than did the developed countries at the time of signing the UNFCCC. If the group of countries adopting quantified commitments after the first commitment period would be limited to middle income developing countries and these countries would initially only take on efficiency improvements targets, and if this would set a precedent for relatively poor, but major developing countries like India and China, CO_2 stabilization levels of 550 ppmv or lower may be out of reach."

Participants of the COOL process also stressed the importance of reaching agreement internationally at an early stage. The international regime for climate change drives national policies but only with a delay. Resulting national policy drives changes in greenhouse gas emissions again with a delay.

3. SPECIFIC DIFFICULTIES IN AGREEING ON FURTHER COMMITMENTS

The following chapter provides some background information relevant to future commitments and an overview of the specific difficulties in agreeing on future commitments.

3.1 THE INTERNATIONAL NEGOTIATION PROCESS

3.1.1 The rules of negotiations under the UNFCCC

Under the UNFCCC, countries negotiate as sovereign states. The system is based on voluntary cooperation. No enforcement mechanism other than political pressure can convince a country to start negotiating or to be bound by an agreement and consequently comply with its commitments. Thus, a country will only take on a commitment that it is considering reasonable.

Any decision under the UNFCCC is taken by consensus, meaning none of the 186 Parties objects. Attempts to change this rule have failed in the past because any voting rules would also have to be agreed upon by consensus.

Consequently, the text that is agreed sometimes formulated vaguely to accommodate everyone. Such unclear agreement needs clarification at later date. Hence, more and more different topics are being discussed and a complicated structure of topics evolves.

Reaching agreement is only possible if a) all countries are willing to reach a decision and b) the chairman proposes a balanced package of decisions on the most important topics. If the package is accepted, it cannot be changed, since changing one item would lead to requests to change other items as well.

These rules have to be kept in mind when considering future commitments and decisions thereon.

3.1.2 History of the negotiation process on commitments

The Convention, in Article 4.2(a) and (b), states that Annex I Parties shall adopt and implement policies and measures to return their greenhouse gas emissions in 2000 to 1990 levels. A review of the adequacy of those paragraphs was called for to take place at COP 1 and a second review not later than 31 December 1998, and thereafter in regular intervals determined by the COP, until the objective of the Convention is met (see Box 2).

"The Conference of the Parties shall, at its first session, review the adequacy of subparagraphs [4.2] (a) and [4.2] (b) above. Such review shall be carried out in the light of the best available scientific information and assessment on climate change and its impacts, as well as relevant technical, social and economic information. Based on this review, the Conference of the Parties shall take appropriate action, which may include the adoption of amendments to the commitments in subparagraphs (a) and (b) above. […] A second review of subparagraphs (a) and (b) shall take place not later than 31 December 1998, and thereafter at regular intervals determined by the Conference of the Parties, until the objective of the Convention is met;"

Box 2. Article 4.2 (d) of the UNFCCC

The first review at COP 1 (1995) concluded that Article 4.2(a) and (b) were not adequate. With the "Berlin Mandate", the COP initiated a process to strengthen the commitments of Annex I Parties without introducing any new commitments for Non-Annex I Parties. The negotiations of the Ad-hoc Group on the Berlin Mandate (AGBM) resulted in the Kyoto Protocol and its binding quantified reduction targets for Annex I Parties.

The second review of adequacy was discussed at COP 4 (1998). No agreement was reached due to a divergence over whether this discussion would apply to commitments for developing countries. At COP 5 (1999), the Group of 77 and China proposed to amend the agenda item title from "review of the adequacy of Article 4.2(a) and (b)" to read "review of the adequacy of implementation of Article 4.2(a) and (b)". This clear shift to exclude a discussion on commitments for developing countries was not accepted. No agreement was reached and the issue was deferred to COP 6. Due to more urgent matters and no movement in Parties positions, again no agreement was reached at COP 6 and later at COP 7.

Article 3.9: "Commitments for subsequent periods for Parties included in Annex I shall be established in amendments to Annex B to this Protocol, which shall be adopted in accordance with the provisions of Article 21, paragraph 7. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall initiate the consideration of such commitments at least seven years before the end of the first commitment period referred to in paragraph 1 above."
Article 9.1: "The Conference of the Parties serving as the meeting of the Parties to this Protocol shall periodically review this Protocol in the light of the best available scientific information and assessments on climate change and its impacts, as well as relevant technical, social and economic information. Such reviews shall be coordinated with pertinent reviews under the Convention, in particular those required by Article 4, paragraph 2(d), and Article 7, paragraph 2(a), of the Convention. Based on these reviews, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall take appropriate action."
Article 9.2: "The first review shall take place at the second session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. Further reviews shall take place at regular intervals and in a timely manner."

Box 3. Review of the Kyoto Protocol

At COP 8 in November 2002, the issue of adequacy of commitments could again not be resolved and was deferred. However, the issue of developing country commitments was raised in the context of the negotiations on a 'Delhi Declaration', which was to become the main outcome of the conference. Members of the Umbrella group, excluding the USA, stressed the need for global participation in order to meet the objective of the Convention. The EU called for a dialogue to kick of a process for future action and stating explicitly that such dialogue would not be about developing country commitments. Still, some developing countries interpreted this (intentionally or inadvertently) as calls for developing country commitments and rejected inclusion of any reference to future actions in the declaration. The final Delhi Declaration

does not refer to the future. It was welcomed and supported by the G77 and the USA, while the EU and Japan and Canada and the Central Group- eleven (CG11, most economies in transition included in Annex I) voiced their disappointment. However, Japan and the EU mentioned in the final plenary that they have seen signs that the divide on future commitments could be overcome in the near future. COP 9 in November 2003 will provide the next official opportunity.

The Kyoto Protocol itself demands review of commitments within two Articles. In Article 3, the Article on the quantified commitments for Annex I Parties (see Box 3), the review of commitments for Annex I Parties as inscribed in Annex B shall be initiated in 2005. Article 9 of the Kyoto Protocol calls for a general review of the Protocol coordinated with the review of the Convention, starting at the second meeting of the Parties to the Protocol, which could be in 2004. Figure 5 summarizes the past and future steps in the discussion on commitments.

The Annex B of the Kyoto Protocol can be amended by the Conference of the Parties serving as the meeting of the Parties to the Protocol (COP/MOP) by consensus or, if all efforts at consensus have been exhausted, by a three-fourth majority (Article 20.3) but only with the written consent of the Party concerned (Article 21.7).

The Convention asks for its continuous review until its objective is met, which probably would, in order to be reached, also include commitments for developing countries. The Kyoto Protocol also is reviewed periodically, not only commitments of Annex I Parties but also the Protocol as a whole. Two formal options exist: A separate Protocol of Non-Annex I Parties is adopted or the Kyoto Protocol is amended to include commitments for countries that are not included in Annex I.

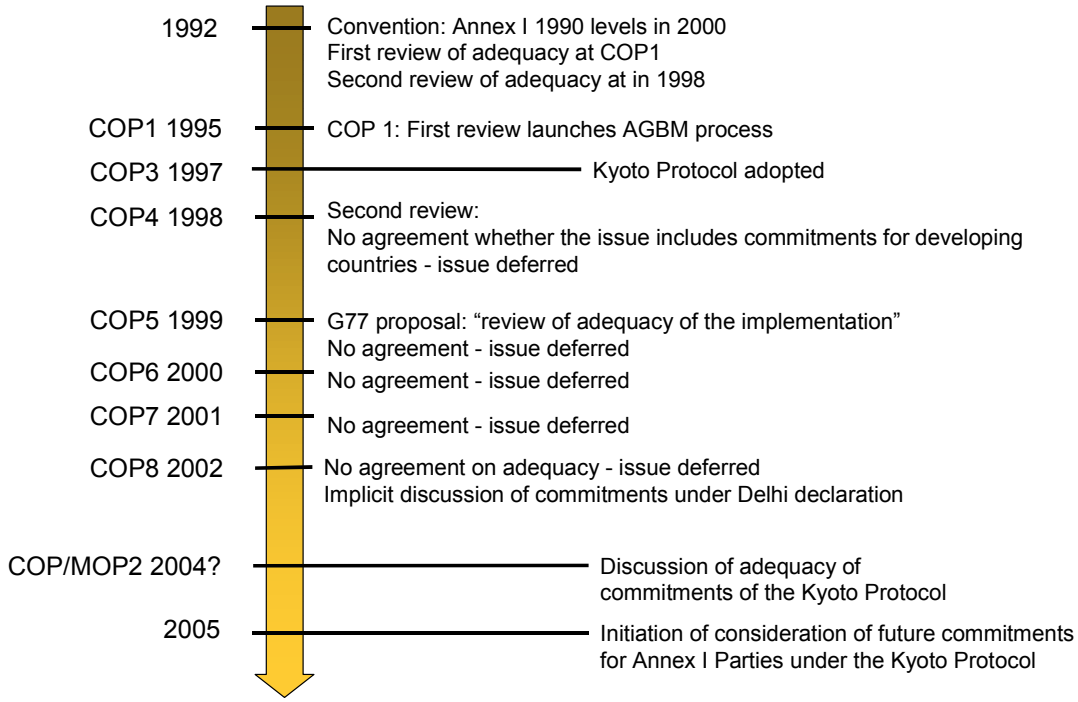

Figure 5. Overview of the negotiating history on commitments

3.1.3 Increasing Annex I

While the "membership" to Annex I was originally designed to be quite flexible under the Convention (see Box 4), increasing Annex I in practice is more difficult.

Two steps are involved for a Party wishing to be included in Annex I: A notification by that Party to be bound by Article 4.2 (a) and (b) and a decision by the Conference of the Parties to amend the Annex by consensus or, if all efforts at consensus have been exhausted, by a three fourth majority (Article 15.3)

For the purpose of the Kyoto Protocol, a "Party included in Annex I" is already that Party that has only taken the first step, that of a notification (see Box 5).

In Kyoto 1997, the Conference of the Parties decided to amend the list of Annex I by those countries that had applied. These include Croatia, Czech Republic, Liechtenstein, Monaco Slovakia and Slovenia.

In Marrakech 2001, after several years of discussion, the Conference of the Parties agreed to delete Turkey, as requested, from Annex II of the Convention. It did however not agree to add Kazakhstan, as requested, to Annex I. It recognized that Kazakhstan would become a Party included in Annex I for the purpose of the Kyoto Protocol, since it made the notification, but will continue to be a Party not included in Annex I for purposes of the Convention.

"(f) The Conference of the Parties shall review, not later than 31 December 1998, available information with a view to taking decisions regarding such amendments to the lists in Annexes I and II as may be appropriate, with the approval of the Party concerned;
(g) Any Party not included in Annex I may, in its instrument of ratification, acceptance, approval or accession, or at any time thereafter, notify the Depositary that it intends to be bound by subparagraphs [4.2] (a) and [4.2] (b) above. The Depositary shall inform the other signatories and Parties of any such notification."

Box 4. Article 4.2 (f) and (g) of the UNFCCC

Including Kazakhstan in Annex I was seen by some developing countries as a door to commitments for all developing counties. Including Kazakhstan was seen as a precedent putting pressure on other developing countries to join Annex I and to take on further commitments. Since the COP has to agree the amendment by consensus, those opposing developing countries successfully blocked the formal inclusion of Kazakhstan in Annex I.

"'Party included in Annex I' means a Party included in Annex I to the Convention, as may be amended, or a Party which has made a notification under Article 4, paragraph 2(g), of the Convention."

Box 5. Article 1.7 of the Kyoto Protocol

3.1.4 Further differentiation in the Convention and in other international agreements

In addition to the well defined differentiation into Annex I, Annex II, EITs and Non-Annex I Parties, the Convention includes further criteria for differentiation between countries without further specifying countries that satisfy those criteria:

- Equitable and appropriate contributions by each of the Parties to the global effort (UNFCCC 4.2a)
- Countries particularly vulnerable to the impacts of climate change such as small island states, countries with low-lying coastal areas, countries with arid and semi-arid areas, forested areas and areas liable to forest decay, countries with areas prone to natural disasters, countries with areas liable to drought and desertification, countries with areas of high urban atmospheric pollution, countries with areas with fragile ecosystems, including mountainous ecosystems (UNFCCC 4.8)
- Countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products (UNFCCC 4.8, 4.10)
- Land-locked and transit countries (UNFCCC 4.8)

The group of least developed countries has a special status under the Convention. This group is understood to include those countries that are designated as such by the United Nations General Assembly. In implementing their commitments, all Parties shall take full account of the special situation of least developed countries with regard to funding and transfer of technologies (UNFCCC 4.8). Least developed countries may choose the timing of the submission of their initial national communications at their discretion (UNFCCC 12.5). With the Marrakech accords an expert group on least developed countries was established to advise on the

preparation and implementation strategy for national adaptation programmes for action (decision 29/CP.7).

It may be worth mentioning that the Montreal Protocol for the protection of the ozone layer differentiates two distinct groups of Parties: Industrialized countries and those developing countries operating under Article 5 of the Montreal Protocol. Those two groups have different phase-out schedules for the production and consumption of ozone depleting substances. "Article 5 countries" can apply for funding under the multilateral fund of the Montreal Protocol (UNEP 2000).

The World Trade Organization (WTO) also divides countries in "developed" and "developing" countries. No WTO definitions are available, members rather announce for each individual agreement under the WTO whether they are "developed" or "developing" countries. Other members can challenge the decision of a member to make use of provisions available to developing countries. In some WTO agreements, these provisions provide developing countries with longer transition periods before they are required to fully implement the agreement. Developing countries can also receive technical assistance. The WTO also recognizes as least-developed countries those countries, which have been designated as such by the United Nations (WTO 2002).

3.2 MAGNITUDE AND SCOPE OF NECESSARY CHANGES

The Montreal Protocol is often presented as a good example of international environmental policy. Countries have reached an agreement how the phase out the chemicals that contribute to the depletion of the ozone layer.

To mitigate climate change, however, is a larger problem by orders of magnitude: While ozone depleting substance were produced by a limited number of companies and are used in a limited number of applications, for most of which alternatives are available, mitigation of climate change affects virtually all areas and aspects of life. Energy is driving most economic processes. The use of energy is closely linked to the individual behavior of the consumers. By far more drastic changes are needed to solve the climate change problem than were required to stop ozone depletion. Some compared the magnitude of the change needed to solve climate change with the magnitude of the change of the industrial revolution.

3.3 INERTIA OF THE CLIMATE SYSTEM

One particular difficulty in the process of agreeing on commitments is the time lag between the emissions and their effects on the climate. To further describe this time lag we need to consider the cause-effect chain which leads from emissions of greenhouse gases to changes in climate as provided in Figure 7: emissions of greenhouse gases, precursors and aerosols change the concentration of these and other gases in the atmosphere. Changed concentrations influence radiative forcing. Changed radiative forcing influences the global-average surface temperature. The absolute change in temperature, as well as the rate of its change, influences the sea level and other parameters such as precipitation and related damages.

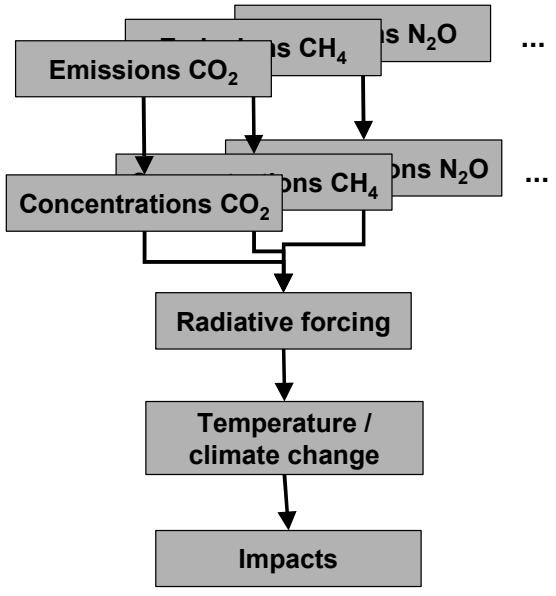

Figure 6. Simplified cause effect chain from emissions to effects of climate change

Many greenhouse gases, once emitted, are only slowly removed from the atmosphere. The decay model for CO_2 as used for the IPCC calculations of the global

warming potentials assumes relatively fast decay in the first 100 years (70% of CO_2 is removed within 100 years) but slow decay afterwards (20% still remain in the atmosphere after 650 years). For other greenhouse gases, lifetimes range from 12 (methane) to 50 000 (CF_4) years. The resulting radiative forcing causes changes in the global-average surface temperature again with a certain time delay. If one is considering only the changes is temperature due to a pulse emission of CO_2 for example, the maximum effect on temperature is only reached 20 to 50 years after the emissions. Changes in sea level will occur even thousands of years after concentrations have stabilized at a higher level. Figure 7 illustrates the different time scales of change involved for stabilization of CO_2 concentrations.

If the damages due to climate change can only be observed with a considerable time delay, the benefits of emission reductions can also only be noticed with a substantial delay. This also makes it difficult to attribute responsibility for climate change to certain sources or countries. This long-term problem is difficult to solve in a world dominated by political 4- or 5-year cycles.

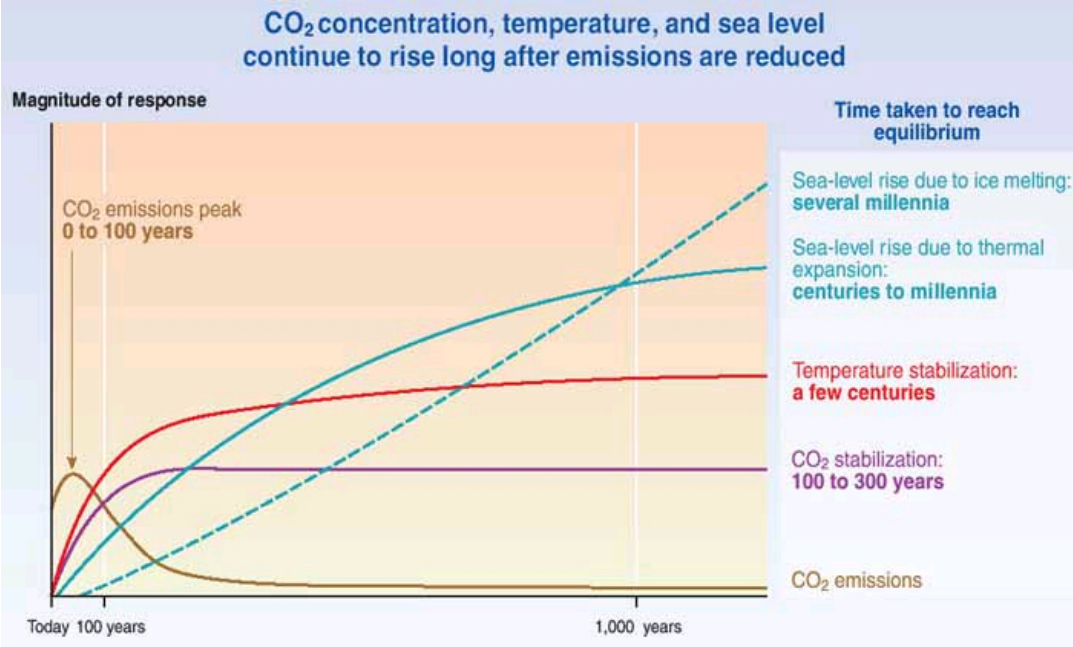

Figure 7: Generic illustration of the time scales involved for stabilization of CO_2 concentrations at any level between 450 and 1000 ppmv (Source IPCC 2001d, figure SPM-5)

3.4 INERTIA OF THE SOCIO-ECONOMIC SYSTEM

Not only the climate system is slow in its response, also the effects of policies and the change in technical systems occurs at a slow rate. For example, some technologies once installed are only replaced very slowly. Power stations are in operation for 20 to 30 years. The stock of buildings is maintained for sometimes longer than 100 years. The basic pattern of the transport infrastructure can last even longer. Technology replacements can be delayed by 'locked in' systems that have competitive market advantages due to available support systems and infrastructure. Early decision are needed on the infrastructure to avoid such a lock-in.

3.5 DECISIONS UNDER UNCERTAINTY

The uncertainty about the magnitude of climate change and the causes has been an obstacle to reaching agreement on how to deal with this problem. The most disputed factor is the climate sensitivity, i.e. the increase in global-average surface temperature, if the CO_2 concentration would rise to twice the pre-industrial level. Typical values for the climate sensitivity range

from 1.5 to 4.5 °C. This range has not been narrowed despite substantial research efforts for almost two decades. (The evolution of this range is further discussed by J. Sluijs, 1997).

Given this uncertainty, the temperature change in 2100 under a stabilized CO_2 concentration at 450 ppm could be between 1°C and 2.2°C (see figure 7).[4]

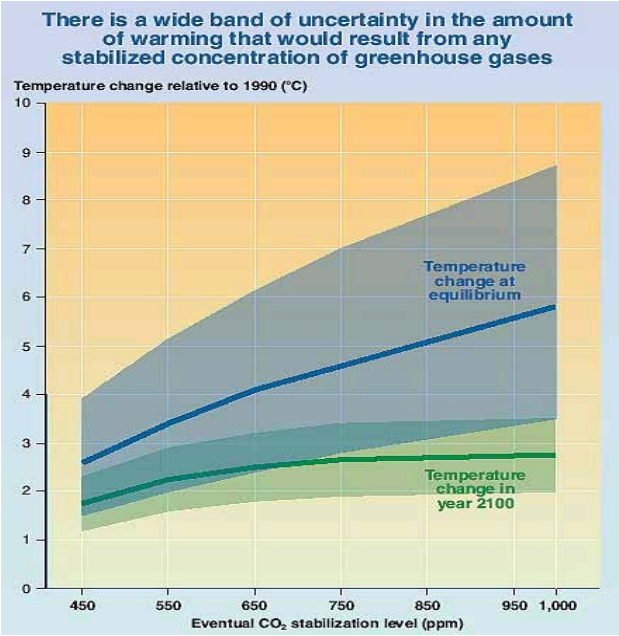

Figure 8. Possible temperature change at different levels of concentrations (source: IPCC 2001d)

Related to the above is the uncertainty of the magnitude of the influence of anthropogenic emissions on the observed temperature increase. The IPCC in its Third Assessment Report (IPCC 2001a) has stronger than before characterized the human influence on the climate: It stated that "most of the observed warming over the last 50 years is likely to have been due to increase in greenhouse gas concentrations", which in turn are due to anthropogenic emissions.

In the past, these uncertainties have been subject of intensive debate and have fueled arguments of the skeptics of climate change. Often the influence of the sun is quoted as a major contributor to the observed warming or the IPCC process is questioned as whole. Most of these concerns receive high visibility in the press but, if followed up, often turn out to not to be based on reviewed science (Rahmstorf 2002). These debates, however, have been used by some country representatives as an argument to delay significant action.

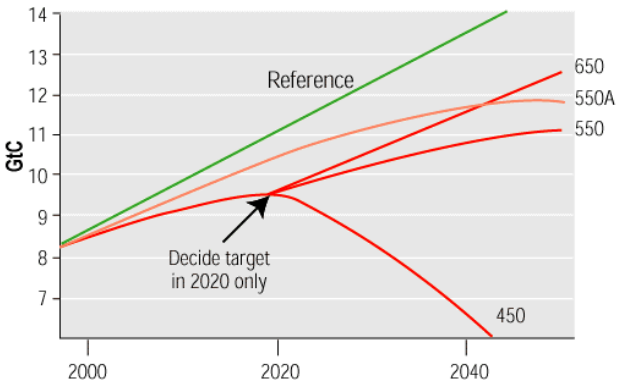

Figure 9. Optimal carbon dioxide emissions strategy, using a cost-effectiveness approach (source: IPCC 2001c)

These uncertainties have also made it difficult to agree on a certain concentration level, e.g. 350, 450, 550, 650 ppmv, that would avoid dangerous anthropogenic interference with the climate system. One option to overcome this difficulty is referred to as hedging strategy (IPCC 2001c, chapter 10, here figure 9): define an intermediate global goal for 2020 that allows reaching any possible long-term goal, and at a later date, e.g. in 2020, define the long-term goal.

3.6 NATIONAL CIRCUMSTANCES

One important consideration in the further development of commitments is the differences in national circumstances of countries. Those differences have lead to the grouping of Annex I and Non-Annex I. Different starting positions result in different responsibilities and capabilities

[4] The changes in temperature are derived taking the CO_2 concentrations as given in the x-axis of the diagram and assuming in addition emission and increased concentrations of other greenhouse gases.

and therefore different political positions. The following section provides some relevant indicators for the national circumstances with numerical data summarized in Table 3.

The structure of the *greenhouse gas emissions* depends on the economic structure of the country and the potential for renewable energy. In most developed countries, emissions from fossil fuel use are dominant, including emissions from electricity production, industrial production, transport as well as commercial and domestic use of energy. Significant differences between countries may occur due to the different potentials for renewable energy. For example, Iceland's economy is almost entirely based on renewable energy.

Emissions from sectors other than energy may also be important to some countries. New Zealand's emissions, for example, are dominated by those of sheep. For developing countries the differences due to different sectoral activities are even more pronounced: For example, Singapore has very low emissions of CH_4 and N_2O while in the Group 'Rest of Southern Africa' fossil CO_2 emissions only account for very small share of the total greenhouse gas emissions.

The amount of greenhouse gas emissions per capita varies considerably between 0.6 $tCO_2eq.$/person to 25 $tCO_2eq.$/person (for CO_2, CH_4, N_2O from fossil fuels, industry and deforestation). The Annex I average is 15 $tCO_2eq.$/person, for Non-Annex I 4 $tCO_2eq.$/person and for the world 7 $tCO_2eq.$/person.

Accordingly, the *reduction options* and related costs as well as the *expected growth in emissions* differ substantially among countries, depending on, e.g., the state of development, the efficiency of the use of resources and energy.

The *historic responsibility* for climate change may be considered as important factor since CO_2 stays in the atmosphere around 100 years. The historic responsibility is dependant on the past emission path of the country. Countries with an early industrial revolution (mainly in Europe) bear a relatively high historic responsibility, while most developing countries bear a relatively low responsibility.

The *state of development* and, with it, the economic capabilities of a country, determine the potential to mitigate climate change, the potential development of future emissions as well as the potential to adapt to climate change. Table 3 provides the gross domestic product based on purchase power parities per capita as indicator. The range of values is considerable. For many developing countries, the national debt can also be used as an indicative parameter.

Vulnerability to climate change depends on a) the geographic condition and b) the economic potential to cope with the possible negative effects of climate change. The appropriate indicator for the vulnerability of a country to climate change is a subject of research. The least developed countries are generally the most vulnerable. As an example, Hurricane Mitch in 1998 caused the GDP of Honduras to drop by 80%.

Some developing countries are dependent on the *export of natural resources,* including fossil fuels. For those countries, measures taken to use less fossil fuels may have a significant effect on the economy.

Public awareness of climate change is also an important parameter to gain support for climate policies. For some countries, environmental problems are high on the public agenda, while for many developing countries the improvement of the quality of life is the most important concern.

Table 3. Indicators for the difference in national circumstances

Code	Region	Fossil and Industrial CO_2 ($Gg\ CO_2$) 1995	Forestry CO_2 ($Gg\ CO_2$) 1995	CH_4 ($Gg\ CO_2eq$) 1995	N_2O ($Gg\ CO_2eq$) 1995	All GHG ($Gg\ CO_2eq$) 1995	Population (1000 persons) 1995	GHG per capita (t CO_2 eq./person) 1995	GDPppp per capita (1000 US$/person) 2000
USA	USA	5 411 800	30 477	835 445	472 906	6 750 628	267 020	25.28	31.81
EU	European Union	3 261 390	9 207	349 365	394 159	4 014 122	371 937	10.79	21.63
JNP	Japan	1 282 155	2 447	60 645	29 926	1 375 173	125 472	10.96	23.69
EEU	Eastern Europe (Annex I)	1 585 830	4 780	274 053	123 865	1 988 529	171 801	11.57	6.51
RUS	Russian Federation	1 901 114	10 355	498 071	64 113	2 473 653	148 097	16.70	6.83
RAI	Rest of Annex I	970 114	2 543	265 447	194 943	1 433 047	62 995	22.75	25.20
TUR	Turkey	184 874	164	25 469	40 848	251 355	61 276	4.10	6.06
REE	Rest of Eastern Europe and former USSR	593 393	1 947	147 578	56 883	799 801	93 272	8.57	3.28
ARG	Argentina	128 472	13 316	86 624	67 269	295 683	34 768	8.50	12.01
BRA	Brazil	276 699	368 980	301 555	243 797	1 191 031	159 346	7.47	6.79
COL	Colombia	70 158	41 149	53 699	21 289	186 295	38 542	4.83	5.59
MEX	Mexico	366 860	29 610	98 439	64 377	559 286	91 145	6.14	7.91
VEN	Venezuela	143 507	75 191	49 414	22 838	290 950	21 844	13.32	5.34
RLA	Rest of Latin America	250 887	248 850	146 446	118 273	764 457	134 245	5.69	4.20
EGY	Egypt	100 274	4 589	27 284	19 464	151 612	62 282	2.43	3.17
ZAF	South Africa	301 036	5 111	53 604	23 547	383 298	37 470	10.23	9.06
NGA	Nigeria	84 133	38 017	70 007	33 474	225 631	98 952	2.28	0.91
RNA	Rest of North Africa	187 893	32 377	84 707	71 714	376 692	94 551	3.98	3.33
RAS	Rest of Southern Africa	94 252	396 618	325 836	280 509	1 097 215	403 454	2.72	1.06
GLF	Persian Gulf States	423 799	924	87 256	11 027	523 006	22 700	23.04	11.48
RME	Rest of Middle East	532 817	10 722	96 068	77 946	717 554	129 406	5.54	4.56
CHN	China	3 894 139	109 552	966 560	539 547	5 509 797	1 227 170	4.49	4.26
IND	India	888 881	101 872	655 471	256 699	1 902 923	933 665	2.04	2.26
IDN	Indonesia	245 446	207 506	214 714	66 595	734 260	197 464	3.72	2.68
KOR	Korea, Republic of (South)	424 803	2 147	27 287	12 284	466 522	44 949	10.38	16.03
MYS	Malaysia	97 968	94 372	24 361	12 316	229 016	20 108	11.39	8.42
PHL	Philippines	51 947	58 905	44 492	20 071	175 414	68 354	2.57	3.75
SGP	Singapore	83 449	0	1 118	923	85 491	3 321	25.74	24.92
THA	Thailand	172 332	32 215	73 091	23 650	301 288	58 610	5.14	5.96
RAA	Rest of Asia	274 007	261 786	387 158	184 530	1 107 481	479 193	2.31	1.62
Annex I		14 597 277	59 973	2 308 495	1 320 762	18 286 507	1 208 597	15.13	19.64
Non-Annex I		9 687 152	2 135 756	4 022 769	2 229 024	18 074 701	4 454 812	4.06	3.53
Global total		24 284 429	2 195 729	6 331 264	3 549 786	36 361 208	5 663 409	6.42	6.81

Notes: For data sources and regional split see Appendix A. "Forestry CO_2" is taken from the EDGAR 3.2 database and includes only direct emissions from deforestation and not the full IPCC source category "land-use change and forestry". "All emissions" includes the sum of the four previous columns.

Due to the different national circumstances, countries with similar conditions and interest formed more or less tight groups for the purpose of negotiating jointly in the international process:

Within Annex I, there are some high consumption and high growth countries, such as the USA, Canada or Australia, whose emissions steadily increased over the last years. Together

with New Zealand, Norway, Island, Ukraine, Russia and Japan, they form the 'Umbrella Group'. This loosely organized group is now weakened, due to the withdrawal of the USA from the Kyoto Protocol.

The European Union acts as a group due to its political integration process. The EU combines countries with decreasing trend (e.g. United Kingdom, Germany) and increasing trend (e.g. Spain, Greece). Those eastern European states that wish to accede to the European Union have formed the CG11 to act collectively.

Non-Annex I countries with their diverse national circumstances, and therefore sometimes opposite interests, are joint to the 'Group of 77 and China' or 'G77'. This group represents the interests of all developing countries, most of which have the common difficulty of having scarce resources available for the international negotiations. Within the G77, small island states (e.g. Marshall Islands, Tuvalu) fear loss of their territory due to sea level rise and have formed the Alliance of Small Island States, AOSIS. Oil producing countries (e.g. Saudi Arabia, Qatar) fear loss of their income and act accordingly. Rapid developing countries like China fear a constraint to development. The group of the least developed countries can receive special benefits under the Convention and more and more act as a group.

3.7 POSITIONS OF PARTIES RELATED TO FUTURE COMMITMENTS

Group of 77 and China

In the past, the general and very strong position of the Group of 77 and China has been, that no further commitments are accepted at least until the developed countries have demonstrated to take the lead in combating climate change. This can be observed from the negotiation history on the topic of the adequacy of commitments (see chapter 3.1.2). Last at COP 8 (November 2002), the G77 was not willing to enter any dialogue on new commitments for developing countries, since emissions of developed countries continue to increase, the Kyoto Protocol has not entered into force and the flow of financial assistance and technology transfer to developing countries is not satisfactory.

This position is also apparent in other items under discussion: During the negotiations of the Kyoto Protocol, the delegation of Brazil proposed to differentiate the commitments of Annex I Parties according to their historic responsibility for climate change. This proposal was overtaken by the adoption of the Kyoto Protocol, but the scientific and methodological aspects were referred to the SBSTA for its consideration. At SBSTA 14 in June 2001, the proposal was to hold a workshop to assess new research results and to broaden the participation in the research especially by developing country experts. Fearing that this agenda item would eventually lead to developing country commitments, China, India and Saudi Arabia proposed that such workshop should be held as late as possible. Positions were firm and a final agreement to hold the workshop one and a half years later (before SBSTA 17 in November 2002) was only reached in the last minute in the SBSTA plenary. Similarly, discussions were difficult at SBSTA 17. An agreement was again reached only in the last minute. Brazil was able to join the G77 to support a continuation of the discussion. Further consideration was deferred, however, to SBSTA 20 (June 2004) and 23 (November 2005).

Another example is the discussion on the further consideration of the Third Assessment Report of the IPCC. The SBSTA, at its 15th session, considered how the findings of the report would feed into the negotiating process. Many Parties argued that the findings and their consequences for the negotiating process should be discussed at a workshop. China was not in favor and Saudi Arabia was very strongly opposing to discuss any matters that related to the future. Only the making of the report and the uncertainty of the information should be discussed. Again a final agreement could only be reached to hold such workshop in the very last minute when some modifications were made to the draft conclusions that isolated Saudi Arabia. Discussion at following sessions of the SBSTA ware equally cumbersome.

Under the discussion of policies and measures, cautious care is taken by some developing countries, that after each mention of the term 'policies and measures' the words 'by Parties included in Annex I' is added. Also the new guidelines for the preparation of national communications for Non-Annex I Parties mostly refer to 'steps taken or envisaged to implement the Convention' and not to 'policies and measures'.

Alliance of small island states (AOSIS)

The Alliance of Small Island States (AOSIS) is a part of the G77 and associates itself with the G77 position on future commitments, also for political reasons to avoid a splitting of the group. Individual members of AOSIS stressed, in particular at COP 8 in November 2002, that the ultimate objective of the Convention provides a basis for a long-term plan and that urgent action is needed by *all* Parties. It was urged that the impasse between Annex I and Non-Annex I would be resolved.

Kazakhstan

As a state of the former Soviet Union and an economy in transition, Kazakhstan applied to have its name added to the Annex I of the Convention (see Chapter 3.1.3). One incentive for this application could be the access to the mechanisms with a relatively modest limitation of emissions as for other economies in transition. Some developing countries opposed to such inclusion.

Argentina

At COP4 in 1998, Argentina offered to be bound by a target for the first commitment period once the COP implements such an option for developing countries that wish to participate in the Kyoto Mechanisms (see Box 6). That target was provided not in absolute terms but as a function of the Gross Domestic Product (GDP).

The major reason for a target as a function of the GDP was the unavailability of a solid estimate of the GDP and therefore projected emissions in 2010. The recent economic decline in Argentina has shown that indeed such predictions have to be treated with care.

After the submission of the national communication, the national government has changed

"The Republic of Argentina, in accordance with the objectives of the United Nations Framework Convention on Climate Change, bearing in mind its differentiated responsibilities, its right to a sustainable socio-economic development and the characteristics proper to its particular production system and emission generating structure, and in its condition as Non-Annex I country under the Convention, and Non-Annex B country under the Kyoto Protocol, voluntarily commits itself to ensure that its net anthropogenic greenhouse gas emissions shall not exceed an amount that is termed 'emission target'.

The compliance period for the said target shall be the period 2008-2012, and it shall be applicable to the annual emission average for that period.

The target shall be equal to the product of an index multiplied by the square root of the five-year average Gross Domestic Product corresponding to the commitment period. The index is established at 151.5. This value implies an effective reduction in Argentina's greenhouse gas emissions relative to the emissions estimated for the most likely scenarios, resulting from projections that do not contemplate intervention measures, and that are estimated at between 2% and 10%.

The calculation of the Gross Domestic Product shall be based on market prices and expressed in 1993 pesos, according to the Republic of Argentina's statistical records of national accounts.

Greenhouse gas emissions shall be considered as aggregate emissions and expressed in metric tons of carbon equivalent, in accordance with the provisions of Article 5 of the Kyoto Protocol. In the context of this commitment, greenhouse gases means those included in Annex A of the said Protocol.

Emissions shall be those originating in the sectors and source categories described in Annex A of the above-mentioned Protocol, plus the net changes in greenhouse gas emissions from sources and removals by sinks resulting from direct human-induced land use change and forestry activities. In this context forestry means afforestation, reforestation and deforestation.

The emission and sequestration of greenhouse gases shall be calculated in accordance with the methodology adopted by the United Nations Framework Convention on Climate Change.

The present commitment shall constitute a binding international commitment once the Conference of the Parties to the United Nations Framework Convention on Climate Change implements a new option that may enable Non-Annex I countries which, like the Republic of Argentina, wish to assume an emission target, to participate in the mechanisms established in Articles 4, 6 and 17 of the Kyoto Protocol and after this Protocol became in force."

Box 6. The voluntary commitment by Argentina as in a revision to its initial national communication 1999

and the economy is going through a severe crisis. The voluntary approach by Argentina was opposed by some developing countries. The COP also never implemented such an option for developing countries that wish to participate in the Kyoto Mechanisms. The offer by the Argentinean government is therefore outdated (see also WRI 2002).

India

As the host of COP 8 in November 2002, The Prime Minister of India, Mr. Atal Bihari Vjpayee, stressed that the contribution of developing countries to increased greenhouse gas concentrations is low and will stay low for several decades to come. A call for developing country commitments would be "misplaced" as Indian per-capita emissions are below the world average, the per capita income and greenhouse gas emissions per unit of GDP are low compared to those of Annex I countries. It was stressed that the only equitable form for the future would be one based on equal per-capita rights.

South Korea

South Korea is currently defining its position on the issue of evolution of commitments. It seems certain that a target of different form than that of Annex I Parties is preferred. A target expressed in terms of greenhouse gas emissions per GDP has been discussed.

USA

During the negotiations for the Kyoto Protocol, the USA was opting for further involvement of developing countries. Any such idea was rejected by the G77 with reference to the mandate of the AGBM process, which explicitly excludes further commitments for developing countries. After Kyoto, the USA continued to request 'meaningful participation' of developing countries.

President George W. Bush announced in March 2001 that he rejects the Kyoto Protocol calling it 'fatally flawed'. A major argument is the apparent 'exclusion' of developing countries, naming specifically China and India. Another argument was the high costs involved for the USA to reach these targets. The USA has presented an alternative target for the USA, measures in terms of greenhouse gas (GHG) intensity, i.e. emissions per unit of GDP. The GHG intensity should decrease by 18% in the next 10 years, which is equivalent to 2% annually. Some observers pointed out that this target would be close to the business-as-usual development of the USA.

A change in the position of the USA towards developing country commitments first emerged at SBSTA 15 (June 2002) and became clear at COP 8 in November 2002: The USA is now no longer calling for developing country commitments and is not supporting the call for a process to discuss the future, but instead stresses the need of economic development for all countries in order to be able to tackle climate change.

European Union

The European Union has been a strong supporter of the theme that developed countries should take the lead to combat climate change and did not call explicitly for actions by developing countries in the past. At COP 8 in November 2002, the EU stressed the progress towards meeting its commitments and called for a dialogue to kick off a process for future action to achieve the ultimate goal of the Convention. Although the EU stressed explicitly that it does not want to impose reductions targets on developing countries with such a dialogue, many developing counties interpreted the EU position as such, either having misunderstood the position or interpreting it this way deliberately.

4. EQUITY CONSIDERATIONS

The international climate negotiations are based on the voluntary participation and cooperation of countries. In the absence of a supranational enforcement institution, any solution or agreement must be considered equitable by all participants. Probably, the most inequitable outcome of all would be reaching no agreement at all.

Equity or fairness is a subjective issue. US President George W. Bush for example called the Kyoto Protocol an unfair means of addressing climate change. On the other hand, Ambassador Raul Estrada, who chaired the negotiations that lead to the Kyoto Protocol, compared the

burden of emission reduction for developed countries ("environmental debt", Byrne 1998) with the burden of external debt services for developing countries. Comparing the amounts would lead to a different interpretation of fairness.

This chapter first describes the principles that are agreed in the Kyoto Protocol, then elaborates on the equity principles used for sharing of emission reductions and finally draws conclusions for the following chapters.

4.1 AGREED PRINICIPLES OF THE UNFCCC AND THE KYOTO PROTOCOL

The UNFCCC, in its Article 3, provides five principles that should guide the negotiations and related actions by Parties:

1. The most prominent and often quoted principle is that Parties should protect the climate "on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities". Following from that developed countries "should take the lead in combating climate change and the adverse effects thereof."
2. As a second principle, the special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, and of those Parties that would have to bear a disproportionate or abnormal burden under the Convention, should be given full consideration.
3. Thirdly, countries should take precautionary measures. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost.
4. Sustainable development is mentioned as the fourth principle. Actions to protect the climate system should be appropriate for the specific conditions of each Party and should be integrated with national development programmes, taking into account that economic development is essential for adopting measures to address climate change.
5. Cooperation is the fifth principle. Measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade.

The agreement on principles has been the key to reaching agreement on several issues during the negotiations in the past. Often opinions are diverse, discussions complicated and on many inter-linked issues at the same time (see also chapter 3.1.1). For many Parties, especially those that participate in the negotiations with limited resources, the agreement on clear principles is seen as priority. Once appropriate principles are agreed, there seems the be some certainty that the fine detail will be developed accordingly.

One example is the agreement on the issue that the use of the Kyoto mechanisms should be supplemental to domestic action. For several years it seemed difficult to reach an agreement on how to define what "supplemental to domestic action" means. Some Parties insisted on a quantitative limit of the use of the mechanisms (e.g. 50% of the emissions reduction effort should be achieved at home), some others were against quantitative limits. An agreement was reached in Marrakech 2001 through a package of a) the inclusion of the principle that Parties should "reduce emissions in a manner conducive to narrowing per capita differences between developed and developing country Parties", and b) no quantitative limit of the use of the mechanisms.

Another example for the use of a principle is the agreement in Marrakech 2001 on the use of the land-use, land-use change and forestry activities for the targets agreed in the Kyoto Protocol. The finally agreed decision begins with a list of principles (e.g., the treatment of the land-use, land-use change and forestry activities be based on sound science). The text that follows in that decision aims at the implementation of these principles.

In these cases, agreeing on principles made it possible that a consensus was reached. Although the discussion on principles is sometimes difficult, because it is an abstract discus-

sion, the concept of agreeing on principles may provide a path to reaching a general agreement also in the future.

4.2 EQUITY PRINCIPLES RELATED TO NATIONAL COMMITMENTS CONSIDERED UNDER THE UNFCCC

One aspect of the commitments of Parties under the UNFCCC is the question how to share emission rights or reductions among countries. Looking at issues as a pure distribution problem, equity principles can lead the way to some distribution rules. Many studies on the evolution of commitments (Rose et al. 1998, Philibert & Pershing 2001, Berk & Elzen 2001, Ringius et al. 2002, IEO 2001) start with a list of equity principles and assign to each principle an allocation rule (distribution of a resource according to equity):

- The *egalitarian* principle (all human beings are equal) would lead to equal per capita emission entitlements.
- The principle of *sovereignty* (all countries are sovereign states) would lead to emission entitlements related to the share of emissions of that country in a base year.
- The principle *ability to pay* would lead to emission limitation or reduction efforts related to the size of a measure for wealth (e.g. the Gross Domestic Product, GDP).
- The *polluter pays* principle would lead to emission limitation or reduction efforts correlated to current emissions or historic contributions to climate change.

Equity principles may be included in a commitment regime not only at the question how to distribute the emission rights. For example the principle of *polluter pays* can be incorporated through accordingly differentiating commitments, but also through the choice of the point in time when a Party starts to take on binding commitments. Therefore, equity principles are present at different aspects of a commitment regime.

Further, proposals for future commitments are usually based on several different equity principles at the same time and not only on a single one. For example, an approach that does not recognize the need for development to satisfy basic human needs will have no prospects of being successful no matter how the emission rights are shared.

A similar view is described by the ECN/CICERO project of global differentiation (Ringius et al. 2002). The authors identified four key equity principles, which can be applied to climate commitment regimes as a whole (summarized in Table 4). A climate commitment regime should preferably satisfy all of these principles. The principles are grouped in one dimension as focusing on the cause of the problem or on the consequences. They are grouped along another dimension whether a cost or a benefit is distributed. The principle of *responsibility* means that the burden (cost of mitigation) should be distributed according to the responsibilities of the actors to the problem (cause). The principle of *capacity* means that the main cost should lie with those that have the most resources. The principle of *need* means that developing countries are granted the possibility of development to satisfy basic human needs. The principle of *contribution* leads to giving those countries credit that "produce" more reductions.

Table 4. Key principles of equity (Ringius et al. 2002)

		Object to be distributed	
		Costs (obligations)	***Benefits***
Focus on	***Cause of current state of problem***	Responsibility (for causing the problem)	Contribution (to solving the problem or providing the good)
	Consequences for actors	Capacity (ability to pay)	Need

Another source, the report of the COOL dialogue (Berk et al. 2001), concludes that "equity aspects would be an important element of future differentiation of commitments, but that it should not become an overriding issue. In looking for acceptable climate change regimes it seems wise not to focus on any single equity principle, but instead to look for approaches embracing different equity principles."

4.3 CONCLUSION ON EQUITY CONSIDERATIONS

We conclude that it is essential that future commitments satisfy certain equity principles. Agreeing on principles and incorporating those into explicit future decisions may be difficult, but also may provide a path to reaching agreement.

For this study, we want to move away from the relatively narrow application of equity principles only to the *distribution* of the emission rights. Instead, we will asses in chapter 6 several commitment regimes (including their approach to the distribution of emission rights) to three equity principles which can be derived from the Convention and which are based on the ones used by Ringius et al. (2002): 'need', 'responsibility' and 'capability'.

The principle of 'need' refers to the fact that countries that are less developed have to satisfy their basic human needs and need to have opportunities for higher economic development than other countries, preferably in a sustainable manner. This principle is included in the ultimate objective of the Convention (Article 2, see Box 1), which mentions that economic development should be able to proceed in a sustainable manner. It is further included in the Convention's fourth principle (Article 3.4), which notes that economic development is essential for adopting measures to address climate change.

The principles 'responsibility' refers to the aspect that those countries should reduce emissions more that are responsible for the problem (polluter pays); it can be defined in terms of current emission or historical emissions. The principle 'capability' refers to the aspect that those countries should act that have most resources (ability to pay). These two principles are derived directly from the first principle of the Convention (Article 3.1), which states that countries should act according to their 'common but differentiated responsibilities and respective capabilities'.

It is assumed that any proposed approach to future commitments must at least satisfy all those three equity principles in at least one aspect of their design in order to be successfully agreed.

5. CURRENT APPROACHES FOR COMMITMENTS

This chapter provides an overview of the approaches to climate commitments that have been agreed or that were proposed by Parties or in scientific literature. In the first section, the different approaches are described. The second section lists the relevant aspects that need to be considered in the discussion on further commitments.

5.1 APPROACHES PROPOSED TO DATE

5.1.1 Official commitments

In this section, those types of commitments are described that are either agreed within the negotiation process or that have been officially proposed by a Party for itself.

Convention

The Convention provides for two types of commitments:

First, there are the commitments that are formulated in a very general sense, such as the implementation of policies and measures, support of research and provision of regular reports, which hold for all Parties. Due to their very general and unspecific nature, compliance is difficult to assess.

Second, there is the "semi-quantified" commitment, the carefully worded return of Annex I emissions individually or jointly to 1990 levels by 2000. Annex I Parties shall adopt national policies "recognizing that the return by the end of the present decade [1990's] to earlier levels of emissions […] would contribute to the modification of long term trends" (4.2(a)). Annex I parties shall *report* information on these policies and measures "with the aim of returning individually or jointly to their 1990 levels" (4.2(b)). Note that the word 'stabilization' was avoided and the a return to earlier emission levels is referred to. Due to this indirect formulation, this commitment is interpreted as non-binding.

Kyoto Protocol

The Kyoto Protocol defines a new type of commitments: Quantified emission limitation or reduction commitments (QELRC) for individual Annex I Parties. The levels of these targets were negotiated on an ad-hoc basis (see chapter 2). The reductions are legally binding. The concept of national *reduction* targets originates from the approach that was also used in the Montreal Protocol.

Voluntary commitments by Parties

Kazakhstan has voluntarily applied to be a member of Annex I and Argentina had offered (but did not insist) to be bound by a target which is expressed as a function of the GDP (see chapter 3.7). While these countries are or have been voluntarily active, the targets would nevertheless be binding once agreed by the COP.

5.1.2 Additional options for commitments proposed for and after Kyoto

A variety of approaches and elements of approaches have been proposed both by Parties during the negotiations of the AGBM process before Kyoto (Torvanger & Godal, 1999) and later in the open literature. These approaches are listed in the following section.

Convergence

During the AGBM process (1996), France proposed a formula for Annex I targets in 2010 based on eventually converging global per-capita emissions by 2100. The EU also proposed in 1997 that emission paths should eventually converge to similar per capita or per GDP levels, without specifying a timeframe or level.

The Global Commons Institute presented the 'Contraction and Convergence' approach in 1996 (Meyer 2000): Governments would agree to a global emission path that leads to stabilization of greenhouse gas concentrations ('contraction'). Each year's ration of this global emissions budget is shared out so that every country converges linearly on the same allocation per inhabitant by an agreed date, for example by 2030 ('convergence'). Emissions trading would be allowed.

At the Center for Science and Environment, New Delhi, India, A. Agarwal (1999) proposed convergence of per-capita emissions and discussed several at different ultimate levels of such per-capita entitlements.

Increasing participation / multistage

While the Global Commons Institute proposed that all countries participate from the beginning (sometimes with growth targets), countries could be required to participate only when certain thresholds are exceeded.

As a further refinement, Den Elzen et al. (1999, 2001) proposed participation in several stages in the FAIR model (Framework to Asses International Regimes for differentiation of commitments). Countries that satisfy certain criteria "graduate" into the next stage. First countries have no commitments, later a de-carbonization target (decreasing emissions per GDP), then stabilization of emissions and lastly reduction of emissions. A global emission path is defined that would lead to stabilization of concentrations. The levels of reductions are assigned to participating countries so that a defined emission path is met.

J. Onigkeit (2000) proposed a similar stage approach: At the first stage there are no commitments, at the second stage there is a freezing of per capita emissions once an income threshold is met, and lastly per-capita emissions have to be reduced once the global average is reached.

Historic responsibility

During the AGBM process, Brazil proposed a method to share emission reductions among Annex I countries, the "Brazilian Proposal": In essence, a total reduction target for Annex I is defined and the emission reduction effort among countries is shared according to their historic responsibility for climate change. The historic responsibility is measured as the impact of a countries' emissions on the global-average surface air temperature increase. An interesting feature of the proposal is that the target was not accounted in terms of emissions (i.e. in Gt CO_2 equivalent) but in "effective emissions", defined as the effect of the emission on the temperature (i.e. in °C).

The concept of contributions to climate change is under scientific discussion (Den Elzen & Schaeffer 2002, Höhne & Harnisch 2002). The scientific and methodological aspects of the proposal are still discussed in the SBSTA (see also 3.7). An information sharing process to assess contributions to climate change has been launched.[5]

The delegation of Brazil did not provide a new proposal after the negotiations of the Kyoto Protocol how this concept could also be applied to more countries than those included in Annex I. The proposed methodology allows only sharing emission *reductions* between participating countries, *increasing* emission targets cannot be accommodated. If this approach is applied also to developing countries reducing below a business as usual level instead of reducing below the current level could be applied.

Berk and Den Elzen (1999, 2000) assessed and modified the methodology proposed by Brazil and applied on a global scale using the FAIR model. The historic responsibility is applied as a burden sharing key for reducing countries.

Multiple criteria for differentiation

During the AGBM process several criteria were proposed by several countries that could be used to differentiate commitments: Emissions/GDP, GDP/capita, Emissions/capita, contribution to global emissions, share of renewable energy sources, industrial emissions as share of

[5] Further information is available at http://www.cru.uea.ac.uk/unfccc_assessment/

total CO_2 emissions, projected GDP, projected population, emissions intensity of exports, fossil fuel intensity of exports, dependency of income on fossil fuels, defense budget, share in international trade, emissions per unit of territory, energy production/capita, energy consumption/cap. Some countries provided formulas with these criteria as variables to calculate emission allowances (see also Torvanger & Godal 1999). Another option is to use the share of contributions to the UN budget as agreed by the general assembly (Babiker & Eckaus, 2000)

Intensity target

An alternative to an absolute national targets is an emission target as a function of the GDP (see also Argentina's voluntary target in 5.1.1).

The World Resource Institute in Baumert et al. (1999) sees potential benefit from targets relative to the GDP, since they would foster the decoupling of greenhouse gas emissions and economic development.

The USA has proposed a greenhouse gas intensity target as alternative to its target under the Kyoto Protocol. The USA would reduce its emissions per GDP by 18% during the next 10 years (USA 2002a, b).

Triptych: Sectoral targets aggregated to a national target

The Triptych approach takes into account explicitly the different technological starting points of countries. It defines certain emission limits for individual sectors and adds the resulting sectoral emissions to a national total.

The Triptych approach was first proposed 1997 (Blok et al. 1997, Phylipsen et al.1997, 1998, Groenenberg et al. 2001) and served as the basis for the EU internal negotiations on how to share the Kyoto target amongst its members. The Triptych approach covers three sectors (as a 'triptych' originally is a painting in three parts). For the heavy industry, a limit of heavy industry growth and an efficiency improvement is defined applicable to all countries. For the sector of electricity production, a limit of electricity production growth and the shares of fossil, CHP, renewables, nuclear and gas are set. For the domestic sector a date is set when per capita emissions of that sector converge. The resulting total of all three sectors is the allowance of the country. Compliance with this target does not depend on the actual emissions of the sectors, the approach is just used to set the national total target.

Sectoral targets combined with convergence

A more elaborate implementation of the Triptych concept with ultimately converging per-capita emissions is the Multi-sector Convergence Approach developed by the Center for International Climate and Environmental Research Norway (CICERO) and the Energy Research Center of the Netherlands (ECN) (Jansen et al. 2001). For seven sectors, it defines global per capita emissions standards to which each country's sectoral per-capita emissions have to converge. The resulting total of all sectors is the allowance of the country. It allows for adjustments for countries with special national circumstances.

Equal cost

During the AGBM process, New Zealand proposed to differentiate the emission reduction as to equalize marginal abatement costs without providing a specific methodology.

Other modeling groups provide cost estimates of different differentiation options as well as differentiation according to equalized costs (Rose et al. 1989, Abare 1995, Babiker & Eckaus, 2000).

Coordinated policies and measures

During the discussions towards the Kyoto Protocol the alternative to emissions limitation or reduction targets was the agreement on coordinated policies and measures. The most prominent option would have been a common tax on CO_2. Other coordinated policies could include research and development, elimination of climate adverse subsidies or generally agreed energy efficiency standards.

Other approaches

The PEW center (Claussen & McNeilly 1998) presented an approach to divide countries in three groups: “Must act now”, “could act now”, “should act now, but differently”. The distinction is based on the three indicators growth (in CO_2 emissions), standard of living (GDP) and opportunity (energy consumption per GDP). No further detail is given how these countries should act.

Philibert & Pershing (2001) proposed targets that could be binding if they were met (so that excess credits could be sold), while they would be non-binding, if not met. As advantage, such targets would not be associated with a risk of high cost if not achieved, they only provide an opportunity and incentive to join a commitment regime.

5.2 ISSUES RELEVANT FOR DECIDING ON FUTURE COMMITMENTS

Considering the approaches listed above, it becomes apparent, many ideas exist how commitments could develop in the future. But not all approaches cover all aspects that would define a complete global commitment regime. For example the Brazilian proposal was originally designed for Annex I. To apply “the Brazilian proposal” to future commitments of all countries, several assumptions have to be made, such as which countries participate and by how much the total emissions should be reduced.

In the following section we, therefore, distill the different aspects that are needed to fully characterize an approach and summarize them in Figure 10. These dimensions could be used to structure a discussion on future commitments. In describing these issues in this section, some considerations may be repeated that have already been described in the preceding section.

Step by step vs. comprehensive long-term approach?

With the Kyoto Protocol, a first step was taken to reach the ultimate objective of the Convention (stabilization of greenhouse gas concentrations). A next round would define further steps. Such an *incremental approach* derives targets based on current possibilities and therefore focuses on the sharing of the burden of emission reductions.

As alternative, a *comprehensive approach* would define rules and criteria for the long term. It could derive a global emission path from a long-term environmental goal. Emission rights would be shared among countries according to well-defined criteria and rules. There would be certainty under which conditions a country would have to participate and with which commitment. The rules would be reviewed at regular intervals, but the general concept would be kept. Such approach would focus on the sharing of resources, since it divides the available emission space into shares for individual countries. An example for such a comprehensive approach would be ‘Contraction & Convergence’.

Some participants of the COOL dialogue (Berk at al. 2001) argued for a comprehensive approach since an incremental approach could lead to the failure to reach an ambitious stabilization target.

A mix of both approaches is also possible.

Will there be “one size fits all” or several types of commitments?

Under the Kyoto Protocol, for Annex I countries have the type of commitment of binding reductions in absolute emissions, Non-Annex I countries have non-quantified commitments. A straightforward option would be to apply the type of commitment of Annex I countries to other countries. But some countries may not accept this type of targets as it is too restrictive and could turn out to restrict economic growth. They could however accept other types of targets. A climate regime could include several types of targets in parallel. There could be a catalogue of commitments or formulas in the future. The Parties could choose the commitments that suit the national circumstance and capabilities best, as log as it is ensured that the global emissions are limited or reduced to the appropriate level.

It is likely that any approach will include exceptions since national circumstances are so diverse. The rules under the Kyoto Protocol include several exceptions to ensure the continued participation of all Annex I countries: Iceland (emissions from single projects), Australia

(emissions from land-use change and forestry), increased allowances for forest management for Japan and the Russian Federation.

National emission targets or non-quantified targets?

On the one hand, targets could be expressed in quantitative form as emission limitation or reduction targets as for Annex I countries under the Kyoto Protocol. Questions relating to quantified targets are discussed further below.

Targets could be also be expressed around policies and measures as an option, which can be applied in parallel to quantified targets. These non-quantified targets could include the general commitments as given in the Convention. Here, general actions need to be implemented, but details are not specified. Another option is to agree on certain common and coordinated policies and measures that all or some Parties have to implement. Examples are taxes or energy efficiency standards.

What if the commitment is not met?

The commitments can be either *legally binding* or *non-binding.* Legally-binding targets would have enforceable consequences if they are not met, while not complying with *non-binding* targets would have no consequences.

As a proposal in-between, quantified targets could be for some countries binding if they are met, but at the same time non-binding if they are not met. If a country under such a target overachieves its target, it could sell emission allowances to other countries with legally binding targets. However, that country has to face no consequences if its emissions are higher than the target. In such a system has to ensure that a country is not selling allowances if it is unlikely to meet its target.

Legally binding quantified emissions limitation targets can be made more flexible and less restrictive, if excess emissions can be 'borrowed' from future commitment periods, restored in future commitment periods with a certain 'interest rate' (as in the Kyoto Protocol) or an additional number of credits can be bought at a fixed price (see also price cap).

Who participates and when?

A separate question is that of who participates in the commitment regime and when. One option is that all participate, some with growth targets (as in 'contraction and convergence'). Participation could also be on a voluntary but binding basis (the Kazakhstan case). Alternatively, a threshold for the participation could be set that defines when a country has to participate. Such threshold could be calculated using following indicators or a combination of them:

- Emissions
- Emissions/capita
- Emissions/GDP
- GDP/capita
- Cumulative emissions
- Contribution to temperature increase
- Human development index

For example, all those countries have to participate, whose GDP per capita or GHG emissions per capita are above a certain level.

The commitment system could also include several stages of commitments. If a country supercedes a thresholds, it would "graduate" into the next commitment stage (Den Elzen 2001).

It could be argued to include the major emitting countries, as the 28 most emitting countries are responsible for 80% of global GHG emissions (see also Appendix A). On the other hand, Annex I countries are responsible for half of the global GHG emissions with only 20% of the global population.

How can political agreement be built?

A whole different set of questions develops around the ways to build a political global consensus. Meetings of scientists and policy makers from all countries on this topic such as the COOL dialogue would be a way forward. Benito Müller (2001) proposed a way to numerically

find a compromise between two proposals based on the population that is supporting the proposals. Further elaboration, however, of this complex issue of building an international consensus it is beyond the scope of this report.

How should national emission targets be set?

What is the type *of the target?*

First, it needs to be defined what is limited or reduced by the commitment. The main alternatives include absolute national emission (Kyoto Protocol) or emissions expressed as a function of the GDP (intensity targets).

It also needs to be defined which *sectors* are included in the target: Energy, industrial processes, solvents, agriculture, waste as well as land-use change and forestry. The Kyoto Protocol includes those sectors but treats land-use change and forestry in a different manner. Further, it needs to be decided which gases are included. The Kyoto Protocol includes CO_2, CH_4, N_2O, HFCs, PFCs, SF_6. A scientific debate is ongoing whether a comprehensive climate strategy should also include ozone precursors and/or aerosols (Hansen 2000). This includes also a discussion on ways to compare effects of different greenhouse gases using global warming potentials (as in the Kyoto Protocol) or any other means (e.g. Godal & Fuglestvedt 2002, O'Neill 2000)

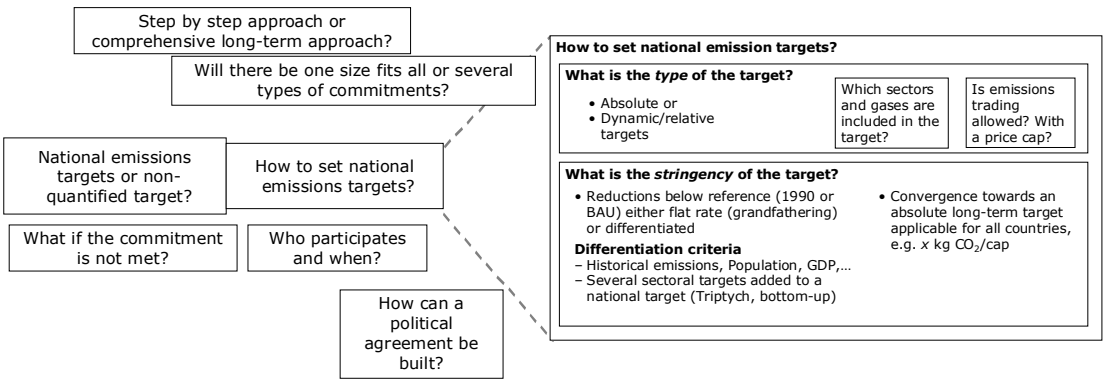

Figure 10. Dimensions of deciding on new commitments

If quantitative targets are set, *mechanisms* such as those applied in the Kyoto Protocol could be allowed: Emissions trading, the clean development mechanism (CDM) and Joint Implementation.

To add further flexibility, a limit on the maximum price per permit, a 'price cap' could be set: In the event that costs to reach the target are unexpectedly high, additional permits could be introduced into the market at a price that had been fixed in advance. The revenue from these permits would be 'recycled', i.e. redistributed among the participants, or used to achieve emission reductions. This would allow for certainty of the maximum costs.[6] Since an emissions trading regime with a price cap is in between a free emissions trading system (certainty on the emissions target, uncertainty on the cost) and a tax (certainty on the cost, uncertainty on the emissions target) it is sometimes referred to as a 'hybrid' instrument.

What is the stringency of the target?

Basically two options exist to define the *stringency* of a target. Either a) the target based on a reference, e.g. the current level of emissions (grandfathering) or a business as usual case, and defines a percentage reduction from it, or b) the level of the target is converging to an absolute allowance, defined as a share of that country of a global limit.

[6] The concept of a price cap is equivalent to a fixed financial penalty for excess emissions over assigned amount at the end of the commitment period. A cap at the price of zero would be equivalent to a target that is non-binding if it is exceeded.

For the option a), either all participants reduce at the same flat rate or they reduce at different rated (differentiated), taking into account specific circumstances of individual Parties. Differentiated reductions could be assigned according to differentiation criteria. Possible differentiation criteria include:

- Current or historic emissions
- Contribution to temperature increase
- Population
- GDP or other measure of welfare or income
- Geographic area
- Reduction potential
- Costs or benefits of reductions
- Sectoral benchmarks
- Several sectoral targets added to a national target (Triptych, bottom-up)

The individual reductions could be tuned so that a global emission target is reached.

For option b), long-term targets could be assigned that are applicable for all countries without use of a reference (e.g. a certain amount of emissions per GDP or per capita as for the 'contraction and convergence' approach). To avoid abrupt changes in emission allowances from the present to such long-term target, the allowances would converge over time toward that target.

Flexibility

Current targets of the Kyoto Protocol are absolute, binding emission targets. Recently, many actors (e.g. developing countries and the United States of America) have called for more flexibility in the targets such as those included in the Kyoto Protocol. Several of the issues discussed above are perceived as options for providing such flexibility: targets that are expressed as a function of the GDP, caps on the maximum price in an emissions trading system, the non-binding nature of commitments if they are exceeded or borrowing from future commitment periods or exceptions for particular cases.

It is argued that, on the one hand, flexibility can lead to broader participation in the regime. On the other hand, too much flexibility in the worst case can lead to targets very close to business as usual or to a symbolic policy.

5.3 CONCLUSIONS FOR THE FOLLOWING SECTIONS

The categorization described above can be used to focus a discussion of commitments. In order to describe a complete regime, all of the above questions have to be answered.

Since the elements and concepts are diverse, a comparative assessment of the approaches can only be made when selecting the most prominent approaches and bringing them to similar level. This is described in the following chapter.

6. ELABORATION AND ASSESSMENT OF EXISTING APPROACHES

6.1 INTRODUCTION

As described in the earlier chapter 5, many concepts exist related to future commitments of Parties. But not all those ideas are fully developed or cover all aspects defining a complete global commitment regime.

In the following chapter we, therefore, select seven types of approaches and extend them to such a global commitment regime. The approaches are described in full detail, including the assumptions made in the extension. We also model the allowed emissions of countries under these approaches and subsequently assess the approaches with respect to common assessment criteria to test their suitability for the international negotiation process.

Selected approaches

For further comparative analysis, the following illustrative cases were selected:

- **Continuing Kyoto**: The most straight forward option would be to continue the current system without changes, assuming that more and more countries join the group of reducing countries which receive binding absolute emission reduction targets.
- **Intensity targets**: As illustrative case it is assumed that all countries reduce their greenhouse gas intensity (greenhouse gas emissions per unit of GDP) at the same rate.
- **Contraction and Convergence**: The approach introduced by the Global Commons Institute assumes that per capita emissions converge to equal levels.
- **Global Triptych approach**: In this approach a national target is derived from bottom-up sectoral targets, which are based on specific considerations of the emission development and reduction potential of the sectors.
- **Multi sector convergence approach:** Similar to the previous approach, a national target is derived from sectoral targets. This approach assumes converging per capita emissions for seven different sectors.
- **Multistage approach (FAIR)**: Using the approach proposed in the FAIR model, it is assumed that countries participate in the commitment regime in 4 stages, 'graduating' from one to the next.
- **Equal mitigation cost**: The targets are distributed among countries distributing the economic burden equally over all countries, based on an agreed model.
- **Coordinated policies and measures**: It is assumed that countries do not receive quantitative emission limitation or reduction targets, but are obliged to implement certain coordinated policies and measures.

These illustrative cases were chosen to cover the broad range of options proposed to date without prejudging how realistic or successful they could be. Elements of the approaches could be used in parallel, e.g. under a continued Kyoto Protocol, some countries receive also intensity targets, while others concentrate on policies and measures. However, we here analyze these cases separately to draw from the results for a discussion on new approaches.

Basic assumptions

The calculations of the emissions limits for all approaches are calculated for common assumptions. If not stated otherwise the assumptions include the following (see also Appendix A):

- The parameters of the illustrative cases (e.g. the reduction level) were chosen as to ensure that global emissions in 2020 are +27% above 1990 levels for the total of CO_2, CH_4 and N_2O emissions in CO_2 equivalents, if possible. The choice of this level was based on the following: Several emission paths could lead to stabilization of CO_2 concentrations at 450 ppmv. A path slowly decreasing as of 2010 would lead to emissions in 2020 around +10% above 1990 levels. A path with increasing emissions to peak in 2020 and to rapidly decrease afterwards would lead to emissions in 2020 around +40% above 1990 levels. The target was chosen to lie in the top third of the range, as to ensure that 450 ppmv still can be reached. In absence of stabilization scenarios of CH_4 and N_2O in the literature, this percentage increase was applied to the total of CO_2, CH_4 and N_2O emissions in CO_2 equivalents.
- Emission inventory figures from the EDGAR 3.2 database (EDGAR 2001) for 1990 and 1995 were used as the basis. Energy and industrial emissions as well as from forestry for CO_2, CH_4 and N_2O are included. For major Annex I countries, emission data from the national submissions to the UNFCCC was used.
- The business a usual path of emissions was calculated from the emission growth rates of the regions of the IPCC SRES scenario A2 applied to the emission estimates of the inventories. The resulting global emission levels in 2020 are +67% above 1990 levels. The A2 scenario is in the middle range of the SRES scenarios for the timeframe 1990 to 2010. The choice to use the A2 scenario is however arbitrary. The sensitivity of the results to other scenarios is analyzed in the particular cases. If the other SRES scenarios were used, total global emissions would range between +25% to +72% above 1990 levels.
- The GDP values for 1990 and 1999 were taken from the World Bank as provided in IEA 2001 in 1995 US$ using purchasing power parities. Future values were derived from the IPCC SRES scenario A2, which provides GDP growth for four world regions. The GDP growth rate of the region was applied to individual countries within that region by applying the average annual growth rate between 1990 and 1999 of the individual countries, linearly de- or increased so that the total GDP increase of the groups matches the total increase as provided in the A2 scenario. (For more information on indicators for human wealth see Appendix B.)
- Resulting emission allowances were aggregated for the group of countries as provided in Appendix A. Quantitative results are provided in Table 10.

Assessment criteria

The discussion of all illustrative cases is based on common assessment criteria. These criteria arise from the intention to strive for an 'optimal' approach that is likely to be agreed successfully. The criteria also take into account earlier assessments (Berk & den Elzen 2001, Philibert & Pershing 2001). The following assessment criteria were used:

Environmental criteria

- **Environmental effectiveness**: The optimal approach must ensure that stringent global emission targets are reached to safeguard the fulfilment of the ultimate objective of the Convention. Accordingly, it should include greenhouse gas emissions from all important sources and sectors and avoid leakage (the transfer of emissions to other countries instead of the reduction). It should promote for ancillary benefits of the emission reductions and should provide certainty of the emission levels on the global level as well as for participating Parties.
- **Encouragement of early action**: Since major reductions of global greenhouse gases emissions are needed to reach the ultimate objective of the Convention, it is necessary that all Parties avoid unnecessary emissions. The optimal approach would encourage countries that do not yet have binding commitments to keep emissions as low as possible.

Political criteria

- **Equity principles**: Three equity principles should be covered by the optimal approach to a certain extent in order to be successful (for the selection see also chapter 4):
  - It should allow that countries to develop economically to satisfy their basic human needs and that this development should be geared towards sustainability (principle of *need*)
  - It should require those countries to take on a burden that have the economic ability to pay and to undertake action (principle of *capability*)

- It should require those countries to take on a higher burden in reducing emissions that pollute more (principle of *responsibility*).

- **Agreement with fundamental positions of major constituencies**: Since the international negotiation process is based on decisions by consensus, the optimal approach would have to be acceptable for all constituencies. This means that the approach is perceived as not posing unproportional burden to some countries, while favoring others. It should also rely not on only one group's position but be a compromise of all proposed approaches. Assessment of this criterion is based on the current positions.

Economic criteria

- **Accounting for structural differences between countries**: Since starting positions of countries are very diverse, the optimal approach would take these differences explicitly into account.

- **Minimizing adverse economic effects**: The optimal approach would require a distribution of reductions so that the global costs are minimized. The optimal approach would also give participating sovereign nations sufficient flexibility to reach their commitments, tailored to their national needs and priorities. Such an approach would avoid being prescriptive in the action but leaving room for the implementation of the target, e.g. reducing emissions in different sectors, or reducing emissions of different gases, etc. In addition, the optimal approach would ensure that participating countries have certainty on the inferred costs of taking on commitments.

Technical criteria

- **Compatibility with the structure of the UNFCCC and the Kyoto Protocol**: The optimal approach would be compatible with the existing international structures of the Convention and the Kyoto Protocol as to benefit from the international negotiations that have taken place to date. Institutions and structures implemented for the use of the Kyoto Mechanisms could be utilized.

- **Moderate political and technical requirements for the negotiation process**: Since the international negotiation process is based on decisions by consensus, the optimal approach should be simple and require a low number of separate decisions by international bodies. In addition, all necessary data and tools should be available and verifiable. If data is not available, there should be the opportunity that it can be collected and verified in the future. If the approach requires a calculation method, these should also be available and verifiable. Finally, the optimal approach would allow that the implementation of the targets can be monitored and verified.

Potential conflicts between these criteria exist. E.g. a very simple approach (such as converging per capita emissions) would be relatively easy to negotiate but cannot explicitly address the national circumstances of individual countries. Complex formulas for future commitments, which can accommodate particular national circumstances, may be difficult to negotiate. Consequently, the 'optimal' approach may not be available. It will always be a compromise that satisfies the above criteria only partly.

The following text provides the description and assessment of the approaches with respect to these criteria. A comparative assessment is contained in chapter 8.

6.2 CONTINUING KYOTO

6.2.1 Description

As a first illustrative case it is assumed that the commitment regime is continued as under the Kyoto Protocol: binding absolute emissions limitation targets. We made the following assumptions and selected the parameters as to ensure that the total emissions in 2020 reach the goal of global emissions being 27% above 1990 levels.

- The group of reducing countries (currently Annex I) reduces emissions by –20% below the 2010 assigned amount until 2020 (average of 2018 to 2022). Intermediate targets would be set for the period 2013 to 2017. The reductions have to be shared among the countries possibly differentiated. A universal reduction is assumed here for the calculations.
- Non-Annex I Parties emissions develop according to the business as usual path until 2010. After 2010, Non-Annex I countries can move to the group of decreasing countries if their GDP per capita in 2010 above 7000 US$/person. If the GDP per capita is lower than this threshold, emissions follow the business as usual path. Each 10-year step this is continued. The threshold for participation in the year 2010 of 7000 US$/person, which can be compared with the assumed Annex I average for 2010 of 23000 US$/person, the Non-Annex I average for 2010 of 4600 US$/person and the global average for 2010 of 8000 US$/person.

6.2.2 Quantified results

Table 10 provides the results for the case 'Continuing Kyoto' based on the assumptions described above. Emissions include the three major greenhouse gases, including industrial and forestry sources.

In order to reach the global environmental goal, the most advanced developing countries would participate in 2020, i.e. would be assigned an emission target. For the given assumptions these would include Argentina, Brazil, Mexico, South Africa, the Persian Gulf states, South Korea, Malaysia, Singapore and Thailand. Since all reducing countries are assumed to decrease emissions at the same percentage, the required reductions for newly participating countries result in abrupt changes in the emission trend: increasing emissions until 2010 to decreasing emissions between 2010 and 2020. Provisions would have to be included to prevent this effect. Total global emissions would be limited to an increase of +27% compared to 1990 levels (see Figure 11), CO_2 concentrations would be at 480 ppmv CO_2eq in 2010.

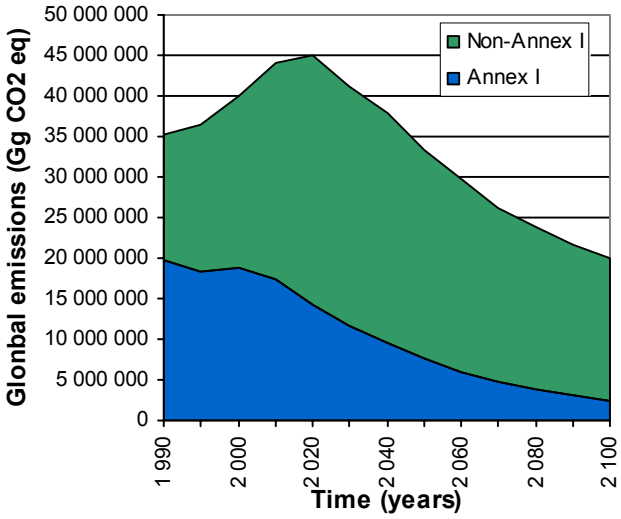

Figure 11: Global emissions under the 'continuing Kyoto' case

The results are very sensitive to the choice of the threshold when Non-Annex I Parties would join Annex I. A decrease in the threshold for participation has a large effect if it leads to the inclusion of a large country. If the threshold is decreased to include also China, the participating countries would have to reduce 7% per decade instead of 20% to reach the same global emission goal in 2020. If China were not included and Annex I countries would reduce emissions by 10% per decade, the total global emission would be +36% above 1990 levels.

The results are also very sensitive to the choice of the 'business as usual' scenario in terms of emissions and GDP growth. Keeping all parameters constant and changing only the SRES BAU scenario, total global emissions in 2020 could range between +2% and +33% of 1990 levels.

Another line of reasoning could be that some Annex I countries are granted an increase in emissions under the Kyoto Protocol. Due to the specific national circumstances Australia may increase emissions by 8%, Iceland by 10% in 2010 above 1990 levels. The EU has internally shared the –8% reduction among its Member States and has granted Portugal, for example, an increase in emissions of +27% in 2010 compared to 1990 levels. In this illustrative case, newly participating countries could therefore also receive growth targets. This interpretation would further increase the global total emissions in 2020 or would lead to further reductions by the current Annex I countries.

6.2.3 Assessment with respect to the criteria

Environmental criteria

Environmental effectiveness: Under this illustrative case, the system would eventually include all major developing countries but only when their GDP (and possibly emissions) are already relatively high. Only if Annex I countries decrease emissions substantially and all major developing countries participate at an early stage, stringent global stabilisation paths could be reached such as 450 - 550 ppmv. The 'Leakage' of emissions (emissions reductions in participating countries at the cost of emission increase in non-participating countries) could occur in this illustrative case: Emission intensive economic activities could be moved from a participating country (reducing its emissions) to a non-participating country (increasing its emissions, which are not limited). This is limited to a certain extent because this leakage would increase the economic activity to possibly exceed the participation threshold.

Encouragement of early action: Non-participating countries have incentives to decrease their emissions by participating in the CDM. There could be however the incentive not to participate in the CDM and not to take early action, since the targets are based on the emission level in 2010 or later. Therefore, some countries may prefer not to sell cheap emission reduction, "low hanging fruits", in the CDM.

Political criteria

Equity principles: The principle of allowing for sustainable economic growth (*need*) is covered in this approach through the stepwise increase of participation once certain economic development is reached. The stepwise increase of participation based on an economic indicator also covers the principle of *capability* (ability to pay) to a certain extent. Calculating targets as percentage of emissions in previous years may be against the principle of *responsibility* (polluter pays). Assigning differentiated targets and not the same percentage reductions to all participating countries would increase the coverage of the principles capability and responsibility.

Agreement with fundamental positions of all major constituencies: Most Parties have agreed to the principles embedded in the Kyoto Protocol. The USA, as a major constituency, has rejected the Protocol and seeks more flexible structures. China has announced that it is willing to participate in the commitment regime once it reaches the economic development of the Annex I Parties. A major obstacle is that *some* developing countries would have to join the group of Annex I countries, which is currently unacceptable for the Group of 77 and China.

Economic criteria

Accounting for structural differences between countries: The use of only one criterion to decide when countries participate (GDP per capita) and assigning the same reduction target to all participating Parties does account for only the one structural differences between countries. Assigning different reduction levels to the reducing countries (as provided in the Kyoto Protocol) could introduce further acknowledgement of the structural differences of countries. Furthermore, exceptions could be made for very particular circumstances (also as provided for in the Kyoto Protocol, e.g. the exclusion of small projects from the accounting under certain circumstances).

Minimizing adverse economic effects: If emissions trading is applied, it is ensured that marginal abatement costs are comparable in all participating countries, that reductions occur where they are the most economically efficient. The Clean Development Mechanism (CDM) will ensure that emission reduction potential in non-participating countries is also used. Parties can reduce emissions across sectors and gases and also outside of their territory. Participating countries, however, have low certainty of the total cost related to meeting their targets. Absolute binding targets may not be attractive for some developing countries, since often the future emissions cannot be predicted with certainty. Therefore, absolute targets could lead to a high economic burden (if economic development was faster than expected) or to a large surplus of emission allowances (if economic development was lower than expected). Flexibility additional to that in the Kyoto Protocol, such as e.g. the opportunity purchase additional emission allowances at a fixed the price, could be accommodated (see also section 5.2).

Technical criteria

Compatibility with the structure of the UNFCCC and the Kyoto Protocol: This illustrative case builds upon the structure agreed in the Kyoto Protocol and is therefore compatible with it and can make use of its processes and institutions. Emissions trading and the CDM could continue to operate.

Moderate political and technical requirements of the negotiation process: Agreements such as this illustrative case would fully retain the negotiation effort that has been invested in the current structure and institutions of the Kyoto Protocol. Countries have gained experience in the negotiations on such targets in the Kyoto Protocol and will again do so soon for the target for Kazakhstan for example. The necessary decisions on the level of the reductions, their differentiation among countries and the point at which a specific country has to participate may be cumbersome, but have been overcome in the past. No technical requirements additional to those embedded in the Kyoto Protocol would need to be met. Due to the legally binding nature of the targets, emissions have to be calculated, reviewed and verified. The operation of such system is currently under preparation or is in part already operating: Emission inventories are reported in detail and reviewed by expert review teams, national registries for emissions trading are being developed. These requirements would also have to be met by the newly participating countries.

Conclusions

Continuing the system of the Kyoto Protocol would be an obvious option for future commitments. Stringent environmental goals can, however, only be reached, if current Annex I countries decrease their emissions more than for the first commitment period (2008 to 2012) and if some developing countries receive emission targets at an early stage. A method to differentiate the targets for the participating countries is not included in this approach. Further, taking on absolute emission targets may be difficult for some developing countries due to the uncertainty in the development of the emissions.

6.3 INTENSITY TARGETS

6.3.1 General remarks on intensity targets

In a second illustrative case, targets are defined in terms of a reduction in greenhouse gas emissions per GDP (GHG intensity). Before describing the actual illustrative case, some general remarks on intensity targets are made in this section.

The reduction in the GHG intensity is the sum of two components: a reduction (or increase) of emissions and an increase (or reduction) of GDP. For example, a 5% reduction in the GHG intensity could be achieved by a 2% *de*crease in emissions plus a 3% *in*crease in GDP. If emissions decline, the percentage decrease in GHG intensity is usually greater than the percentage decrease in absolute emissions, since the GDP usually increases over time.

Explaining the same fact differently is to describe the intensity target as "grandfathering x growthsweetener x reduction" (See Müller 2001b and Box 7). The absolute level of allowed emissions in the target year under an intensity target is based on the levels of a base year (grandfathering). Further that level is *in*creased proportional to the economic growth (growthsweetener) and *de*creased by a reduction factor.

$$\frac{Emissions_{\text{target year}}}{GDP_{\text{target year}}} = \frac{Emissions_{\text{base year}}}{GDP_{\text{base year}}} \cdot Reduction$$

$$Emissions_{\text{target year}} = Emissions_{\text{base year}} \cdot \frac{GDP_{\text{target year}}}{GDP_{\text{base year}}} \cdot Reduction$$

Box 7. The absolute level of allowed emissions in the target year under an intensity target

Including the GDP in the equation takes account of the fact that economic activity is the major driver of emissions. For most countries the relationship between GDP and national emissions is significant. The question is: how exactly do emissions and GDP relate to each other:

$$Emissions = C \cdot GDP^{\alpha}$$

Box 8. Relationship between emissions and GDP

Using the intensity target as described above uses a linear relationship between GDP and emissions. If GDP increases by 1%, emissions also increase by 1% (α=1 in Box 8). But not all emissions of a country are closely related to monetary economic activity. For this reason Argentina, in its voluntary target announced in 1999 (see also section 5.1.1), did not choose a linear relationship between emissions and GDP, but related emissions to the square root of the GDP (equivalent to α=½ in Box 8). A 1% increase in GDP increases the emissions only by roughly ½%. This was based on the fact that agricultural emissions in Argentina are not well correlated with the GDP.

As a consequence, intensity targets should ideally take into account the relationship between GDP and emissions. It also depends on the historic relationship of the GDP to the emissions, whether an intensity target provides more or less certainty about the available surplus or debit in the commitment period than an absolute target. If emissions are linked very closely to the GDP, an intensity target provides the advantage that the future emission intensity can be forecasted with some certainty, possibly with more certainty than the absolute emissions. If the emissions are only loosely correlated with the GDP, an absolute target may be more appropriate since the absolute level of emissions may be forecasted with more certainty.

Intensity targets are perceived as providing this flexibility and allowing for more emissions if the economy is growing faster than expected. Almost unconstrained economic development can be pursued under an intensity target that is close to the business-as-usual GHG intensity development. If, however, significant reductions in the GHG intensity below business-as-usual are required, an intensity target can be equally restraining as an absolute target. An intensity target is only more flexible if *unexpected* economic developments occur.

If equal reductions in GHG intensity are set for several countries, the one with higher economic growth is in advantage. For any GHG intensity target, a country that is increasing economic activity, e.g. in the financial services sector, without significantly increasing emissions, is in advantage over a country that is increasing economic activity in an emission intensive economic sector, e.g. energy-intensive heavy industry.

Another issue is the case of economic decline, where the emission intensity usually tends to increase (GDP declines faster than emissions). If in such a case the intensity target is set with a strict link between emissions and GDP (i.e. α=1), unexpected economic decline makes the target more difficult to reach. If however the intensity target is set with a weaker link between emissions and GDP than it actually occurs (e.g. the extreme case: α=0, absolute target), unexpected economic decline makes the target easier to reach.

International emissions trading would be possible under GHG intensity targets but would have to be treated with care. Under absolute targets, the total allowance is known before the commitment period (the assigned amount), but under intensity targets, it is know only after the

commitment period. One option would be to trade only after the commitment period (*ex-post* trading) once the GDP value and the respective level of allowed emissions in the target year are known. Such ex-post trading is however seen as less effective compared to trading before the end of the commitment period (*ex-ante* trading). This second option would also be possible under GHG intensity targets with uncertainty about the total allowance.

Another option, which is not considered further here, would be to set an absolute target, but link it loosely to the GDP, e.g. that the absolute target is increased by x% if the GDP inadvertently would have grown faster than y%.

6.3.2 Description

For this illustrative case, the intensity targets are applied as follows: We assume that, until 2010, emissions of Annex I Parties develop according to their Kyoto targets, while emissions of Non-Annex I Parties follow the business as usual path. From 2010 to 2020 onwards, all countries reduce their GHG intensity by 3% per year as to ensure that global total emissions would be only +27% higher in 2020 than in 1990. A uniform reduction of the GHG intensity is applied to all countries. In the multistage approach (section 6.6) intensity targets are applied for some countries and absolute targets for others. As for other approaches, emissions trading could be allowed and targets would be of legally binding nature.

6.3.3 Quantified results

The calculations for the case 'Intensity targets' are based on the same set of data used for the first case 'Continuing Kyoto'. Table 10 provides the results for the case 'Intensity targets'. Under this illustrative case most Parties would be required to reduce absolute emissions after 2010.

These results are highly sensitive to the assumption on the GDP growth for individual countries. The global GHG intensity decreases as business-as-usual according to the IPCC SRES scenarios between 0.4% and 3.3% per year from 2010 and 2020. Depending on the business-as-usual path, a uniform decrease between 1.7% (scenario B2) and 4.3% (scenario A1B) per year in GHG intensity would be sufficient to reach the given global reduction level of global emissions +27% above 1990. In addition, results are significantly different, if the GDP of individual countries is not based on purchase power parities but based on exchange rates or expressed in local currencies. Alternatively, other indicators for the economic development of a country could be used (see also Appendix B).

6.3.4 Assessment with respect to the criteria

Environmental criteria

Environmental effectiveness: Under GHG intensity targets, the absolute future emission levels are not fixed, leaving uncertainty whether a global stabilization path can be reached. Intensity targets for all countries alone would have to be set at high percentages to reach stringent concentration levels. However, hot air could be introduced, if an equal rate of GHG intensity reduction in applied to all countries and a country's business-as-usual GHG intensity reduction is higher than the applied rate.

Encouragement of early action: As for the earlier case, assigning targets based on the emission levels of 2010 or later is an incentive to increase emissions until then to be granted a higher targets once participating. Early action is not explicitly encouraged.

Political criteria

Equity principles: Intensity targets can allow for economic growth. Almost unconstrained development can be pursued, if the intensity target is close to the business-as-usual GHG intensity development. If, however, significant reductions in the GHG intensity below business as usual are required, an intensity target can be equally stringent as an absolute target. An intensity target is only more flexible if *unexpected* economic developments occur. Applying

GHG intensity reduction target equally to all countries may not satisfy the principle of *need*. Care also has to be taken in the case of economic decline. If reductions in GHG intensity are equal for all countries, the principle of *capability* (ability to pay) is violated, since countries with higher economic growth have to reduce emissions less. The principle of *responsibility* is not satisfied, if equal GHG intensity reduction rates are introduced. Only differentiating the GHG intensity reductions for the different countries could lead to satisfying the principles of *need*, *capability* and *responsibility*.

Agreement with fundamental positions of all major constituencies: This type of target has been proposed by the USA as alternative to the Kyoto Protocol and had earlier been proposed by Argentina. Other countries have not yet voiced their positions on this type of target.

Economic criteria

Accounting for structural differences between countries: For intensity targets, differences in economic structure and the economic growth would have an additional influence on the target. An equal reduction in GHG intensity could account even less for the structural differences of countries than equal absolute reductions, especially for countries where the GDP is not well correlated to the emissions.

Minimizing adverse economic effects: Intensity targets are often seen as avoiding reductions at high cost, if economic growth exceeds expectations. Participating countries could have some additional certainty on the inferred cost compared with the 'continuing Kyoto' case, if the GDP is well correlated with the emissions and therefore the amount of credits available is more certain. Allowing emissions trading ensures, as in the other cases, that marginal abatement costs are comparable in all participating countries.

Technical criteria

Compatibility with the structure of the UNFCCC and the Kyoto Protocol: Intensity targets could be integrated into the commitment regime under the Convention and the Kyoto Protocol, for some countries or for all. Emissions trading could be applied, but with care.

Moderate political and technical requirements of the negotiation process: This form of target is new to the negotiation process and rules to set such targets would require additional negotiation time. The intensity targets may be more difficult to negotiate than absolute targets, since they involve an explicit judgment of the relationship between emissions and the GDP. A reduction percentage and an elasticity has to be agreed. Further, several methodologies could be applied for the calculation of the GDP. It could be expressed in local currency, based on exchange rates or on purchase power parities. For many developing countries, the GDP does not cover the informal sector. For centrally planned economies, the GDP growth rates are sometimes challenged as being overestimated. Resulting growth rates would differ significantly. However, whether the GDP is calculated in local currency, based on exchange rates or on purchase power parities is only relevant if drastic changes occur (like a crash of one currency used) or a target of one country is compared to that of another. The International Monetary Fund has established rules and review procedures for the calculation of the GDP. In addition to reviewing GHG emission inventories, the calculation of the GDP would need to be reviewed and verified to assess compliance with legally binding intensity targets. Such review is likely to be more difficult than reviewing inventories of greenhouse gas emissions alone.

Conclusions

A 2% to 4% decrease in GHG intensity per year on average over all countries would be required to reach stringent environmental goals. Intensity targets would always have to be differentiated, since the relationship between emission and GDP will be different in all countries. The differentiated intensity targets may be more difficult to negotiate than differentiated absolute targets, since a reduction *and* an elasticity has to be agreed. The judgment of the stringency of the target involves also an explicit judgment of the relationship between emissions and GDP. More variables influence the emission intensity (all activity data, all emission factors and also the activity in emission extensive sectors). This makes it more difficult to agree on intensity targets than on absolute targets.

6.4 CONTRACTION AND CONVERGENCE

6.4.1 Description

Converging per capita emissions has been proposed by several groups (see chapter 5.1.2). The most simple implementation would be that per capita emission allowances would converge linearly until a certain year. The 'Contraction and Convergence' approach by the Global Commons Institute (Meyer 2000) is slightly more sophisticated: In a first step, a global emission path is agreed for each future year that leads to a long-term global stabilization level: 'contraction' (here 450 ppmv CO_2). In a second step, the global emission limit for each year is shared among all countries so that per-capita emissions converge: 'convergence' (here by 2050). Emissions trading would be allowed as to balance out shortages in supply and demand of emission allowances.

To reach any stabilization level, global per capita emissions have to decrease below the current world average and even below the current Non-Annex I average. Connecting the converging per capita emissions to a stabilization path (as in this approach) leaves more room for growing developing country emissions in the shorter term.

6.4.2 Quantified results

The calculations for the case 'contraction and convergence' are based on the same set of data as the first case 'Continuing Kyoto'. In addition, population data were used by the UN population division as provided in WRI (2000). As of 2050 the population is assumed constant.

The original contraction and convergence approach includes only energy related and industrial CO_2 emissions. The illustrative case presented here is based on converging emissions of energy, industry and forestry CO_2 as well as CH_4 and N_2O. We assume that, until 2010, emissions of Annex I Parties develop according to their Kyoto targets and emissions of Non-Annex I Parties follow the business as usual path. From 2010 onwards, all countries participate, per capita emissions converge from 2010 to 2050 to the level of 3.1 $tCO_2eq.$/person and decrease further to 2.1 tCO2eq./person in 2100 (Figure 13).

Currently per capita emission levels differ considerably between countries ranging from 2 $tCO_2eq.$/person in India to 25 $tCO_2eq.$/person in the USA (based on the EDGAR database for the three major greenhouse gases and including also emissions from forestry in 1995) (see also Table 3). The Annex I average is 15 $tCO_2eq.$/person, Non-Annex I 4 $tCO_2eq.$/person and the global average is 6 $tCO_2eq.$/person.

A stabilization path was chosen as to reach 450 ppmv CO_2, global total emissions would be +28% higher in 2020 than in 1990 (Figure 12).

The changes in emissions under this illustrative case are provided in Table 10. Under these assumptions some Parties would be allowed to increase emissions from 2010 to 2020 (e.g. Egypt, India, China and Malaysia), but all major developing countries would have to reduce their emissions as of 2010 below the business as usual path. Only some smaller states in Africa and Asia would be allowed to increase the emissions above business as usual. The Philippines would be an example, where emissions would also be allowed to increase above business as usual mainly due to population growth. For most countries, the reductions would result in an abrupt change in the emission trend.

Due to the low per capita emission level required to reach the stringent global goal, the possible transfer of easily earned emission allowances could be relatively low. Only a few countries would receive more emission allowances than their business-as-usual path in 2020. Using the assumptions as described, the 'demand' of allowances (sum of differences between business-as-usual and target for countries that have to reduce emissions) could only be met in 2020 to only around 30% to 10% by the 'free supply' (sum of the differences between target and business-as-usual for countries that may increase emissions) for most business-as-usual path. To the extremes, the demand could be met to 100% (B2) or 8% (A1FI).

These results are sensitive to the fact that in this illustrative case the three major greenhouse gases from all sectors were included. For most developing countries, emissions from forestry as well as emissions of CH_4 and N_2O are significant. The average inhabitant of an Annex I country in 2000 emitted 3.5 times more CO_2, CH_4 and N_2O together, but 6 times more CO_2 than an average inhabitant of a Non-Annex I country. Additional sensitivity is due to the choice of the business-as-usual path. Such choice has an influence on the statement whether developing countries would need to reduce emissions below their respective business-as-usual path. The calculation methodology applied here is based on a middle range scenario for a large group of countries. The path of individual countries could differ significantly from the path used here. Under the different IPCC SRES scenarios, Annex I countries have to reduce emissions between 76% and 81% of the 1990 level by 2020.

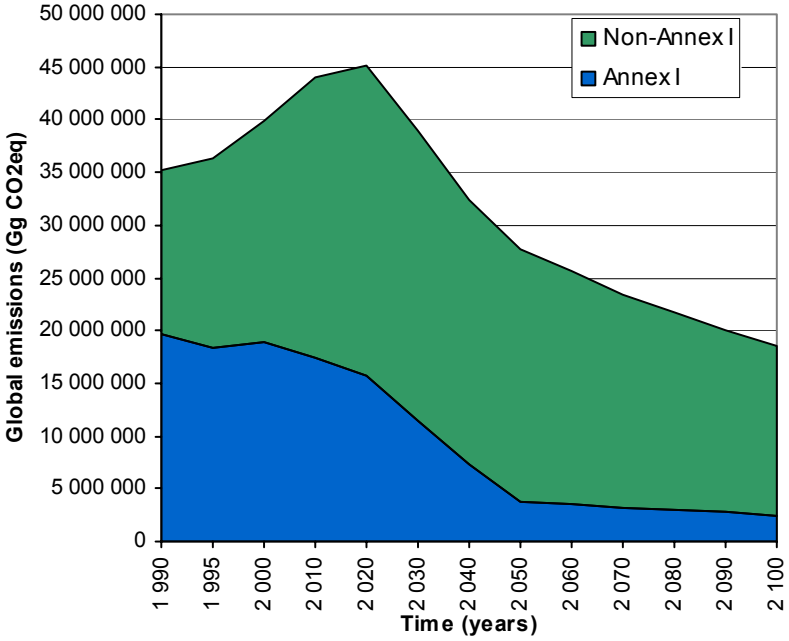

Figure 12: Global emissions under 'contraction and convergence'

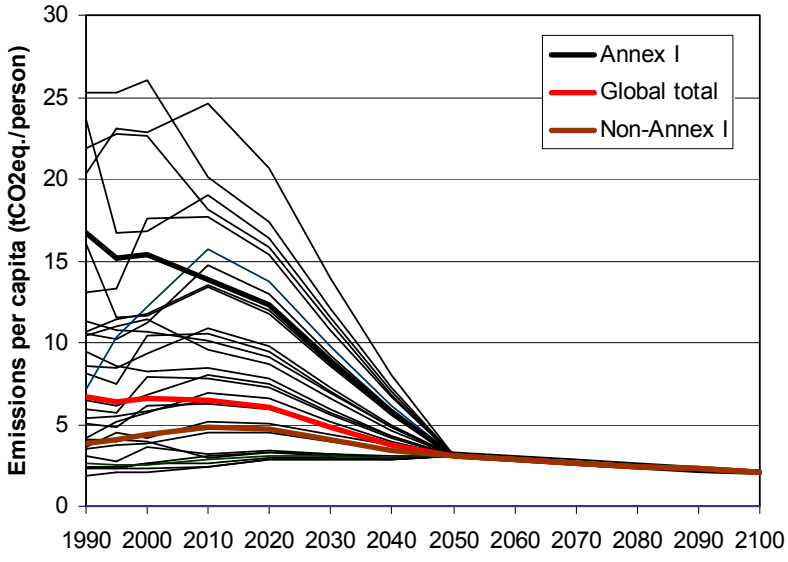

Figure 13: Converging per capita emissions under the 'contraction and convergence'

6.4.3 Assessment with respect to the criteria

Environmental criteria

Environmental effectiveness: This illustrative case would include all countries as of 2010. By choosing the stabilisation path, stringent concentration levels could be reached such as 450 - 550 ppmv CO_2. There would be certainty over the level of allowed global emission. However, this approach would imply abrupt changes in the emission trend of many Parties, including major developing countries. Leakage would be avoided since all countries would participate.

Encouragement of early action: Since ultimately all countries are required to reach equal per-capita emission levels, early action before 2010 is rewarded since less reductions will be necessary. This approach is one of the few that encourages early action.

Political criteria

Equity principles: The principle of allowing economic growth (*need*) is covered for the least developed countries. These countries can increase emissions and could even sell unused emission allowances. Most developing countries and all developed countries would be restricted in their path of emissions as of 2010. The principle of *capability* (ability to pay) is not explicitly addressed. The principle of *responsibility* (polluter pays) is addressed partly through the fact that those countries that have higher emission levels must reduce emissions more. The historic responsibility of countries is however not taken into account. A newly industrialized country with currently high per capita emissions (e.g. South Korea) has to reduce emissions by the same amount as an industrialized country with the similar level of per capita emissions (e.g. France).

Agreement with fundamental positions of major constituencies: Most developing countries have clearly indicated their preference for the convergence of per capita emissions. The G77 and China has succeeded to introduce related language in the Marrakech Accords in the context of the use of the mechanisms: “reducing emissions in a manner conducive to narrowing per capita differences between developed and developing country Parties”. However, some developed countries are strictly opposed to the concept of per-capita emissions. For example, reporting emissions per capita in national communications was excluded from the requirements for the preparation of national communications upon request of those Parties.

Economic criteria

Accounting for structural differences between countries: The only criterion for the differentiation of targets would be the current level of per capita emissions. Since no other criteria are considered, this approach is not considering all structural differences of countries.

Minimizing adverse economic effects: If emissions trading is allowed, marginal abatement costs are comparable in all participating countries. As in the other cases, emission reductions would occur where they can be obtained for a low price. Countries have low certainty of the inferred costs that are due to their targets. As in the previous cases, countries can reduce emissions across sectors and gases and also outside of their territory.

Technical criteria

Compatibility with the structure of the UNFCCC and Kyoto Protocol: This illustrative case of converging emissions could be built upon the structure agreed in the Kyoto Protocol. All countries would participate with a certain emission limitation or reduction target.

Moderate political and technical requirements of the negotiation process: This approach is simple and transparent and can be explained easily. Agreement on such an approach would involve the decision on the convergence year and the convergence level (through a global stabilization path), possibly also a decision on which gases and sectors to include. This low number of decision would make it relatively easy to reach an agreement from a purely process point of view. The current system of reporting and reviewing GHG inventories would have to be expanded to all countries. In other approaches, it is possible that some countries, e.g. least developed countries, do not have detailed reporting obligations. Under Contraction and Convergence especially these countries would want to participate, because they would

be allowed to *sell* emission rights. They would therefore have to fulfil detailed reporting requirements.

Conclusions

The contraction and convergence approach is intriguing due to the simplicity of the approach. It also is one of the few approaches that encourage early action by countries that are not yet part of the commitment regime. The simplicity of the approach is also the major disadvantage, that it does not account for the structural differences of countries and their ability to decrease their emissions. For stabilization levels of 450 or 550 ppmv CO_2, per-capita emissions have to decrease below the current world average and many developing countries would have to decrease emissions below their business as usual path. Only a few least developed countries could sell for a short period of time easily earned emission allowances to developed countries.

6.5 GLOBAL TRIPTYCH

6.5.1 Description

As the next illustrative case, the Triptych approach is discussed as one example of those approaches that derive national targets based on sectoral considerations (bottom-up). Another example of this type, the multi-sector convergence approach, is described in the following section.

The Triptych approach is a method to share emission allowances among a group of countries. The Triptych approach as such does not define, which countries should participate. It was originally developed to share the emission allowances within the European Union. It has been extended here to the global scale, bearing in mind that it could be applied to any group or subgroup of countries.

In the Triptych approach, three broad categories of emissions are distinguished: The power sector, the group of energy-intensive industries and the 'domestic' sectors. The selection of these categories is based on a number of differences in national circumstances raised in the negotiations that are relevant to emissions and emission reduction potentials: differences in standard of living, in fuel mix for the generation of electricity, in economic structure and the competitiveness of internationally-oriented industries.

The emissions of these three categories are treated differently: For each of the categories a reasonable emission allowances is calculated, in the light of the relevant national circumstances. The allowances of the categories are added up to a national allowance for each country. Only one national target per country is proposed, no sectoral targets, to allow countries the flexibility to pursue any cost-effective emission reduction strategy.

In the **power sector**, CO_2 emissions differ greatly from country to country due to large differences in the shares of nuclear power and renewables and in the fuel mix in fossil-fuel-fired power plants. The potential for renewable energy is different for each country, as is the case for the public acceptance of nuclear energy. To calculate the emission allowance for the power sector of a country, assumptions about the future electricity generation is made (here from the WEC/IIASA scenarios, WEC 1995) and limits are set in how this electricity may be generated: Minimum requirements are set for the share of renewables and combined heat and power in total electricity production, a limit is set for the allowed shares of solid and liquid fossil fuels. Nuclear power in 2020 is allowed at the same share of as it occurred in 1990. The resulting emissions are the limits of that country.

The activities of the **internationally-oriented energy-intensive industry**[7] differ substantially between countries. Countries with a high share of (heavy) industry will have relatively higher

[7] According to the IPCC methodology emissions from electricity generation are attributed to the electricity-producing sector only, i.e. not to the sector consuming the electricity. For both the domestic sector and the industry, therefore, only emissions due to use of fuel are included and not the emissions from electricity generation.

CO_2 emissions than countries that focus primarily on light industry or services, even if the emission reduction potential is relatively small. This sector includes the internationally oriented industry where competitiveness is determined by the costs of energy and of energy efficiency improvements: building materials industry, chemical industry, iron & steel industry, non-ferrous metals industry, pulp & paper industry, refineries, coke ovens, gasworks and other energy transformation industries (excluding electricity generation). To calculate a country's emission allowance for this sector, physical production growth rates are used together with annual efficiency improvement rates for each country (both derived from the rates distinguished for various regions in the WEC scenario, WEC 1995), taking into account potential newcomers. The resulting emissions are used as the sectoral allowance for the industry sector.

The **'domestic' sectors** comprise the residential sector, the commercial sector, transportation, light industry and agriculture. They are treated as one separate category for a number of reasons. First, countries are assumed to be more homogeneous in these sectors. Second, emission reductions can be achieved by means of national measures. Third, emissions in this category are assumed to be correlated with the number of people that live in dwellings, have a workplace, transport themselves, i.e. with population size. To calculate the emission allowance for the domestic sectors, it is assumed that in the long run emissions in the domestic sectors will converge (in 2030) due to a convergence of the standard of living (e.g. number of cars, number of appliances) and a reduction in existing differences in energy efficiency.

The emission allowances of the three categories are added to obtain one national target. It is important to note that the targets are fixed before the commitment period based on assumptions about the production growth. Whether the assumed production growth really occurs is not relevant.

In principle the Triptych approach is a mixture of basing emission rights on the current levels and convergence of per capita emissions: For the power sector and the industrial sectors, limits are introduced to improve the emissions per unit of production, while for the domestic sectors, convergence is applied.

The approach is applied here to all major emitting countries. Emissions trading would be allowed among countries with emissions reduction targets. Targets would be of a legally binding nature.

6.5.2 Quantified results

The current analysis is a further elaboration of the work done by Phylipsen, Bode and Blok (1998) for the burden sharing among EU Member States for 2010 and by Groenenberg, Phylipsen and Blok (2001) for the burden sharing in 50 countries (Annex I and non-Annex I) in 2015.

The following assumptions have been made:

- The triptych analysis only covers energy-related CO_2 emissions, based on the same set of data as the first case 'Continuing Kyoto'. Population data used are the same as in the third case 'per capita convergence' (from the UN population division as provided in WRI 2000).
- Production growth rates and energy efficiency improvement rates for the heavy industry (in physical terms) are not available from SRES scenarios, and are derived from (WEC, 1995). Growth figures are taken from the 'ecologically driven scenario', meaning lower production growth rates and higher energy & material efficiency improvement rates are assumed than in a business as usual development. Electricity production growth rates are based on WEC/IIASA.
- For the **power sector**, minimum requirements for renewable energy are set at 20% of 2020 electricity generation, and for CHP at 30%. Coal and oil use for power generation is limited to 70% of 1990 levels.

- For the **internationally-oriented energy-intensive industry**, the efficiency improvements are derived from the rates distinguished for various regions in the WEC scenario (WEC 1995).
- For the **domestic sector**, the per capita emissions are set to converge linearly until 2030 to the level of 3 t(CO_2)/cap, i.e. 30% below the average per capita emissions in the EU in 1990.
- The analysis includes all Annex I countries and all non-Annex I countries for which data were available. For the countries not included in the analysis, a business as usual emission path has been assumed up to 2020.

Total Annex I CO_2 emissions in the elaborated Triptych approach in 2020 are 34% below 1990 emissions. Non-Annex I emissions grow with to 230% compared to the 1990 level (for individual country or region data, see Table 10). For the world as a whole, emissions increase with 27% compared to 1990 levels.

For the given assumptions, the Triptych approach leads to substantial reductions from 1990 levels for the OECD countries (excluding Mexico). Even larger reductions are needed from countries with carbon intensive industries such as the Eastern European states and former states of the Soviet Union. In contrast most developing countries would be able to increase their emissions substantially. The fact that for some countries the allowance under Triptych is higher than the business as usual path in Table 10 is due to the fact that the values for the triptych approach includes only CO_2 emissions from fossil fuels and are based on different assumptions for production growth.

The sensitivity of the results is the largest for the assumption on future growth rates for electricity production and heavy industry. Further, the choice of the convergence year for the domestic sectors is important for the outcome.

6.5.3 Assessment with respect to the criteria

Environmental criteria

Environmental effectiveness: Depending on how the Triptych criteria are set, stringent global emission goals can be reached. In the present analysis, with all major countries included, the emissions of the world as a whole are consistent with a stabilisation path, even if CO_2 from forestry and non-CO_2 emissions develop according to business as usual. Similar triptych criteria could be developed for CO_2 emissions from forestry as well as CH_4 and N_2O and other greenhouse gases (see also chapter 7.1).

Encouragement of early action: Early action in the domestic sectors is rewarded, since emissions of these sectors will eventually converge and less reduction will be necessary to reach the per capita convergence level. For the power sector and the industrial sector, assigning targets based on future emission levels may be an incentive to increase emissions until then to be granted a higher targets once participating.

Political criteria

Equity principles: The principle of allowing economic growth (*need*) is addressed in this approach. Countries are allowed to grow in terms of electricity production and industrial production, but have to improve their production efficiency. The targets are set in a way that they can be reached with increasing implementation of energy efficient and renewable energy technology without prescribing reduction measures. The principle of *capability* (ability to pay) is not explicitly addressed. The principle of *responsibility* (polluter pays) is addressed through the fact those countries that have higher emission levels in the domestic sector must reduce emissions more. The historic responsibility of countries is not explicitly taken into account.

Agreement with fundamental positions of all major constituencies: Most developing countries have clearly indicated their preference for the convergence of per capita emissions. However, some developed countries are strictly opposed the concept of per capita emissions. The combination of the convergence of the standard of living attractive to developing coun-

tries (in the domestic sectors) with the flexibility for growing emissions (in industry and electricity production) could be attractive to many countries as a compromise solution.

Economic criteria

Accounting for structural differences between countries: Structural differences are taken into account explicitly at a sector level. The differences in the standard of living, in future population growth, in fuel mix for power generation, in the economic structure and energy efficiencies and projected future changes in economic structure are taken into account. A major downside of the original Triptych approach is that the choice of sectors is based on the emissions structure of industrialised countries. For developing countries emissions of other sectors and gases may be more important (see also section 7.1)

Minimizing adverse economic effects: Electricity production and industrial production may grow, but efficiency has to be improved. This way, emission targets will largely be compatible with the existing technical emission reduction potentials in the various countries. Allowing emission trading introduces an additional degree of economic effectiveness, as for the other cases. Although based on sectoral considerations, a national target is provided instead of several sectoral targets, to allow countries the flexibility to pursue cost-effective emission reduction strategies. Parties can reduce emissions across sectors and, if emission trading and CDM is allowed, also outside of their territory.

Technical criteria

Compatibility with the structure of the UNFCCC and the Kyoto Protocol: The Triptych approach is essentially a method to differentiate emission targets among countries before a commitment period. As such it can be part of the structure of the UNFCCC and the Kyoto Protocol.

Moderate political and technical requirements of the negotiation process: The Triptych approach is relatively complex compared to some of the other approaches. The concept of the Triptych approach can nevertheless be explained easily. Countries have to agree on the Triptych criteria applicable to all countries, such as the convergence level of the domestic sectors and changes in the fuels mix for electricity generation. Further, the approach requires a set of scenarios, including expected growth rates of production in the various sectors. The countries themselves could provide these. There is, however, the incentive to provide high growth scenarios. This problem could be overcome by applying adjustments after the commitment period, if the projected growth rate was considerably higher than the actual one or using the actual production growth rate (see also performance targets, section 7.3). Once the targets are defined, the requirements regarding verification of the implementation of the targets are the same as for the Kyoto Protocol.

Conclusions

The Triptych approach is a method to differentiate emission reductions among countries based on technological considerations on the sector level. In its original form it is based on the emission structure of developed countries and accommodate the emission profiles of developing countries to a lesser extent. Extension to include CH_4 and N_2O as well as land-use emissions would improve the approach (see 7.3). Major downside of the approach is its complexity and the necessity of projections of production growth rates.

6.6 MULTI-SECTOR CONVERGENCE APPROACH

6.6.1 Description

The Multi-sector Convergence Approach by the Center for International Climate and Environmental Research Norway (CICERO) and the Energy Research Center of the Netherlands (ECN) (Jensen et al. 2001) is another approach that defines national targets based on sectoral considerations.

The approach provides a full set of rules for a commitment regime, based on the convergence of sectoral per-capita emissions. It distinguishes seven sectors:

- Power
- Industry
- Transport
- Households
- Services
- Agriculture
- Waste

At the global level, sector emission standards, expressed in per capita terms, for a convergence year are developed starting with the global average in the base year and applying an annual mitigation rate to that standard.

Starting point for the determination of emission limitation target for each sector in a country is its sector levels of per-capita emissions in the base year (2010). The per-capita sector emission levels for each country in intermediate target years are obtained by geometric interpolation between the actual national sector emission levels in the base year and the global sector emission standards of the convergence year. Finally, these sector emission levels are added up and multiplied by total population in order to determine national emission mitigation targets for the countries and years concerned. This total target is relevant and not the separate sectoral targets.

Countries with relatively low per capita emission levels have the right to economic development without any emission limitation constraints up to some defined point, the so-called graduation threshold. Low-emission countries with emissions exceeding the graduation threshold in some future emission accounting (budget) period are granted a pre-set adjustment period. After this period has lapsed, they are due to take on commitments to meet the targets consistent with the above rules. More country-specific elements, such as country-specific emission factors or population density can be included if desired.

6.6.2 Quantified results

Based on the model that is provided by CICERO/ECN on their web site, we provide some example calculations. For this analysis, the annual mitigation standards per sector have been set such as to lead to a level of 450 ppmv (according to the model corresponding to an emission level of 33% above 1990 levels in 2020). The convergence year is set at 2050, and the adjustment period for newly participating countries has been set at 5 years. Table 5 provides the mitigation rate applied to the global average in the base year to derive the global emission standard in the convergence year (the knobs to tune the model). Table 10 provides the results of allowed emissions under these assumptions for the multi sector convergence approach (fluorinated gases and forestry emissions are not included).

Table 5. Mitigation rate applied to the global average in the base year to derive the global emission standard in the convergence year

Sector	Convergence rate (%/yr)
Power	-6%
Industry	-5%
Transport	-3%
Households	-4%
Services	-3%
Agriculture	-3%
Waste	-4%

6.6.3 Assessment with respect to the criteria

Environmental criteria

Environmental effectiveness: The multi-sector convergence approach defines national emission limits based on a global stabilization goal. Accordingly, stringent global emission goals can be reached.

Encouragement of early action: Early action in the sectors is rewarded, since emissions of these sectors will eventually converge and less reduction will be necessary to reach the per capita convergence level.

Political criteria

Equity principles: The principle of allowing economic growth (*need*) is addressed in this approach, since countries only participate if they have reached a certain graduation level (defined in terms of emissions per capita). The principle of *capability* (ability to pay) is not explicitly addressed. The principle of *responsibility* (polluter pays) is addressed through the graduation criteria based on per-capita emissions and the fact those countries that have higher emission levels must reduce emissions more. The historic responsibility of countries is not taken into account.

Agreement with fundamental positions of all major constituencies: Most developing countries have clearly indicated their preference for the convergence of per capita emissions. However, some developed countries are strictly opposed the concept of per capita emissions.

Economic criteria

Accounting for structural differences between countries: For all countries, per capita emissions of the different sectors have to converge. This neglects however, that some countries have more industrial activity of a certain kind per inhabitant than other countries. For individual countries the sectoral targets may be stringent or loose, depending on the national circumstances and the share of the industrial activity per inhabitant. However, detailed rules for adjustments for specific national circumstances are provided in the approach.

Minimizing adverse economic effects: Although based on sectoral considerations, a national target is provided instead of several sectoral targets, to allow countries the flexibility to pursue cost-effective emission reduction strategies. If emissions trading is allowed, marginal abatement costs are comparable in all participating countries. Parties can reduce emissions across sectors and, if emission trading and CDM is allowed, also outside of their territory.

Technical requirements

Compatibility with the structure of the UNFCCC and the Kyoto Protocol: The multi-sector convergence approach can be built upon the current structure of the UNFCCC and the Kyoto Protocol.

Moderate political and technical requirements of the negotiation process: The multi-sector convergence approach is relatively complex compared to some of other approaches. Especially the detailed rules for the exceptions are difficult. The essence of the approach is, however, explained easily. The establishment of the targets does not require large amounts of data. Once the targets are defined, the requirements regarding verification of the implementation of the targets are the same as for the Kyoto Protocol.

Conclusions

The multi-sector convergence approach describes a full system of future targets in all the necessary detail. In essence, it is describing on which path per-capita emissions converge. A major downside of the approach is that it uses per-capita emissions at a sectoral level for different industrial and agricultural activities, while these activities may not be directly related to population.

6.7 MULTISTAGE APPROACH (FAIR)

6.7.1 Description

Several approaches can be found in the literature that are based on the increasing participation of countries in the commitment regime. One of the most sophisticated is the multistage approach by den Elzen et al. (1999, 2001) using the FAIR model. This approach is a combination of several of the approaches described above.

In the multistage approach, countries participate in the commitment regime in several stages:

- *No commitments*: Countries follow the business as usual path
- *Decarbonization*: Countries receive GHG intensity targets (emissions per unit of GDP) differentiated per GDP per capita level
- *Stabilization*: Countries are required to stabilize their absolute emissions
- *Reduction*: Countries are required to reduce their absolute emissions.

Countries graduate into these stages if they exceed a certain threshold, e.g. GDP per capita. Each 5-year period the system is reviewed and countries can graduate into the next step.

A global emission ceiling for each 5-year step is chosen as to ensure the stabilization of CO_2 emissions at a certain level. Countries in the first three stages follow their path as defined in those stages. The remaining global emission allowances (difference between the global emission ceiling and the emissions of countries in stages 1 to 3) are shared among the countries in the 'reduction' stage. The extent of the individual reductions can be shared among the reducing countries according several 'differentiation keys' such as the contribution to total emissions or the contribution to the temperature increase (see the Brazilian proposal).

As for the other approaches, emissions trading would be allowed among countries with emissions reduction targets. CDM would be a means for countries to participate that do not have emission reduction targets. The targets would be legally binding.

6.7.2 Quantified results

For this illustrative case, we use the individual country data as for the previous illustrative cases (see Table 10) and not the FAIR model itself. The Fair model is publicly available but only provides aggregated data for 17 world regions.

As we consider here only emissions until 2020, we model only the first step of this approach: We assume that, until 2010, emissions of Annex I Parties develop according to their Kyoto targets and emissions of Non-Annex I Parties follow the business as usual path. A stabilization path is chosen, which results in global emission levels for 2020 which are at +28% compared to 1990 levels as in the other cases. From 2010 onwards, all Non-Annex I Parties receive a GHG intensity reduction target of -3% annually until 2020. The remaining available emission allowances are shared among Annex I countries according to their relative contribution to current emissions, i.e. all Annex I countries reduce emissions at the same percentage rate.

An important element of the multistage approach is that the emission allowances of the reducing countries (in stage 4) are dependant on the emissions of all other countries: The reducing countries share the emission allowances that remain, taking the global emission limit minus the emissions of the countries at stage 1 to 3. Accordingly, if emissions of these other countries are relatively high, only limited or even no emissions are left for the reducing countries (in stage 4).

In this illustrative case, the parameters have to be set in a way, so that a reasonable amount of allowances are available for the reducing countries (here Annex I): For that it is necessary that, all countries automatically graduate to step 2 and receive a GHG intensity reduction target of relatively high 3% per year, which for most countries is more stringent than business as usual. If another SRES scenario is used (such as the A1B scenario with higher economic growth), a GHG intensity reduction target of 5% for those countries would have resulted in similar emission limits for the reducing countries (here Annex I).

The range of the business-as-usual decline in the greenhouse gas intensity is wide, as already noted for the illustrative case for intensity targets.

Under the given assumptions, all Non-Annex I countries participate as of 2010 but in total with only a minor reduction. To reach the global emission limit of +28% above 1990 levels in 2020, the Annex I countries, therefore, have to reduce emissions to a large extent. The exact ratio of the effort of Annex I countries and Non-Annex I countries depends on the parameters, which have to be chosen carefully, as well as on the underlying business as usual scenario.

6.7.3 Assessment according to the criteria

Environmental criteria

Environmental effectiveness: By agreeing on the absolute level of global emission for every 5-year step, stringent global stabilization levels could be reached such as 450 - 550 ppmv CO_2. These stringent paths could, however, only be reached together with early graduation and stringent GHG intensity targets at stage 2, otherwise no emissions are available for the 'reducing' Parties. If the GHG intensity targets for the countries in stage 2 are set lower than the business-as-usual development, 'hot air' could be introduced. Leakage would be avoided since all countries would participate.

Encouragement of early action: This approach also assigns targets based on the emission levels of 2010 or later, which is an incentive to increase emissions to be granted a higher targets once participating. However the approach is flexible to also define a threshold of per capita emissions to graduate into a next stage instead of a threshold based on per capita income, which would be an incentive to encourage early action.

Political criteria

Equity principles: The principle of promoting sustainable development and allowing economic growth is covered for those countries that are in a low state of development. Rapidly developing countries would be restricted in their path of emissions as of 2010 with an intensity target. The principle of *capability* (ability to pay) is included through the threshold when countries participate in the regime. The principle of *responsibility* (polluter pays) is addressed through the choice of the differentiation key, i.e. the distribution of the required reductions among the reducing countries. The historic responsibility of countries can also be incorporated into this differentiation key.

Agreement with fundamental positions of major constituencies: The notion of countries gradually phasing into a reduction regime would seem to be acceptable to many countries. In order to reach stringent target, all major countries would have to participate as of 2010 with GHG intensity targets. This may be unacceptable to some developing countries.

Economic criteria

Accounting for structural differences between countries: The national circumstances can be accommodated at several places in the multistage approach. The threshold for participation can be differentiated according to income or other criteria. The reductions in stages 2 to 4 can be differentiated, taking into account the structural differences.

Minimizing adverse economic effects: Emissions trading can ensure – as in other approaches – that marginal abatement costs are comparable in all participating countries. The participating countries have low certainty of the inferred costs that are due to the targets that they need to comply with. As for the other approaches, countries can reduce emissions across sectors and gases and also outside of their territory.

Technical criteria

Compatibility with the structure of the UNFCCC and the Kyoto Protocol: The multi stage approach can be built upon the structure agreed in the Kyoto Protocol: The notion of gradually increasing the group of countries that reduce emissions is built into the Convention. It is a step-by-step approach, but at the same time has the long-term perspective through the definition of a global stabilization path.

Moderate technical and political requirements of the negotiation process: This approach combines many ideas into one system. The operationalization of such system would require several decisions on the thresholds and on the global reduction targets. Setting generic rules such as the global emission ceiling and participation thresholds for all countries could be considered difficult but possible. These rules would, however, have to be updated regularly as to ensure that the agreed global reduction path is met. If the multistage approach makes use of the GDP as an indicator for when countries participate, questions would arise on the calculation of the GDP, such as the use of local currency, based on exchange rates or on purchase power parities as well as its review. As for other approaches, emissions have to be calculated, reviewed and verified due to the legally binding nature of the targets. While such proc-

ess is in development or operation for Annex I Parties, it would have to be broadened to include all Parties as of stage 2.

Conclusions

Since the multistage approach can combine many ideas, it could be a framework for a compromise. Discussion on the threshold for moving into a next step or the exact emission targets would have to be agreed, but the general concept of several stages seems promising.

6.8 EQUAL MITIGATION COST

6.8.1 Description

The following illustrative case describes the allocation of emission reductions so that all Parties have the same economic burden of mitigating climate change. It could also be extended to include mitigation *and* adaptation costs, although calculating the costs of adaptation would be even more difficult than calculating the costs of mitigation. Such concept could be implemented in various ways, e.g. choosing emission reduction targets so that all participating countries have the same percentage reduction in GDP (see e.g. Babiker & Eckaus 2000).

Assuming that such an approach would be chosen, countries would have to agree on a model that would calculate the inferred cost of reduction targets *ex-ante*. Targets for absolute emissions in the commitment period would be chosen and fixed before the commitment period, in a manner that the economic burden is the same for all participating countries. These targets would be binding, even if experience in the commitment period would show that the real cost would be different than those calculated ex-ante. Or they could be adjusted taking into account the real developments.

For this case we assume that after 2010 all countries participate. Emissions trading would be allowed; targets would be legally binding. For this illustrative case, no attempts were made in this study to provide quantitative results.

6.8.2 Assessment with respect to the criteria

Environmental criteria

Environmental effectiveness: Depending on the individual target chosen, it would be possible that stringent overall targets are reached. Possibly, some countries could agree to more stringent targets than with other approaches if the costs are distributed fairly, knowing that all countries have a comparable economic burden and no competitive advantage.

Encouragement of early action: Early action would not be rewarded: Targets would be based on the emission levels when the country starts to participate. Any action that has taken place before the point of participation would not be counted as economic burden and would therefore be to the disadvantage of the country.

Political criteria

Equity principles: Under this approach, all countries would be limited in their economic growth. The concept of *need* would be violated if all countries (rich and poor) have the same economic burden. Only if the costs of adaptation to the effects of climate change are included, this approach would cover the full costs. The principle of *capability* (ability to pay) would only be included, if the economic burden is defined as reduction related to the GDP, assigning higher cost to those countries with higher GDP, i.e. a progressive reduction rate. The principle of *responsibility* (polluter pays) is not addressed, if not violated for some countries: Countries with large inexpensive reduction potential (many developing countries) would have to reduce emissions substantially. The historic responsibility of countries is not considered.

Agreement with fundamental positions of all major constituencies: Parties differ in how they view the problem of climate change: Some Parties view it primarily as an economic problem to be dealt with in an economic way, while other Parties focus on the environmental as-

pects. This fundamental difference in view could make it difficult for some Parties to agree on the concept of equal cost.

Economic criteria

Accounting for structural differences between countries: The model, with which the inferred costs are calculated, would take into account the structural differences of countries, depending on the amount of detail included in the model. The specific emission structure and reduction potentials and related costs would be considered.

Minimizing adverse economic effects: It is the aim of the approach to minimize global costs and to share these costs equally among countries. Countries would have high certainty of the inferred costs that are due to their targets. In addition, as for other approaches, emissions trading will ensure that marginal abatement costs are really comparable in all participating countries. As for the other approaches, countries can reduce emissions across sectors and gases and also outside of their territory.

Technical criteria

Compatibility with the structure of the UNFCCC and the Kyoto Protocol: This approach could be built upon the structure agreed in the Kyoto Protocol, agreeing that all countries participate and agreeing on emission reduction targets for all countries according to the calculations of the inferred costs.

Moderate technical and political requirements of the negotiation process: This approach would be based on the assumption that the economic burden of reduction targets can be calculated in a way that satisfies all involved Parties. All countries would have to agree on a method to calculate costs, on a detailed model for the calculations. An extensive review process would have to support such a process. The amount of negotiation time would be considerably high with uncertainty whether agreement could be reached at all.[8]

Conclusions

In summary, the approach of assigning targets based on equal cost seems to be a powerful solution at first sight, but the difficulties in overcoming the technical requirements for its implementation make it a rather theoretical approach.

6.9 COORDINATED POLICIES AND MEASURES

6.9.1 Description

In this illustrative case we assume that all Parties agree on a set of coordinated policies an measures that have to be implemented by all Parties. Several studies discuss the effectiveness of policies and measures (e.g. Grubb 2001) and mostly conclude that “coordinated actions among countries and sectors may help to reduce mitigation cost, address competitiveness concerns, potential conflicts with international trade rules, and carbon leakage” (IPCC 2001c, SPM).

Such coordinated portfolio of measures could include the following elements:

Coordinated fiscal measures: Energy or carbon taxes are a matter of international discussion, some countries have already implemented such taxes on the national level. Since taxes influence the competitiveness of companies active on the international market, coordination would make the implementation more effective and acceptable.

Coordinated efficiency standards: Emission efficiency standards (emissions per kWh electricity, per tonne of steel, per vehicle-km, per number of cattle) could impose a climate rele-

[8] One example of an international negotiation process agreeing on a complex model for the assigning targets is the RAINS model. This model is used as a basis within UNECE to set national targets for emissions of trans-boundary air pollutants such as NO_x or SO_2.

vant constraint without limiting economic development. These standards, if internationally agreed, could also reduce trade barriers.

As alternative to the prescribed coordinated measures, a list of 'good practice' examples could be provided as menu for developing countries. This would provide for flexibility on the side of the implementing country.

We here discuss this option of coordinated policies and measures in isolation from other forms or commitments such as emission limitation or reduction targets, although both could be implemented in parallel.

6.9.2 Quantification of results

In this section, we illustrate possible implications of such polices at the example of coordinated efficiency standards for electricity generation. A 'best practice' emission standard is derived from technology information. Subsequently, the difference between the current average of countries and the standard is calculated.

The assumptions used for the calculations are as follows:

- Data on electricity generation by fuel type and the associated emissions have been taken from (ECOFYS 2002). For countries for which no data were available, data were derived from the World Energy Outlook (IEA 2000). For South Korea data are from (Phylipsen 2000).
- Best practice efficiency for coal-fired power plants and gas-fired power plants is assumed to be 45% and 57% respectively (Phylipsen et al., 2000).

Table 6 shows the results for the analysis for best practice standards for coal-fired power plants and gas-fired power plants. The resulting CO_2 intensity of electricity generation (CO_2 emissions per kWh of electricity generated), distinguishing between coal and gas, are shown compared to the best practice technology (=100%).

Table 6. Difference of the CO_2 emissions per kWh of electricity generated compared to the best practice efficiency standards (=100%) for several countries or groups

	Coal				Gas				Source
	Electricity produced	CO_2 emissions	Emission factor	Comparison to BAT	Electricity produced	CO_2 emissions	Emission factor	Comparison to BAT	
	GWh	Gg	kg/kWh		GWh	Gg	kg/kWh		
USA	1733592	1636511	0.94	**126%**	581950	320654	0.55	**156%**	ECOFYS
European Union	756473	666120	0.88	**117%**	341645	127852	0.37	**106%**	
Japan	185242	173757	0.94	**125%**	172496	74346	0.43	**122%**	
Eastern Europe (Annex I)	-	-	-	**-**	115578	62487	0.54	**153%**	
Russian Federation	-	-	-	**-**	-	-	-	**-**	
Rest of Annex I	267175	256090	0.96	**127%**	76093	31975	0.42	**119%**	
Turkey	33744	41437	1.23	**163%**	25427	11112	0.44	**124%**	
Brazil	5000	6000	1.20	**160%**	-	-	-	**-**	WEO for 1997
Latin America	39000	38000	0.97	**130%**	85000	52000	0.61	**173%**	
Africa	204000	194000	0.95	**126%**	59000	38000	0.64	**182%**	
Middle East	25000	21000	0.84	**112%**	159000	80000	0.50	**142%**	
China	863000	1035000	1.20	**159%**	7000	4000	0.57	**162%**	
India	339000	400000	1.18	**157%**	28000	14000	0.50	**141%**	
South Korea	77247	68546	0.89	**118%**	43063	20410	0.47	**134%**	Phylipsen 2000

From Table 6 it can be observed, that the efficiency in electricity production, in CO_2 emissions per kWh produced, differs substantially among countries. Data quality differs widely among

countries and regions and complete consistent datasets are not available. It can, however, be concluded that not all developing countries have low standards. The efficiency for coal fired power plants in South Korea and Middle East is in the range of that of the USA and Western Europe. No examined country fulfills the best practice standard.

In order to calculate the effect on absolute national emissions of a coordinated measure that requires implementation the best practice technology, not only total electricity generation by fuel type would be needed, but also the expected growth rates by fuel type for each region, compared to a business as usual development. This calculation is not provided here.

6.9.3 Assessment with respect to the criteria

Environmental criteria

Environmental effectiveness: For this illustrative case specific policies and measures would be implemented but no absolute cap would be set on emissions. It is uncertain whether a global emission goal could be reached. Requirements on the relative emissions (e.g. per kWh electricity) are set through e.g. the implementation of efficiency standards. The environmental effectiveness of this illustrative case has to be ensured by designing a comprehensive package of policies to avoid unconstrained emission growth in some sectors.

Encouragement of early action: Action taken before an official commitment would be rewarded once policies and measures would have to be implemented. Assigning targets based on energy efficiency standards, for example, rewards early action, since such early action reduces the distance between the actual standard and the best practice emission level.

Political criteria

Equity principles: The principle of allowing economic growth to satisfy basic human needs is addressed in this approach. The efficiency standards, e.g., result in the implementation of modern technology (if standards are set sufficiently stringent) and do not constrain the absolute production. The absence of absolute emission caps leaves room for economic growth. The principle of *capability* (ability to pay) is not addressed. The principle of *responsibility* (polluter pays) is addressed to some extent, since countries with high relative emissions have to reduce more than countries with low relative emissions levels. The historical responsibility is however not taken into account.

Agreement with fundamental positions of major constituencies: During the negotiations the EU has always labored for including specific policies and measures. The USA has been one of the strongest opponents on this issue. The implementation of policies and measures could be a promising approach acceptable to developing countries. Although currently major developing countries work against any policies and measures for Non-Annex I countries, such approach could be attractive to developing countries in the future, since it reduces emissions without compromising the room to grow.

Economic criteria

Accounting for structural differences between countries: The implemented policies and measures generally focus on specific sectors therefore take into account structural differences between countries. In this regard, it makes a difference whether an efficiency target is set for e.g. the electricity sector as a whole, or for gas-fired and coal-fired power plants separately, as is done here. In the latter case, structural differences are accounted for. The emission structure or reduction potential is explicitly considered. On the other hand, certain prescribed policies may be effective for one country, but may be ineffective for another country or even seen as inappropriate. For a full policies and measures regime, a balanced portfolio has to be designed to account for structural differences between countries.

Minimizing adverse economic effects: For emission standards, the burden on the countries depends on their currently implemented standard and may differ substantially. Therefore marginal costs may vary between countries. Emissions trading could not be applied to equalize marginal abatement costs. The absence of an absolute cap on emissions provides flexibility to countries and room to grow. However, there is no flexibility to reduce emissions in other sectors through the implementation of other measures than those that are prescribed.

Technical criteria

Compatibility with the structure of the UNFCCC and Kyoto Protocol: The implementation of policies and measures to limit the emissions of greenhouse gases is required according to the Convention, for Annex I countries as well as non-Annex I countries. The structure or binding emission limitation or reduction targets and associated possibility of emissions trading as introduced by the Kyoto Protocol would not have to be maintained.

Moderate technical and political requirements of the negotiation process: For a full policies and measures regime, countries would have to agree on a large balanced portfolio of measures. For example, efficiency standards would have to be agreed for a large variety of sectors. Other policies such as taxes would have to be agreed. This large number of decisions could be difficult to handle by the negotiation process. In addition, the effectiveness of the policies and measures would need to be assessed. In the assessment of the energy efficiency, a number of issues would need to be settled, e.g. corrections for heat extraction (for CHP and district heating) and corrections for the regional climate. In addition, statistics would need to be sufficiently reliable. Substantial technical work would be needed.

Conclusions

Coordinated policies and measures can be applied to supplement an emission limitation regime. Given the current regime it seems unlikely that policies and measures would be applied as the only form of commitment.

6.10 PRELIMINARY CONCLUSIONS OF THE COMPARISON OF APPROACHES

As a full set of conclusions on the comparison of all different approaches is contained in chapter 8, this section only contains some preliminary conclusions, that have lead to the selection of the new approaches described in chapter 7:

None of the approaches considered so far accounts for structural differences between countries in a satisfactory manner, differentiating commitments within a group of countries poses a problem. Of the considered approaches, the Triptych approach considers the national circumstances to the largest extent, but applied in its original form on developing countries, this approach has also some shortcomings.

Approaches that combine several ideas can accommodate many aspects and have a higher chance of being accepted since all constituencies find elements of their concern in the mixed approach. Accordingly, the scores for mixed approaches under equity are relatively high. A key for a potentially successful regime could therefore be that it provides a well-balanced mix of approaches.

Providing opportunities for economic growth instead of capping it is a major concern of developing countries when considering targets. Of the considered approaches, only intensity targets are usually seen as providing such flexibility. Other creative ways need to be developed to make targets cap emissions but not growth.

Further, not many approaches encourage early action. For the considered approaches, only converging per capita emissions and the policies and measures approach provide an advantage to those countries that have acted before they had commitments.

As the main problems are the lack of solutions for differentiation, a need for a good mix of approaches and the need for acceptable targets that allow economic growth, we further elaborate in the next section an extended global Triptych approach, a new multistage approach and ‘performance targets’.

7. NEW APPROACHES

The previous sections have shown that there are quite a number of approaches to future commitments available, some more, some less comprehensively developed, all with advantages and disadvantages. In this chapter, additional new ideas are presented, how some of those proposals could be modified to increase their effectiveness and acceptability. These include an extended Triptych approach, further discussion on a staged approach, and the new concept of 'performance targets'.

7.1 EXTENDED GLOBAL TRIPTYCH

The original triptych approach was developed to share emission reductions between members of the European Union. The Triptych approach therefore builds upon the emissions structure of those countries and does not include emissions of CH_4 and N_2O as well as CO_2 emissions from forestry. For developing countries, however, these emissions are of higher relevance than for developed countries. We have therefore adapted the Triptych approach to also include these gases and sectors.

7.1.1 Description

For the power sector, the energy intensive industry and the domestic sectors, the approach has been applied unchanged as described in chapter 6.5. In addition, the following new categories were added:

Emissions of CH_4 and N_2O from the energy sector are assumed to be proportional to energy consumption. Therefore, we have assumed the same changes in emissions as calculated for CO_2 emissions from energy for each country in the original Triptych approach.

Emissions from industry (CO_2, CH_4 and N_2O) and CO_2 emissions from the "non-energy use" category are assumed to be proportional to the growth in production in the industrial sectors. Emissions from industry are therefore assumed to grow with the same rates as assumed in the original Triptych approach for industrial production.

Emissions from agriculture include CH_4 emissions from animals, animal waste, rice production, agricultural waste burning and savanna burning as well as N_2O emissions from fertilizer use, animal waste management, agricultural waste burning and savanna burning. One option would be to let emission may grow in relation to production indicators for e.g. meat, rice, etc, and then reduced according to a certain technical emission reduction percentage. This acknowledges the differences in economic structure within the agricultural sector. At this moment we do not have the data to do so for all countries. However, Groenenberg (2002) made such an analysis at the regional level using 17 regions. She also assessed the technical reduction potentials for each of the different categories of emissions. Based on these analyses, she concluded that the growth in activity would be outweighed by the effect of the reduction measures, leading to a stabilization of the emissions from these categories. Therefore, we have assumed a stabilization of agricultural emissions at the 1990 levels.

Emissions from forestry include CO_2 emissions from deforestation.[9] We have assumed per-capita emissions from forestry to converge in 2050 to a level of zero, assuming that by that time, forest cut down or burnt will be replaced (somewhere within the country) by new forests. Assuming that emissions per capita converge to zero allows countries with high population growth to reduce emissions at a later date.[10]

[9] Net emissions from the IPCC source category "land-use change and forestry" should ideally be used, including afforestation, reforestation and deforestation and emissions from soils. These were however not available.

[10] Due to high population growth assumed, Persian Gulf states may even increase forestry emissions between 1990 and 2020.

Emissions from waste (landfill sites, wastewater treatment) are assumed to be proportional to population size. Therefore a per-capita convergence approach is used, assuming a reduction of emission per capita through the implementation of technical measures. Convergence of per-capita emissions will occur in the year 2030.

7.1.2 Quantification of results

Table 7 includes the relative changes in emissions under the original Triptych approach (CO_2 from energy use in the power, industrial and domestic sectors), as well as the additional sectors. Comparing the first and the last column one can observe that including the additional sectors with the given assumptions decreases the relative change in emissions between 1990 and 2020. Non-Annex I countries as a group can under this approach increase emissions of CO_2, CH_4 and N_2O less as they could increase CO_2 emissions under the original Triptych approach.

Table 7. Changes in emissions between 1990 and 2020 under the extended global Triptych approach

	Original Triptych (CO_2 from energy only)			CH_4 and N_2O from energy			Industry			Agriculture			Deforestation			Waste			Total
	1990	2020	Change	1990	2020	Change	1990	2020	Change	1990	2020	Change	1990	2020	Change	1990	2020	Change	Change
	Mt CO_2eq		%	Mt CO_2eq			Mt CO_2eq		%	Mt CO_2eq		%	Mt CO_2eq		%	Mt CO_2eq		%	%
USA	5605	3655	**65%**	509	332	**65%**	194	172	**88%**	457	457	**100%**	29	18	**62%**	230	110	**48%**	**68%**
EU	3204	2232	**70%**	128	83	**65%**	297	246	**83%**	454	454	**100%**	7.0	3.6	**52%**	104	71	**69%**	**74%**
JPN	1057	793	**75%**	20	15	**75%**	90	75	**84%**	23	23	**100%**	2.0	1.0	**50%**	31	23	**73%**	**76%**
EEU	1521	1035	**68%**	220	152	**69%**	70	56	**79%**	237	237	**100%**	4.8	2.2	**45%**	33	25	**78%**	**72%**
RUS	1859	825	**44%**	504	224	**44%**	64	47	**74%**	213	213	**100%**	9.0	4.3	**47%**	52	29	**57%**	**50%**
RAI	801	598	**75%**	88	70	**80%**	50	43	**86%**	295	295	**100%**	1.8	1.1	**63%**	41	23	**55%**	**81%**
TUR	137	272	**199%**	4	9	**199%**	15	23	**154%**	61	61	**100%**	-	-	**-**	5	12	**237%**	**169%**
REE	251	123	**49%**	31	15	**49%**	4.5	3.0	**67%**	46	46	**100%**	0.11	0.06	**52%**	2.5	2.8	**110%**	**57%**
ARG	97	162	**166%**	13	21	**166%**	4.9	8.5	**172%**	126	126	**100%**	28	19	**70%**	10	9	**89%**	**124%**
BRA	218	662	**203%**	14	41	**303%**	49	77	**157%**	393	393	**100%**	465	330	**71%**	45	41	**92%**	**130%**
COL																			
MEX	303	531	**175%**	27	47	**175%**	27	41	**150%**	110	110	**100%**	35	26	**75%**	28	26	**93%**	**147%**
VEN																			
RLA																			
EGY																			
ZAF	299	343	**115%**	29	33	**115%**	17	27	**161%**	40	40	**100%**	8.9	5.8	**66%**	8.2	8.1	**99%**	**114%**
NGA																			
RNA																			
RAS																			
GLF	169	238	**141%**	50	71	**141%**	17	23	**135%**	10	10	**100%**	0.6	0.7	**114%**	2.7	6.0	**223%**	**140%**
RME	198	310	**157%**	50	78	**157%**	11	16	**142%**	65	65	**100%**	7.2	5.7	**79%**	9	15	**155%**	**144%**
CHN	2373	5614	**237%**	312	738	**237%**	113	183	**162%**	898	898	**100%**	127	80	**63%**	129	218	**169%**	**196%**
IND	604	3371	**558%**	105	585	**558%**	30	48	**160%**	637	637	**100%**	102	76	**75%**	117	198	**170%**	**308%**
IDN	155	728	**469%**	75	353	**469%**	25	35	**140%**	122	122	**100%**	218	156	**72%**	27	42	**153%**	**231%**
KOR	238	229	**96%**	8	7	**96%**	23	37	**164%**	18	18	**100%**	1.5	0.9	**60%**	10	9	**97%**	**101%**
MYS	60	115	**192%**	13	25	**192%**	7.9	11.0	**140%**	10	10	**100%**	93	76	**82%**	2.7	4.7	**174%**	**130%**
PHL																			
SGP	34	42	**123%**	0	0	**123%**	2.2	2.9	**133%**	0.10	0.10	**100%**	-	-	**-**	0.6	0.7	**116%**	**123%**
THA	94	234	**248%**	4	10	**248%**	11	17	**152%**	73	73	**100%**	43	27	**64%**	8	11	**143%**	**160%**
RAS																			
ROW	3304	6653	**201%**	1016	2045	**201%**	-	-	**-**	-	-	**-**	-	-	**-**	-	-	**-**	**180%**
Annex I	14184	9410	**66%**	1473	885	**60%**	780	661	**85%**	1740	1740	**100%**	53	30	**56%**	496	295	**59%**	**70%**
Non Annex I	8397	19353	**230%**	1745	4069	**233%**	342	530	**155%**	2547	2547	**100%**	1129	805	**71%**	399	591	**148%**	**192%**
Global total	22582	28763	**127%**	3218	4953	**154%**	1123	1191	**106%**	4286	4286	**100%**	1182	835	**71%**	895	886	**99%**	**123%**

7.1.3 Assessment according to the criteria

The approach has not been modified except emissions of CH_4 and N_2O as well as CO_2 emissions from forestry were included. The assessment is therefore largely the same as described in chapter 6.5. Only the structural differences are better accounted for in this extended global Triptych:

Structural differences are taken into account explicitly at a sector level. The differences in the standard of living, in future population growth, in fuel mix for power generation, in the economic structure and energy efficiencies and projected future changes in economic structure are taken into account. In addition, the emissions of CH_4 and N_2O as well as CO_2 emissions from forestry are considered, therefore covering all major emission sectors of developing and developed countries.

In conclusion, the Triptych approach is a method to differentiate emission reductions among countries based on technological considerations on the sector level. In its extended form it accommodates the emission profiles of developed and developing countries to a better extent. Major downside of the approach is still its complexity and the necessity of projections of production growth rates.

7.2 NEW MULTISTAGE: FIRST SUSTAINABLE DEVELOPMENT THEN EMISSION LIMITS

This section further elaborates on the idea that countries participate in climate commitments in several stages. Currently there are the stages Annex I, with quantified commitments, and Non-Annex I, with a general commitment but without quantified commitments. Several approaches with additional steps were proposed.

For example, the FAIR model (see section 5.1.2 and 6.6) implements four stages: No commitments, decarbonization, stabilization and reduction. In this case, the commitments for all stages are defined in a quantitative way as intensity targets, absolute stabilization targets or absolute reduction targets.

Alternatively – and that is what we analyze in this section – the first commitment of a newly entering country could be a 'soft' commitment such as the pledge to phase out inefficient equipment or the clear commitment to sustainable development (see also WRI 2002). This way, 'soft' and 'hard' commitments are combined in one approach.

7.2.1 Description

For this staged approach, we assume the following stages:

- *Stage 1- No commitments:* Countries with low level of development do not have climate commitments. At least all least developed countries would be in this stage. (Representation of this stage in a model: countries follow their business as usual path according to IPCC SRES A2 scenario)
- *Stage 2 - Pledge for sustainable development:* Countries with higher level of emissions per capita commit in a clear way to sustainable development. The environmental objectives should be built into the development policies. Requirements for such a sustainable pathway could be defined, e.g., that inefficient equipment is phased out and requirements and certain standards are met for any new equipment or a clear deviation from the current policies depending on the countries. The implementation of such sustainable development pathway has to be monitored and verified. The additional cost could be born by the country itself or by the countries in stage 4. (Representation of this stage in a model: countries follow their emission path according to the sustainable IPCC SRES scenario B1. This stage is invoked at 5 tCO_2eq/cap, slightly below the current world average.)
- *Stage 3 - Moderate absolute target:* At even higher levels of per capita emissions, countries may voluntarily commit to a moderate target for absolute emissions. The emission level may be increasing, but should be below a business as usual. An incentive to take on

a voluntary target would be the possibility to participate in emissions trading. A 'safety valve' could allow a deviation from the target if economic growth has been higher than expected. The additional cost could be born mainly by the country itself with limited contributions by the countries in stage 4. (Representation of this stage in a model: countries follow their emission path 10% per 10 years below the sustainable IPCC SRES scenario B1. This stage is invoked at 8 tCO_2eq/cap.)

- *Stage 4 - Absolute reduction:* Countries in the highest stage have to reduce absolute emissions substantially until a sustainable per-capita level is reached. (Representation of this stage in a model: countries reduce emissions every 10 years by 20% based on the emissions at the beginning of that 10 year period until 2 tCO_2/cap is reached. This stage is invoked in 2010 at a threshold of 14 tCO_2eq/cap, the Annex I average in 2010. This threshold decreases gradually to 6 tCO_2eq/cap in 2100.)

Thresholds for graduating into different groups are defined in terms of greenhouse gas emissions per capita. The threshold defined as emissions per capita is an incentive to keep emissions low, in order not to move to the next stage. As alternative to rigid threshold levels, countries could be asked to position themselves in one of the stages and/or exceptions could be made.

Countries can only move to higher stages and not to lower ones, even if per-capita emissions fall below the threshold for the stage a country is in. This ensures, that a country that had very high emissions in one point in time, will have to reduce to the sustainable level of per capita emissions. Countries that never reached the stage 4 can continue to emit at a higher level, than those countries that reached stage 4. For this illustrative case, the threshold for participation in stage 4 is at least 6 $tCO_2eq./cap$, while countries at stage 4 have to reduce to 2 $tCO_2eq./cap$.

All current Annex I countries would be automatically at stage 4. For all other countries, every 10 years it is reviewed whether a country moves up a step. Newly entering countries can only move to stage 2 or 3, not directly to stage 4 as to ensure a gradual phase-in of commitments. Based on the data for 2010 it will be judged whether countries move up a stage for the next 10 years.

7.2.2 Quantitative results

The emission paths of individual countries are modeled as described above for all individual countries, based on the same data as for chapter 6. Due to the associated uncertainties in future emissions and the difficulty to model stage 2 (pledge for sustainable development) in a simple way, these results should be seen as indicative. The consequences for individual countries may be different under different assumptions.

Under this approach, some countries move to stage 3 and immediately to stage 4 (reduction) in 2020. For the described parameters these are Venezuela, South Africa, Persian Gulf states, Republic of Korea and Singapore. Immediately jumping on stage 3 are Argentina, Brazil, Mexico and Malaysia.

After the initial placement, only a few countries move to a higher stage, e.g. Argentina moves to stage 4 as of 2020, Mexico as of 2030. Most other countries stay one stage from the start, e.g. India stays on stage 1 until 2090 and China on stage 2 until 2100: Once a country is on a sustainable path, emissions do not grow as fast and current per-capita emission levels of Annex I countries are not reached.

The resulting total emissions in 2020 are +33% above 1990 levels and would lead to approximately 510 ppmv CO_2 in 2100. The emission paths are shown in Figure 14. The results are dominated by assumption of very low emissions under sustainable development. We here assumed that emissions follow the path of the IPCC SRES B1 scenario (see also Figure 3, page 7), which describes a reduction in global emissions as of 2050. With stage 3 assigning further reductions, global emissions decrease fast in the second half of the century. If the B2 scenario is used as the sustainable path instead of B1, global emissions as of 2050 would be higher, but more countries would have moved to higher stages. Further, the choice of the emissions until 2010 changes the starting positions of countries. Using the A1FI scenario for

the business as usual path, which has moderate growth rates until 2020, total emissions in 2020 are +29% above 1990 levels, scenario A1B would lead to 43% above 1990 levels in 2020. Changes in the threshold parameters only lead to significant changes in global emissions, if a large country is moved to a higher or lower stage.

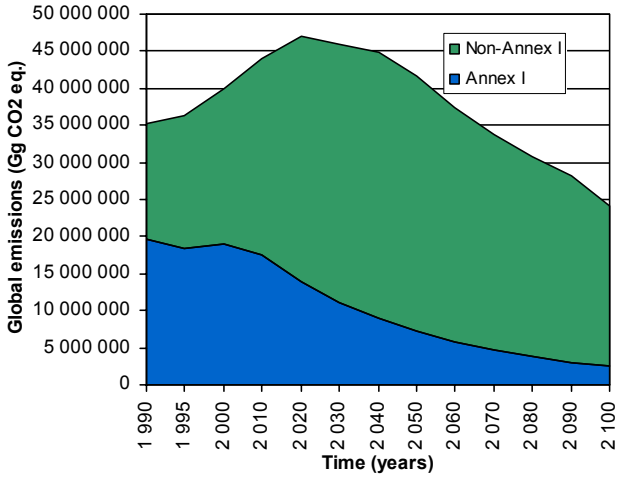

Figure 14: Global emissions under the new multi stage approach

Table 8: Stages for the new multistage approach (rounded average if more than one country in a group)

Data for	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
Determines commitment in	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**	**2010**
USA	4	4	4	4	4	4	4	4	4	4
European Union	4	4	4	4	4	4	4	4	4	4
Japan	4	4	4	4	4	4	4	4	4	4
Eastern Europe (Annex I)	4	4	4	4	4	4	4	4	4	4
Russian Federation	4	4	4	4	4	4	4	4	4	4
Rest of Annex I	4	4	4	4	4	4	4	4	4	4
Rest of Eastern Europe and former USSR	2	2	2	2	2	2	2	2	2	2
Argentina	3	3	4	4	4	4	4	4	4	4
Brazil	3	3	3	3	3	3	3	3	3	3
Colombia	2	2	2	2	2	2	2	2	2	2
Mexico	3	3	3	4	4	4	4	4	4	4
Venezuela	3	4	4	4	4	4	4	4	4	4
Rest of Latin America	2	2	2	2	2	2	2	2	2	2
Egypt	1	1	1	1	2	2	2	2	2	2
South Africa	3	4	4	4	4	4	4	4	4	4
Nigeria	1	1	1	1	1	1	1	1	1	2
Rest of North Africa	2	2	2	2	2	2	2	3	3	3
Rest of Southern Africa	1	1	1	1	1	1	1	1	1	1
Persian Gulf States	3	4	4	4	4	4	4	4	4	4
Rest of Middle East	2	3	3	3	3	3	3	3	3	3
China	2	2	2	2	2	2	2	2	2	2
India	1	1	1	1	1	1	1	1	2	2
Indonesia	1	2	2	2	2	2	2	2	2	2
Korea, Republic of (South)	3	4	4	4	4	4	4	4	4	4
Malaysia	3	3	3	3	3	3	3	3	3	3
Philippines	1	1	1	1	1	1	1	1	1	1
Singapore	3	4	4	4	4	4	4	4	4	4
Thailand	2	2	3	3	3	3	3	3	3	3
Rest of Asia	1	1	1	1	1	1	1	1	1	1
Annex I	4	4	4	4	4	4	4	4	4	4
Non-Annex I	2	2	2	2	2	2	2	2	2	2
Global total	2	2	2	2	2	2	2	2	2	2

Table 9: Per capita emissions for the new multistage approach

	2 010	2 020	2 030	2 040	2 050	2 060	2 070	2 080	2 090	2 100
	tCO2eq	tCO2eq	tCO2eq	tCO2eq	tCO2eq	tCO2eq	tCO2eq	tCO2eq	tCO2eq	tCO2eq
USA	20.06	15.08	11.50	8.93	7.01	5.61	4.49	3.59	2.87	2.30
European Union	10.14	8.21	6.73	5.60	4.71	3.77	3.01	2.43	2.06	1.90
Japan	9.55	7.85	6.58	5.57	4.75	3.80	3.04	2.43	1.94	1.94
Eastern Europe (Annex I)	13.35	11.00	9.19	7.75	6.62	5.30	4.24	3.39	2.71	2.25
Russian Federation	18.97	15.58	12.97	10.88	9.25	7.40	5.92	4.74	3.79	3.03
Rest of Annex I	18.17	13.60	10.33	7.99	6.23	4.99	3.99	3.22	2.61	2.12
Rest of Eastern Europe and former USSR	8.50	7.93	6.23	5.18	4.39	3.73	2.77	2.36	2.11	2.00
Argentina	10.83	12.05	12.31	9.26	7.06	5.65	4.52	3.62	2.89	2.31
Brazil	10.52	10.65	8.60	7.61	7.38	6.13	5.11	3.76	2.85	2.07
Colombia	6.25	7.15	7.09	7.46	7.62	7.04	6.35	5.30	4.43	3.64
Mexico	8.02	9.22	9.85	10.47	8.13	6.50	5.20	4.16	3.33	2.66
Venezuela	17.70	18.61	13.41	9.88	7.44	5.95	4.76	3.81	3.05	2.44
Rest of Latin America	7.77	8.11	6.84	6.19	5.52	4.84	4.27	3.64	3.16	2.81
Egypt	3.03	3.96	4.60	4.82	5.09	4.71	4.16	3.58	3.01	2.49
South Africa	14.75	18.36	13.74	10.37	7.98	6.38	5.11	4.09	3.27	2.61
Nigeria	2.63	2.90	3.00	2.94	2.90	3.28	3.66	4.10	4.61	5.12
Rest of North Africa	4.76	5.59	5.88	6.15	5.80	5.56	4.97	4.44	3.71	2.99
Rest of Southern Africa	3.13	2.82	2.06	1.81	1.66	1.68	1.69	1.72	1.77	1.82
Persian Gulf States	24.65	25.99	17.85	12.75	9.20	7.36	5.89	4.71	3.77	3.01
Rest of Middle East	6.53	7.19	7.30	7.48	6.09	5.21	4.32	3.55	2.88	2.34
China	5.13	6.40	7.09	7.50	7.03	6.09	5.15	4.32	3.57	2.94
India	2.43	2.87	3.26	3.50	3.78	4.17	4.57	5.00	5.47	4.29
Indonesia	4.49	5.14	5.19	5.12	4.58	4.02	3.47	2.90	1.83	1.83
Korea, Republic of (South)	15.72	16.68	13.09	10.51	8.64	6.91	5.53	4.42	3.54	2.83
Malaysia	13.52	12.07	10.75	9.36	7.32	5.67	4.31	3.14	1.39	1.39
Philippines	2.80	3.11	3.16	3.10	3.12	3.28	3.44	3.68	4.01	4.33
Singapore	37.76	39.72	30.92	25.04	20.72	16.57	13.26	10.61	8.49	6.79
Thailand	6.95	7.66	8.37	7.90	6.61	5.12	3.87	2.88	1.97	1.97
Rest of Asia	2.43	2.28	2.09	1.91	1.74	1.68	1.62	1.60	1.55	1.59
Annex I	13.89	10.97	8.78	7.14	5.86	4.72	3.80	3.07	2.51	2.14
Non-Annex I	4.81	5.30	5.09	4.92	4.48	4.13	3.79	3.51	3.27	2.81
Global total	6.49	6.26	5.67	5.24	4.67	4.21	3.79	3.45	3.16	2.72

7.2.3 Assessment according to the criteria

Environmental criteria

Environmental effectiveness: Under this approach, stringent long-term goals can be reached, but only if industrialized countries decrease emissions significantly in the next 50 years and developing countries move very soon (best even as of 2010) at least to a sustainable emission pathway, which is considerably lower than an average business-as-usual pathway. If this stage 2 is not successful, the thresholds ensure that countries need to reduce their emissions through limitation targets. The prospect of having to apply an emission limitation target is an incentive not to increase emissions until the threshold. Therefore also leakage is not the interest of countries that do not yet have targets.

Encouragement of early action: Setting the threshold for moving into higher stages using per capita emissions encourages early action by countries, since it avoids moving to higher steps and to stricter targets. Having low per-capita emissions in this system always is an advantage.

Political criteria

Equity principles: Economic growth for developing countries (principle of *need*) is supported since no restrictions apply until a certain emission per capita level is reached. Developing countries with already high per capita emissions would be restricted in their path of emissions as of 2010. The principle of *capability* (ability to pay) is only implicitly included in that Annex I countries have to reduce emissions considerably. The principle of *responsibility* (polluter pays) is addressed through the per-capita emissions threshold. The historic responsibility of countries is incorporated in the way that countries that once reached high per capita emis-

sions have to reduce their emissions fast, and countries that never reached high per-capita emission levels do not have to undertake large reductions.

Agreement with fundamental positions of all major constituencies: The notion of countries gradually phasing into a reduction regime would seem to be acceptable to many countries. In addition, the concept of sustainable development is generally agreed, although possibly because it is a very vague concept. An essential question will be, who will pay for this phase of sustainable development. In order to reach stringent target, all major developing countries would have to participate as of 2010. This may not be acceptable to some of those developing countries.

Economic criteria

Accounting for structural differences between countries: Participation is differentiated according to per capita emissions, reductions are equal for all countries. The particular economic structure or emission reduction potentials of a country is not considered here, but could be build into the approach. E.g. the reduction levels of the countries in stage 4 could be set individually to account for the national circumstances.

Minimizing adverse economic effects: The second step, pledge for sustainable development, is economically effective for developing countries, because efforts for development are joint with possibly small additional efforts for climate. Those countries have the freedom to implement any sustainable policy as long as emissions stay below a certain threshold. As for other approaches, the participating countries have low certainty of the inferred costs that are due to the targets that they need to comply with. If emissions trading is allowed, it can ensure that marginal abatement costs are comparable in all participating countries. In the emission reduction stages, countries can reduce emissions across sectors and gases and also outside of their territory, as for other approaches.

Technical criteria

Compatibility with the structure of the UNFCCC and the Kyoto Protocol: This approach can be built upon the structure agreed in the Kyoto Protocol: The notion of gradually increasing the group of countries that reduce emissions is built into the Convention. Elements to achieve sustainable development are included in the system in the principles of the Convention as well as in the financial mechanisms and the CDM, assisting developing countries to develop in a sustainable way. These programmes would however have to be enhanced to achieve the necessary significant changes in emission pathways. Further, the reductions by the countries in stage 4 would also have to be more stringent than those agreed in the Kyoto Protocol.

Moderate political and technical requirements of the negotiation process: This approach combines many ideas into one system. The implementation of such a system would require several decisions on the thresholds and how to set emission reduction targets in stages 3 and 4. Setting generic rules for participation thresholds for all countries and emission reduction could be considered as difficult but possible. These rules would have to be updated regularly. As for other approaches, emissions have to be calculated, reviewed and verified due to the legally binding nature of the targets.

Conclusions

It can be concluded that with this approach stringent long-term goals can be reached, if industrialized countries decrease emissions significantly in the next 50 years and developing countries move very soon (best even as of 2010) to a sustainable emission pathway or a higher step. It remains uncertain whether the step of pursuing sustainable development is effective.

7.3 PERFORMANCE TARGETS

This section briefly introduces the concept of ‘performance targets’, a new form to formulate emission limitation or reduction targets. Performance targets are ‘dynamic’ as they define an amount of allowed emissions relative to a unit of production of the most important sectors in a country (e.g. tonnes of steel or kWh of electricity). These individual targets are aggregated to

one total national target. The total allowed emissions depend on several variables (e.g. tonnes of steel or kWh of electricity), which are only known during the target year.

The approach of performance targets is borrowing the idea of the Triptych approach to define one national target based on different sector targets. Only the total national emissions in the target year are relevant, not the emissions in the different sectors. The performance target is not prescribing where the emissions have to be reduced, it describes only a total bnational limit.

The Triptych approach is however static, it defines a fixed limit of absolute emissions before the commitment period. Performance targets are dynamic as GHG intensity targets (emissions per GDP), absolute emissions may vary depending on the level of production that actually occurs.

The targets for the sectors are defined as improvement in the 'performance', i.e. emissions relative a measure of the activity. This could be an improvement in CO_2 emissions per kWh electricity produced or improvement in CO_2 emissions per tonne of steel produced or improvement of CH_4 emissions per head of sheep.

An advantage of dynamic targets is, that they provide flexibility in the case the economy develops unexpectedly. The level of absolute emissions is adjusted according to the development of a variable. For intensity targets, this variable is the GDP, but for some countries emissions may not change proportionally to the GDP. For performance targets, this variable is the unit of production, which is closer related to emissions than the GDP. An unexpected change in the economic development would change the activity rate and therefore the allowed emissions as well as real emissions in the same way. Whether the target is reached or not is more independent of unexpected economic developments than for absolute targets and for intensity targets.

With this approach only the emission performance of an activity is capped, not the activity itself. Therefore, such targets allow for economic growth (increased production of steel), but require improvements in the production process making them attractive to developing counties, which exhibit a rapid increase of their economic activity. However, performance targets do not provide incentives for efficient material use or savings in electricity. A decline in activity (intended as a emission reduction measure or unintended due to economic decline) is counted to the favour of the country. As the total amount of emissions is not fixed, it is uncertain whether a particular environmental goal can be reached.

For performance targets, a limited amount of additional data have to be collected compared to absolute emission targets. For many sectors, the performance, i.e. the emission factor, is an *input* to the calculation of the emissions, e.g. the CO_2 emissions from cement production are calculated based on the amount of cement produced. These emission factors are estimated and are reviewed. For fuel combustion, emissions are usually calculated based on the amount of fuel used and not on the activity (e.g. amount of electricity produced). However, the activity rate, is needed to assess the quality of the emission estimates and is in some cases available. Still, for some categories, the indicators for the activity are rarely available, e.g. person-km in the transport sector or square meters of heated space in the households. In any case, it would be beneficial to have comparable statistics on the parameters for all countries, also for the review of the emission inventories.

The total performance target is defined as the sum of several sectoral targets, as in the Triptych approach. There are several options to split the total emissions into categories. The split should be along the source categories in which the emissions are reported. The IPCC Guidelines for national greenhouse gas inventories, the reporting standard, define a large number of source categories, but for most countries only 20 are "key source categories", the most important ones. Performance targets could be applied for those key source categories or only for the five globally most important, or only the five most important for the country together with absolute targets for the other categories.

With performance targets it may also be easier to differentiate the stringency of targets between countries than for absolute targets. For all major source categories, a percentage reduction in the emission factor could to be agreed. This equal reduction could be applied to all countries. Alternatively, a formula could be set so that the emission factors converge. As in all

other approaches, exceptions could be made. The judgment, whether these reductions are a high or low burden, is much easier than for absolute emissions or emission intensity, because the emission factors depend only on a few variables, while the absolute emissions and the emission intensity depends on may variables.

We here only briefly introduced the concept of performance targets. This idea still needs to be developed into a full approach but warrants further analysis.

8. COMPARISON OF APPROACHES AND CONCLUSIONS

In this chapter contains the comparison of approaches that were described and assessed in the in chapter 6 and 7 as well as the resulting conclusions.

8.1 QUANTITATIVE COMPARISON

Table 10 provides a comparison of the results obtained from the quantification of the different approaches for different regional groups. All results are based on the same data (see 6.1 and Appendix A), except the Triptych and multi-sector convergence approach.

The results presented in Table 10 are one snapshot out of the diverse possibilities to quantify the approaches. The results could be varied along two dimensions: Varying the business-as-usual scenario (the IPCC SRES A2 scenario is used here) and varying the parameters needed for the individual approaches, such as for example participation thresholds or convergence years. Any variation along these dimensions can change the results considerably. Further, the results obtained for the triptych approach and the multi-sector convergence approach are based on different data than the other approaches. Accordingly, these results should be viewed as indicative.

Under all approaches, Annex I countries have to reduce emissions considerably. Most approaches have some free parameters that allow adjusting the balance of Annex I reductions versus Non-Annex I reductions. In this comparison the multi-sector convergence approach results in the lowest emissions for Annex I countries, because it includes a period of no action for newly participating developing countries.

Only a few Non-Annex I countries under a few approaches can follow their business as usual path. The group of these countries may vary with the choice of the parameter. Under most approaches, also Non-Annex I countries have to reduce emissions below business as usual paths, to ensure that ambitious global environmental goals are met.

8.2 QUALITATIVE COMPARISON

Comparing the different approaches across the different criteria is a subjective task, which depends on the judgment, whether an approach meets the criterion, and the weight given to the individual criteria. Table 11 provides an attempt for such a comparison. The eight criteria are evaluated for each approach and rated ‘completely not met’ (--), ‘mainly not met’ (-), ‘neutral’ (0), ‘mainly met’ (+) and ‘completely met’ (++). ‘/’ denotes that the criterion may or may not be fulfilled depending on the specific variation of the approach. As an attempt to further condense the assessment, always two criteria are grouped together to four general criteria (environmental, political, economic and technical) using the rules described below. The first column of Table 11 provides a possible weighting for these general criteria. A further condensation of the ratings, however, is left to the reader.

Table 10. Changes in total greenhouse gas emissions (allowances) from 1990 to 2020 for groups of countries (1990=100%, includes CO_2, CH_4 and N_2O for fossil fuels and forestry, except global Triptych)

Region	BAU (IPCC SRES A2)	Continuing Kyoto	Intensity targets	Contraction and convergence	Global Triptych (CO_2 from energy only)	Multi-sector convergence approach	Multi-stage approach (FAIR)	Extended global Triptych	New Multi-stage
USA	138%	74%	83%	85%	*65%*	*47%*	88%	68%	74%
European Union	118%	74%	76%	82%	*70%*	*49%*	87%	74%	74%
Japan	139%	75%	75%	83%	*75%*	*50%*	89%	76%	75%
Eastern Europe (Annex I)	94%	76%	81%	68%	*68%*	*45%*	75%	72%	64%
Russian Federation	92%	63%	79%	66%	*44%*	*41%*	74%	50%	63%
Rest of Annex I	140%	80%	89%	93%	*75%*	*51%*	94%	81%	80%
Turkey	141%	80%	89%	121%	***199%***	***178%***	94%	**169%**	80%
Rest of Eastern Europe and former USSR	120%	115%	104%	102%	*49%**	*59%**	104%	57%*	104%
Argentina	224%	129%	223%	158%	*166%*		223%	124%	195%
Brazil	210%	133%	167%	165%	***203%***	***261%***	167%	130%	185%
Colombia	232%	**232%**	179%	190%			179%		227%
Mexico	248%	135%	183%	173%	*175%*	***251%***	183%	147%	215%
Venezuela	271%	**271%**	182%	198%			182%		240%
Rest of Latin America	235%	210%	206%	193%		***295%****	206%		217%
Egypt	266%	**266%**	226%	223%		***382%***	226%		266%
South Africa	266%	140%	154%	161%	*115%*	*240%*	154%	114%	228%
Nigeria	245%	**245%**	183%	**252%**		***431%***	183%		245%
Rest of North Africa	242%	234%	195%	198%			195%		233%
Rest of Southern Africa	206%	**206%**	151%	**236%**		***431%****	151%		195%
Persian Gulf States	313%	163%	202%	212%	*141%**	*284%**	202%	140%*	267%
Rest of Middle East	287%	191%	221%	213%	*157%**	***293%****	221%	144%*	254%
China	226%	**224%**	196%	176%	***237%***	*205%*	196%	196%	222%
India	227%	**227%**	186%	222%	***558%***	***294%***	186%	**308%**	**227%**
Indonesia	213%	**213%**	164%	187%	***469%***	***294%***	164%	**231%**	**213%**
Korea, Republic of (South)	360%	205%	277%	232%	*96%*	*170%*	277%	101%	282%
Malaysia	236%	147%	213%	183%	*192%*		213%	130%	185%
Philippines	196%	**196%**	138%	**197%**			138%		**196%**
Singapore	290%	163%	246%	181%	*123%*		246%	123%	226%
Thailand	263%	158%	195%	198%	*248%*		195%	160%	232%
Rest of Asia	189%	188%	157%	**205%**			157%		166%
Rest of the World					***201%***			**180%**	
Annex I	119%	73%	81%	80%	*66%*	*47%*	84%	70%	71%
Non-Annex I	227%	196%	182%	189%	*230%*	*301%*	182%	192%	211%
Global total	167%	127%	126%	128%	*127%*	*133%*	128%	123%	133%

Note: **Bold and green** are those values that are equal or above the business as usual path.

*: The Triptych approaches are based on different data resulting for some countries in higher emissions than the business-as-usual. Further: REE includes Kazakhstan only, GLF includes Saudi Arabia only, RME includes Iran only, 'Rest of the world' includes all countries not covered above.

The multi-sector convergence approach is based on different data: REE includes Kazakhstan only, RLA includes Bolivia only, RSA includes Tanzania only, GLF includes Kuwait and Saudi Arabia only, RME includes Iran and Yemen only.

Table 11. Indicative assessment matrix for the qualitative comparison of the approaches

Criterion \ Approach	Possible weighting	Continuing Kyoto	Intensity targets	Contraction and convergence	Global Triptych (CO_2 only)	Multi-sector convergence approach	Multistage approach (FAIR)	Equal mitigation cost	Coordinated Policies and measures	Extended global Triptych	New multistage	Performance targets
Environmental criteria	**3**	**+**	**0**	**++**	**+**	**++**	**+**	**0**	**+**	**+**	**++**	**+**
Environmental effectiveness		++	+	++	++	++	++	++	0	++	++	+
Encouragement of early action by Parties that do not yet have binding commitments		-	-	++	0	+	/	--	++	0	+	+
Political criteria	**3**	**0**	**0**	**0**	**+**	**0**	**++**	**0**	**0**	**+**	**++**	**0**
Equity principles		+	0	+	+	+	++	0	-	+	++	+
Agreement with fundamental positions of major constituencies		0	+	-	+	0	+	-	0	+	+	0
Economic criteria	**2**	**0**	**0**	**-**	**+**	**+**	**+**	**++**	**-**	**++**	**+**	**++**
Accounting for structural differences between countries		/	/	--	+	+	+	++	-	++	+	++
Minimizing adverse economic effects		+	+	+	+	+	+	++	-	+	+	+
Technical criteria	**1**	**++**	**0**	**++**	**0**	**0**	**+**	**-**	**0**	**0**	**+**	**0**
Compatibility with UNFCCC and Kyoto Protocol		++	+	+	+	+	+	+	0	+	+	+
Moderate political and technical requirements of the negotiation process		++	-	++	-	-	+	--	-	-	+	-

Note: '--' criterion completely not met, '-' criterion mainly not met, '0' neutral, '/' depends on the specific variation of the approach, '+' criterion mainly met, '++' criterion completely met

Rules used for combining two criteria:

'++' and '++' equals '++'
'++' and '+' equals '++'
'++' and '0' equals '+'
'++' and '-' equals '+'
'++' and '--' equals '0'
'+' and '+' equals '+'
'+' and '0' equals '0'
'+' and '-' equals '0'
'0' and '0' equals '0'
'/' is treated as '0'

8.3 CONCLUSIONS FROM THE COMPARISON

From the comparison of the approaches, we draw the following conclusions:

Several approaches are available: Several approaches to future commitments are available that would lead to emissions consistent with stringent environmental goals. For all approaches, reductions additional to those in the Kyoto Protocol are necessary.

Significant reductions by industrialized countries are necessary: For all these approaches, significant emission reduction by industrialized countries (in the order of cutting emissions more than in half by 2050 and continuing to decrease) are necessary as soon as possible to leave some room for increasing developing country emissions and still to reach stringent environmental goals. For same global emission limit, emission allowances for industrialized countries are lower under a global Triptych approach than under contraction and convergence, because the Triptych approach allows emissions of Non-Annex I countries to grow considerably. Emission allowances for industrialized countries are even lower under the multi-sector convergence approach, because sectoral emissions converge on a per-capita basis resulting in major reductions in those countries with high industrial activity and relatively low population.

Early involvement of developing countries is needed: If per-capita emissions in developing countries reach current levels of industrialized countries, stringent stabilization goals

would be out of reach. Even more, early deviation from current business-as-usual paths of developing countries is necessary. This can be achieved through emission limitation and reduction targets, but also through an enhanced sustainable development approach and through positive spillover of emission reductions from developed countries to developing countries. Not many of the existing approaches encourage early action by countries that are not yet participating. In fact, basing emission reductions on levels in the future is counterproductive to early action. A threshold for participation in emission limitation targets defined as per-capita emissions would encourage early action to stay beneath this threshold.

A mix as compromise: Every approach has advantages and disadvantages. Converging per capita emissions for example is straightforward, but probably unacceptable for some countries. Those approaches that mix several elements receive good marks in the assessment and have a higher chance of being accepted since all constituencies find elements of their concern in the mixed approach. A good mix of approaches can be the key to finding a broadly acceptable solution.

Forms of targets that allow economic growth and limit emissions: If developing countries agree to further commitments, these must be designed to avoid a restriction of economic growth as much as possible to be politically acceptable but at the same time have to limit emissions. The approach to aim as a first step for enhanced sustainable development accommodates this concern. Intensity targets are seen as allowing growth, but they can be as restrictive as absolute targets if they are set at stringent levels. They only allow additional emissions, if *unexpected* growth occurs. The Triptych approach is a method to accommodate growth in production and shares emission allowances accordingly between countries. Even more, 'performance targets' limit only specific emissions without limiting the activities themselves. In all cases the balance has to be found between allowing economic growth and keeping emissions at a low level.

Differentiation not solved: No generally acceptable approach is available how to differentiate targets within a group of countries. Many indicators are available, including the historical responsibility (Brazilian Proposal). Differentiation on the basis of an economic model equalizing the abatement costs among countries may not be realistic. No magic rule is available how to adequately account for structural differences between countries. For intensity targets, the differentiation is more difficult than for absolute targets, since it involves also the knowledge on the relationship between emissions and GDP. The Triptych approach is a method that specifically accommodates the structural differences by defining differentiated levels of national emissions based on sectoral considerations. Performance targets may not need differentiation between countries.

The following conclusions can be drawn for the approaches that were analyzed in this study:

Continuing Kyoto without any changes or additions would be an obvious option for future commitments. Stringent environmental goals can, however, only be reached if current Annex I countries decrease their emissions more than for the first commitment period (2008 to 2012) and if developing countries deviate from their business-as-usual paths at an early stage. In this system a method to differentiate the targets for the participating countries is to be found. Taking on absolute emission targets may be difficult for some developing countries due to the uncertainty in the development of the emissions. To help these countries, relatively small additional changes in the rules could be introduced such as 'price caps' (additional permits at a fixed price) or slightly looser compliance mechanisms.

Intensity targets can play a role in future commitments as one form of target for a particular group of countries, possibly in parallel to other types of targets for other countries. If it is applied to all countries, the global emission intensity (Emissions per GDP) has to decrease rapidly (2-4% per year) in order to reach stringent environmental goals. If equal percentage reductions in emission intensity are agreed for a group of countries, those are in advantage that have higher economic growth, which are at present some Asian states. Agreeing on differentiated intensity reductions is more difficult than absolute reductions, since it involves country specific knowledge of the relationship between emissions and GDP, which also may evolve with time.

Contraction and convergence, where per capita emissions converge, is intriguing due to the simplicity of the approach. Since major reductions in emissions are necessary it is likely, that

in the long run under any regime per-capita emissions will converge to a very low level. The question is on which path. The simplicity of the approach is also the major disadvantage: The approach does not account for the structural differences of countries and their ability to decrease their emissions. For stabilization levels of 450 or 550 ppmv CO_2, per-capita emissions have to decrease below the current world average. Also many developing countries would have to decrease emissions below their business as usual path and only a few least developed countries could sell for as short period of time easily earned emission allowances to developed countries.

The Triptych approach has potential as a method to differentiate emission reduction targets between members of a group of countries. The extended version presented here also can accommodate the emission structure of developing countries and includes forestry and non-CO_2 greenhouse gas emissions. Major downside of the approach is its relative complexity and the necessity of projections of production growth rates. Still, such differentiation approach can produce a starting point for a negotiation between the countries of that group.

Multi-stage approaches will be the future of the climate regime, but there are many possibilities on types of stages and thresholds for moving into a next stage. The current two stages (Annex I and Non Annex I) could be extended. As one promising criteria to move to a further stage would be the emissions per capita. As a first stage, a well-defined commitment to sustainable development could increase the acceptability for developing countries.

The multi-sector convergence approach is describing a complete set of rules for a future climate regime defining in essence the path on which sectoral per-capita emissions converge. A major downside of the approach is that sectoral activities are not necessarily directly related to the population.

Equal mitigation costs: Setting targets so that mitigation costs are equal for all participating countries (e.g. a percentage share of the GDP) seems to be, from a theoretical point of view, a fair option. In practice, however, it may be impossible to agree on a model or calculation method for calculating the cost of countries. It is therefore not a realistic option.

Policies and measures can also be a part of a mix. Especially for newly entering countries, policies that combine development and environment objectives are very attractive and could form a first stage of commitments.

9. SOME CURRENT VIEWS

This chapter intends to provide a first snapshot of the views on future commitments among delegates to the UNFCCC process. It is based on only a limited number of interviews (seven) and therefore is not to be seen as representative overview, but rather as an indicator of the important topics. In total seven delegates from Burkina Faso, Brazil, India, Malaysia, Norway, UK and USA were asked to provide their personal views on the question of future climate commitments. Interviews were held mostly during the session of the subsidiary bodies in July 2002. This chapter summarizes the results.

Implementation of existing commitments: Being asked very openly about the issue of future commitments, interviewees from developing countries always first stress the need for implementation of the existing commitments as a prerequisite of beginning a discussion on future commitments. First, trust has to be built, that the promised emission reductions are met and the promised financial support for developing countries is provided. This trust is currently not felt by most developing country interviewees. On the question on how the trust could be build, some mentioned 10 to 15 year technical cooperation programmes, CDM or other cooperation and, not at last, an active role of the USA (see below). One interviewee did not see a need to talk about the issue of future commitments now, since it is a "hypothetical issue". In his view, even a scientific discussion would not accelerate the process.

USA participation: All interviewees stressed with high importance that the withdrawal of the USA from the Kyoto Protocol is blocking any progress on the question of future commitments. It was seen as a prerequisite that the USA (and all other Annex I Parties) demonstrate serious action before a meaningful discussion on further commitments, especially for Non-Annex I Parties can start.

In the current situation, the USA could follow two strategies: Either it is proactive in the discussions on future developing country commitments, with the intention that *all* countries receive acceptable targets. Or the USA could be passive on the question of future commitments, as no agreement would also mean no new target for the USA. One interviewee speculated that the USA is currently following the latter option.

Long term goals: Industrialized country interviewees generally first stressed the importance of long term goals, such as stabilization of greenhouse gas concentrations, when being asked broadly about future commitments. Some felt that a discussion on long term goals is necessary, because a step-by-step process without the long-term view would result in targets not ambitious enough to solve the climate change problem. Such a long-term discussion would not necessarily have to lead to an agreement on a specific concentration target (such as 450 ppmv CO_2), but would guide the choice of next steps.

On the other hand some interviewees mentioned that a discussion on ultimate concentration levels would be a "non-starter". Due to the uncertainty involved, it would be impossible to agree on a level and a discussion would be unproductive. It was mentioned that some developing countries are frightened already by a discussion on concentration levels (without agreeing on a level), because they fear that such discussion would, in their view, lead automatically to immediate commitments for developing countries. Another argument against setting stabilization targets is that AOSIS could not agree to any stabilization target, since under all feasible options, they would agree to unacceptable damages to their countries.

The idea of setting a global intermediate target for, e.g., 2020 or 2030, from which it would still be possible to reach several different concentration targets, seemed very attractive to many interviewees. Such intermediate target could evolve from a discussion on the long term goals, but could take into account the present uncertainties associated with any long term goal. From such intermediate global target, targets for individual countries could be derived.

Form of commitment: Many interviewees mention greenhouse gas intensity targets (emissions per GDP) as a very attractive option, also because the USA recently proposed such a target. It is seen as providing the necessary flexibility. It seems that the interviewees see it as a currently politically attractive option, also for "cosmetic" reasons (An increase in absolute

emissions can be expressed as a decrease in emission intensity). But no detailed analysis on implications of intensity targets has been made.

Others, however, do not favor intensity targets since they are seen as providing insufficient certainty on the total level of allowed emissions.

For yet others, the form of the target is not relevant, as long as the targets are set stringent enough to be credible. Any form of target can be set to be a stringent target.

Almost all interviewees think that several forms of targets could and will coexist, e.g. absolute targets for developed countries and intensity targets for newly entering countries.

Differentiation of commitments: Setting different levels of targets for participating countries was seen as a difficult task and no interviewee had concrete proposals or formulas for differentiation. Sectoral approaches, as the Triptych approach, were considered less attractive, since seen as complicated.

Participation: It was broadly agreed that in some point in time all countries will have climate commitments. But only a few options were mentioned to decide who and when.

One interviewee mentioned that the terms Annex I and Non-Annex I have become very rigid and so loaded, that possibly new names of groups of countries could help to overcome this divide. There could also be more than two groups.

Others mentioned that some countries could graduate into Annex I, but no satisfactory indicator for such graduation could be mentioned. Indicators such as emissions per GDP, GDP per capita and emissions per capita do all favor some and disadvantage other countries.

An alternative view is that there should be no intentions to split the group of 77 and China. The group always has acted as a group and will resist any attempt to be split. One option was mentioned as a promising one: to give an overall target to the group of G77 and let the group decide how to distribute it among its members.

Process: It was mentioned, that a new round of negotiations under the UNFCCC could be launched on this issue. Such process would be guided by scientific analysis on the design of new targets.

One interviewee described a process building on the experience of the past negotiations: First, the form of the target is agreed. Then the chairman of the negotiations, who has the political responsibility, makes a proposal how to differentiate the targets, based on transparent scientific analysis. Third, political negotiations modify this proposal, taking into account special national considerations.

Another view was that the UNFCCC process as such is not capable of providing an agreement, since decision making by consensus provides room to disrupt the process. For a global solution, the maybe 15 largest emitters[11] could separately meet and agree on a solution.

Completeness of the concepts: A general impression was that the interviewed delegates see the issue as fundamental, but did not have fully developed opinions or concepts. There is a feeling of need for action on the one hand but mistrust on the other. Many open questions remain and more creative thinking, discussion and education are needed.

[11] For largest emitters see Appendix A.

10. RECOMMENDATIONS

Based on the previous chapters of this report, the authors in this chapter formulate recommendations that aim at a successful agreement on global action against climate change that is acceptable to all countries. First, recommendations for action by the German Federal Environmental Agency (Umweltbundesamt) and the German Federal Environment Ministry (Umweltministerium) are provided. Further, recommendations for the design of an international agreement and, finally, issues for further research are identified.

10.1 RECOMMENDATIONS FOR ACTION

Start an informal, international dialogue process: In the formal UNFCCC process, the issue of future commitments has been blocked in the last years, due to the call for developing country participation, the uncertainty of the entry-into-force of the Kyoto Protocol and the withdrawal of the USA. But there is a great need for research, information sharing and discussion on this fundamental issue on the scientific side as well as on the policy maker side. To prepare for the negotiation in the formal UNFCCC process, an informal, international dialogue could be organized to educate a discussion and to build trust among delegations. Such dialogue should bring together scientists and policy makers to discuss the science of climate change (emissions to concentrations, stabilization, range of uncertainties) and possible actions (absolute and intensity targets, form and stringency, sustainable development approach). Germany has a credible role in the international process and could actively initiate and support such a dialogue. To build trust, the focus should be on “finding global solutions for the long-term problem of climate change” and not on “developing country commitments”.

Build trust by action: One of the main agreements of the climate change convention is that Annex I countries have to take the lead in reducing greenhouse gas emissions. The perception by most developing countries, that Annex I countries do not take sufficient action, blocks the discussion on future commitments. This leads to the (almost trivial) recommendation, that Annex I countries have to build trust by actively reducing emissions, getting involved in the CDM and making available the agreed funds. This also includes working with the USA to find ways of their participation. In any case, strong efforts by developed countries are likely to also have reducing effects on developing country emissions (positive spillover).

Communication of the achieved results: Part of the trust building needs to be the communication of action taken and results achieved to date. It is often difficult to assess the quantitative importance of climate policies versus that of other factors (e.g. the effect of the German unification) for the path of emissions. Disentangling the various effects is not a straightforward task and common approaches and formats are recommendable. The European Union could take an initiative on this point in supporting the development of methodologies for the assessment of climate policy.

Stress the need for significant reduction in Annex I countries in the long term: This and other analyses show that in all scenarios that lead to ambitious long-term goals, industrialized countries have to reduce emissions significantly until 2050, otherwise no room is available for moderately increasing developing country emissions. Efforts should focus on actions that reduce emissions not only temporarily in the short-term but sustainably in the long run. A clear statement by developed countries to this effect could be a signal to developing countries.

10.2 RECOMMENDATIONS FOR THE DESIGN OF AN AGREEMENT

10.2.1 Participation

Support early involvement (not necessarily ‘participation’) by all countries: The IPCC Special Report on Emission Scenarios (IPCC 2000) illustrates the diverse paths global emissions could take irrespective of climate policies. Our analysis shows that the way emissions are shared depends to a large extent on the business-as-usual path that is chosen for the analysis. Sustainable development of *all* countries, not including policies aimed directly at the

climate, is equally important for low emissions as reductions induced by commitments under the UNFCCC. Unconstrained business-as-usual emissions of Non-Annex I Parties will foreclose certain options for stabilization. All efforts have to be made to enable developing countries to develop in a sustainable way. Further thoughts are necessary how such a sustainable path way can be achieved, e.g. use of the currently available tools, such as the financial cooperation, CDM or additional investment programmes. Initial further commitments for developing countries could take the form of a pledge for enhanced sustainable development or targets that allow economic growth but limit emissions at the same time (see above).

Work together with the G77 to break the deadlock: The G77 stands as a group in the international negotiations and is likely to do so in the near future, although the interests of the members of the group are diverse. In the past, efforts by some developing counties to break out of the group to take on commitments have failed, mainly due to the opposition within the G77. Currently, it seems unlikely that only some developing countries take on commitments. One way to overcome this problem could be to agree on a total indicative target for the G77 and let the group decide itself which members have to take which action.

Let countries place themselves in groups: Until the present some industrialized countries stated the general condition of 'meaningful participation of developing countries', but did not differentiate, which of the developing countries are expected to act. Indicators, that would define when a country has to take on climate commitments, are available (greenhouse gas emissions, emissions per GDP, GDP per capita, human development index, vulnerability etc.) but no single one, or combination, is generally acceptable to all countries. Collection of data on such indicators can support a process in which countries are asked to place themselves in one of a number of groups, e.g. 'binding target', 'voluntary, non-binding target', 'No need to act'. Such process would have to take into account the structure of the G77 as explained above. Publicly available indicators and political pressure could move countries to place themselves in a certain group.

10.2.2 Process

Focus long-term discussion on the lost options: A discussion on greenhouse gas concentration levels, for example on 450 or 550 ppmv CO_2, or maximum levels of climate change, such as 2°C temperature rise, may be difficult and an agreement on a specific level may be impossible, given the uncertainties involved. However, a discussion on the long-term perspective would inform the direction of next steps. A discussion could be framed around questions such as 'At what level of global emissions in the year 2020 do we loose the option to stabilize concentrations at 450 ppmv CO_2?'. Answers could lead to the definition of an intermediate global emission target, for e.g. 2020, from which it would still be possible to reach several concentration levels. Further analysis on this subject is necessary (see section 10.3).

Build upon existing system, but be creative: International negotiations are very time consuming and only ten years after the Convention was agreed, the rules for the next step, the Kyoto Protocol, are set. Most approaches can be build upon the existing system that is already agreed by the international community: Legally binding emission targets for some countries, inclusion of all greenhouse gases in a basket, commitment periods, emissions trading, limited use of forestry activities, incentives for developing countries to participate e.g. through CDM. That does not mean that the system is rigid. The structure allows to build in creative new approaches. E.g. emission intensity targets could be integrated in a further development of the Kyoto Protocol, if so desired. Another idea could be a separate Protocol for a special sector, e.g. a non-deforestation protocol. Such new protocol could build upon the Kyoto Protocol or be based on the Convention. Links to the Conventions on biodiversity and desertification could be extended.

Be prepared to evaluate targets of other countries: From the procedural point of view, there are at least two ways to agree on commitments: Countries propose targets for themselves, all evaluate each others proposals and then start to negotiate. Alternatively, a chairman or another person with the political responsibility makes a proposal based on a scientifically credible formula and the following negotiations will provide for the exceptions to particular national circumstances. Countries need to have the analytical capacity to evaluate the

proposals by other countries. If a government is supporting the chairman, it must have the capacity to make a scientifically based proposal.

10.2.3 Form and stringency of targets

Allow diverse forms of targets: The concept of absolute emission targets may be appropriate for some countries, but less appropriate for others. Intensity targets may help some but harm others. Several forms of targets are available. In a diverse world possibly many different approaches need to be available to account for the diverse needs of all countries. Also this analysis showed that approaches that mix different proposals incorporate more issues important to the stakeholders and therefore have a higher chance of being agreeable. One way to accomplish this would be the 'menu approach' to let (newly entering) groups of Parties choose the appropriate form of their target from options such as absolute targets, GDP intensity, certain policies and measures. The form of the target is not significant as long as it is ensured that the targets are stringent enough. Many forms of targets (absolute emissions, intensity targets, policies and measures) can reach stringent environmental objectives, as long as they are set at the appropriate level. This, however, stresses the need to have the capability to be able to evaluate a variety of targets (see above).

Focus on forms of targets allow developing country economic growth but limit emissions: Absolute targets are seen by developing countries as capping their economic growth. Intensity targets are intending to provide such flexibility but may not do so, if they are set stringently or emission intensive activities increase that do not contribute much to the GDP. 'Performance targets', that are dynamic as intensity targets, but relate to the activity level not the GDP, or the Triptych approach could to a greater extent provide room for economic growth in activities but limit emissions per level of activity. Technology standards also do not limit activities but limit only the specific emissions. Also the pledge for sustainable development focuses on the *development* first and is therefore attractive.

Explore forms of targets that allow evaluating the stringency easily: The evaluation of the stringency of absolute reduction targets is relatively difficult, because many variables influence the total absolute emissions. The stringency of differentiated intensity targets may be more difficult to evaluate, since a specific reduction and the relationship between emissions and GDP has to be evaluated. The evaluation of 'performance targets' would involve judgment on more separate sectors per country but the judgment of these reductions would be easier than for total emissions or emission intensity, because these emission factors depend on only a few variables. A drawback is that these targets are more complex and depend partly on statistical data that are not generally available. Nevertheless, the advantages in terms of negotiations may be so large, that further exploration is justified.

Further develop a mix of indicators to set the stringency of targets: Many indicators and formulas have been proposed to differentiate emission reduction targets between countries to adapt them to their national circumstances. For example, reductions have been proportional to historical emissions, GDP or any combinations of those and other indicators. Another example is the Triptych approach, which defines limitation or reduction parameters for all sectors that are applied equally for all countries. No ideal method to differentiate the targets is available and further efforts have to be made to develop a transparent and simple formula.

10.3 RECOMMENDED FURTHER RESEARCH

Analysis on form and stringency of targets as well as criteria for participation: Several forms of targets are available, but limited analysis is available on some of these. E.g. intensity targets currently seem to be very attractive, but implications and applicability is not studied in detail. Also no simple formula can be provided for differentiating emission reduction targets among countries. Further criteria for participation in the regime are not generally accepted. A tool for such analysis could be the following:

Country by country future commitment model: Current models to analyze future commitment regimes represent the world in geographical regions and cannot provide information on individual countries. E.g. the FAIR model has 17 world regions. In this report we analyzed

data for individual countries. As a next step, an interactive model for the analysis of commitments could be developed that can provide individual country data. It would also include a database on country specific data such as emissions of at least CO_2, CH_4 and N_2O, as well as GDP, human development index and an indication of the vulnerability to climate change. This would be crucial in the analysis of proposals by individual countries during the negotiations.

Consider 'spillover' in commitment calculations: Current models for evaluating future commitments usually take a business-as-usual path and calculate a reduction below that level. These business as usual paths of different countries are treated independently. But it is likely that actions by some countries have significant effect on the emissions of other countries. Emissions of other countries could be increased by "leakage", the migration of emission intensive activities to countries which have no targets. But emission paths of other countries would also be decreased if e.g. new technologies, developed and commercialized in industrialized countries, are used in developing countries. Action at one point in time changes the business-as-usual path of all countries for the next point in time. Recent work (Grubb et al. 2002) suggests that the positive effects could outweigh the negative ones. A next generation of models to analyze future commitments should take these linkages into account.

Develop an intermediate global target for 2020 including all greenhouse gases: For the stabilization of greenhouse gas concentrations at low levels, global emissions may not increase above certain levels in the near future. Such levels are known for CO_2, but to a lesser extent are analyzed for the other greenhouse gases CH_4 and N_2O. The share of these gases to total greenhouse gas emissions is larger for developing countries than for developed countries. Further research is necessary to develop intermediate global emission targets for all greenhouse gases (in e.g. 2020) that would allow a stabilization of CO_2 concentrations at 400, 450, 500, 550, 600, 650 ppm (and respective levels for the other greenhouse gases). This analysis would be free of a value judgment whether one should act now or later.

Elaborate on 'sustainable development': A pledge for sustainable development was proposed as one first step for some developing countries towards commitments. If such an approach should be further pursued, it would be necessary to define more precisely how it should be designed. In addition, it would also merit further research on which coordinated measures could lead to global sustainable development.

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APPENDIX A CALCULATION DETAILS

Emission inventory figures from the EDGAR 3.2 database (EDGAR 2001) for 1990 and 1995 were used as the basis. Energy and industrial emissions as well as from forestry for CO_2, CH_4 and N_2O were included. For major Annex I countries, the emission data from the national submissions to the UNFCCC were used. The business a usual path was calculated from the emission growth rates of the regions of the IPCC SRES scenario A2 applied to the emission estimates of the inventories.

The GDP values 1990 and 1999 were taken from the World Bank as provided in IEA 2001 in 1995 US$ using purchasing power parities. Future values were obtained based on the IPCC SRES scenario A2, which provides GDP growth for four world regions. The GDP growth rate of the group of countries was applied to individual countries by applying the average annual growth rate between 1990 and 1999 of the individual countries, linearly de- or increased so that the total GDP increase of the groups matches to total increase as provided in the A2 scenario.

Exceptions:

EU: CO_2 emissions 1990 to 1999 ware taken from the Third National Communication of the EU.

USA: Emissions from 1990 to 2000 were taken from the draft 2002 inventory submission to the UNFCCC.

Argentina: The GDP growth rate was taken as provided by the Worldbank (http://www.worldbank.org/data/countrydata/aag/arg_aag.pdf) 1990 to 2000 as +4.3% annually.

China: CO_2 Emissions have decreased from 1995 to 2000 according to the IEA statistics (IEA 2001). The percentage decrease given in IEA (2001) from 1990 to 1999 was applied to the absolute value of 1990 emissions as provided by the EDGAR database. This leads to substantially lower emissions for China. In addition the growth rate of the GDP between 1990 and 1999 was 9.6% annually. For the future years a 7% increase was the base for the calculations.

Groups of countries

01: USA **USA**

02: EU **European Union**

Austria	Belgium	Denmark
Finland	France	Germany
Greece	Ireland	Italy
Luxembourg	Netherlands	Portugal
Spain	Sweden	United Kingdom

03: JPN **Japan**

04: EEU **Eastern Europe (Annex I)**

Belarus	Bulgaria	Czech Republic
Croatia	Estonia	Hungary
Latvia	Lithuania	Poland
Romania	Slovakia	Slovenia
Ukraine		

05: RUS **Russian Federation**

06: RAI Rest of Annex I

Australia	Canada	Iceland
Liechtenstein	Monaco	New Zealand
Norway	Switzerland	

07: TUR Turkey

08: REE Rest of Eastern Europe and former USSR

Albania	Armenia	Bosnia & Herzegovina
Macedonia (FYROM)	Yugoslavia, Federal Republic of	Azerbaijan
Georgia	Kazakhstan	Kyrgyzstan
Moldova	Tajikistan	Turkmenistan
Uzbekistan		

09: ARG Argentina

10: BRA Brazil

11: COL Colombia

12: MEX Mexico

13: VEN Venezuela

14: RLA Rest of Latin America

Aruba	Aruba	Anguilla
Netherlands Antilles	Antigua and Barbuda	Bahamas
Belize	Bermuda	Bolivia
Barbados	Bouvet Island	Chile
Costa Rica	Cuba	Cayman Islands
Dominica	Dominican Republic	Ecuador
Falklands Islands (Malvinas)	Guadeloupe	Grenada
Guatemala	French Guinea	Guyana
Honduras	Haiti	Jamaica
St Kitts & Nevis (St Christopher)	St Lucia	Montserrat
Martinique	Nicaragua	Panama
Peru	Puerto Rico	Paraguay
El Salvador	Suriname	Turks & Caicos Islands
Trinidad and Tobago	Uruguay	St Vincent & The Grenadines
British Virgin Islands	Virgin Islands (US)	

15: EGY Egypt

16: ZAF South Africa

17: NGA Nigeria

18: RNA Rest of North Africa

Algeria	Libyan Arab Jamahiriya	Morocco
Sudan	Tunisia	

19: RAS Rest of Southern Africa

Angola	Burundi	Benin
Burkina Faso	Botswana	Central African Republic
Cote d'Ivoire (Ivory Coast)	Cameroon	Congo
Comoros	Cape Verde	Democratic Republic of the Congo (former Zaire)
Djibouti	Eritrea	Western Sahara
Ethiopia	Gabon	Ghana
Guinea	Gambia	Guinea-Bissau
Equatorial Guinea	Kenya	Lesotho
Liberia	Madagascar	Mali
Mauretania	Mozambique	Mauritius
Malawi	Mayotte	Namibia
Niger	Reunion	Rwanda
Senegal	St Helena	Sierra Leone
Somalia	Sao Tome & Principe	Swaziland
Seychelles	Chad	Togo
Tanzania, United Republic of	Uganda	Zambia
Zimbabwe		

20: GLF Persian Gulf States

Kuwait	Qatar	Saudi Arabia
United Arab Emirates		

21: RME Rest of Middle East

Bahrain	Cyprus	Iran, Islamic Republic of
Iraq	Israel	Jordan
Lebanon	Oman	Syrian Arab Republic
Yemen		

22: CHN China

China	Hong Kong	Macau
Taiwan		

23: IND India

24: IDN Indonesia

25: KOR Korea, Republic of (South)

26: MYS Malaysia

27: PHL Philippines

28: SGP Singapore

29: THA Thailand

30: RAA Rest of Asia

Afghanistan	Afghanistan	American Samoa
Bangladesh	Bhutan	Britisch Indian Ocean Terr. (Chagos)
Brunei	Cambodia (former Kampuchea)	Christmas Island (Australia)
Cocos (Keeling) Islands	Cook Islands	Fiji
French Polynesia (Tuamotu & Marquesas)	Guam	Kiribati
Korea, Democratic People's Republic of (North)	Lao Peoples Democratic Republic	Maldives
Marshall Islands	Micronesia, Federated States of	Mongolia
Myanmar (former Burma)	Nauru	Nepal
New Caledonia	Niue	Norfolk Island
Northern Mariana Islands	Pakistan	Palau
Papua New Guinea	Samoa	Solomon Islands
Sri Lanka	Timor Timur (East Timor)	Tokelau
Tonga	Tuvalu	Vanuatu
Vietnam	Wallis & Futuna	

Major emitting countries

Source: EDGAR 3.2 database (EDGAR 2001) for 1995, includes energy and industrial emissions as well as from forestry for CO_2, CH_4 and N_2O

No.	Country	Total GHG emissions 1995 Gg CO2eq	Share of global emissions	Accumulative share of global emissions
1	United States of America	6750628	19%	19%
2	China	5246667	14%	33%
3	Russian Federation	2473653	7%	40%
4	India	1902923	5%	45%
5	Japan	1375173	4%	49%
6	Brazil	1191031	3%	52%
7	Germany	1075628	3%	55%
8	Indonesia	734260	2%	57%
9	Canada	693434	2%	59%
10	Ukraine	690767	2%	61%
11	United Kingdom	666068	2%	63%
12	Mexico	559286	2%	64%
13	France	527320	1%	66%
14	Italy	516964	1%	67%
15	Australia	503032	1%	68%
16	Poland	471907	1%	70%
17	Korea, Republic of (South)	466521	1%	71%
18	Iran, Islamic Republic of	403146	1%	72%
19	South Africa	383297	1%	73%
20	Saudi Arabia	334054	1%	74%
21	Spain	320682	1%	75%
22	Thailand	301287	1%	76%
23	Argentina	295682	1%	77%
24	Venezuela	290949	1%	77%
25	Pakistan	271204	1%	78%
26	Kazakhstan	260358	1%	79%
27	Turkey	251355	1%	80%
28	Malaysia	229016	1%	80%

Major emitting countries sorted by emissions per capita

Source: EDGAR 3.2 database (EDGAR 2001) and WRI (2000) for 1995, includes energy and industrial emissions as well as from forestry for CO_2, CH_4 and N_2O

	Country	Emissions per capita tCO_2 eq / cap	Total GHG emissions 1995 Gg CO_2eq	Accumulative share of global emissions
1	United Arab Emirates	56.47	124 793	0%
2	Qatar	44.18	24 210	0%
3	Bahrain	34.24	19 093	0%
4	Brunei	33.91	9 981	0%
5	Gabon	29.32	31 588	1%
6	Australia	28.03	503 033	2%
7	Singapore	25.74	85 491	2%
8	United States of America	25.28	6 750 628	21%
9	New Zealand	24.70	90 685	21%
10	Luxembourg	24.12	9 813	21%
11	Kuwait	23.64	39 949	21%
12	Canada	23.41	693 435	23%
13	Norway	19.98	86 898	23%
14	Saudi Arabia	18.30	334 054	24%
15	Azerbaijan	17.27	130 622	25%
16	Trinidad and Tobago	17.05	21 526	25%
17	Antigua and Barbuda	16.85	1 108	25%
18	Ireland	16.71	60 309	25%
19	Russian Federation	16.70	2 473 653	32%
20	Bulgaria	16.52	140 415	32%
21	Kazakhstan	15.77	260 359	33%
22	Finland	15.07	76 954	33%
23	Bolivia	14.97	111 020	33%
24	Czech Republic	14.48	149 498	34%
25	Estonia	14.43	21 441	34%
26	Turkmenistan	14.31	58 370	34%
27	Belgium	14.30	144 241	34%
28	Denmark	14.15	73 912	34%

APPENDIX B MEASURES OF HUMAN DEVELOPMENT

The following text is taken from the IPCC special report on emission scenarios (IPCC 2001, box 3-1):

On Measures of Human and Economic Development

Writing 220 years ago in *The Wealth of Nations*, Adam Smith noted that: "whatever the soil, climate, or extent of territory of any particular nation, the abundance or scantiness of its annual output fundamentally depends on its human resources – the skill, dexterity, and judgement of its labour" (Smith, 1970). Although economists recognized the importance of land, labor, and capital in explaining economic growth and national wealth, in the post-World War II period national well-being has usually been measured by GDP or gross national product (GNP). GDP is defined as the monetary equivalent of all products and services generated in a given economy in a given year. GNP equals GDP plus the net balance of international payments to and from that economy. Few questions were asked about the underlying resource base for GDP growth and whether or not it was sustainable. Further, since GDP does not reflect all economic transactions it does not provide a full measure of human well-being. Nevertheless, GDP is very widely used because it is universally accepted as the monetary indicator of all products and services generated in a given economy within a given year.

Environmental and Social Modifications to GDP

More recently, several new approaches have been developed to address the inherent shortcomings of GDP measures. These include "green" national accounts that incorporate the role of the stocks and flows of renewable and non-renewable resources, and the related concept of genuine savings (UN, 1993). "Green" GDP is the informal name given to national income measures that are adjusted for the depletion of natural resources and degradation of the environment. The types of adjustment made to standard GDP include a measure of the user costs of exploiting natural resources and a value for the social costs of pollution emissions. In terms of measuring the sustainability of development, the green accounting aggregate with the most policy relevance is "genuine saving." This represents the value of the net change in assets that are important for development – produced assets, natural resources, environmental quality, foreign assets, and human resources, which include returns to education and raw labor and the strength and scope of social institutions. Human resources turn out, not unexpectedly, to be the dominant form of wealth in the majority of countries (World Bank, 1997a).

Purchasing Power Parities

A further problem arises in international comparisons, in which economic indicators are converted from local currencies into a common currency, such as dollars. Traditionally, market exchange rates are used to make these conversions. In theory, exchange rates adjust so that the local currency prices of a group of identical goods and services represent equivalent value in every nation. In practice, such adjustments can lag far behind changing economic circumstances. Policies, such as currency controls, may further distort the accuracy of market-based rates. Moreover, many goods and services are not traded internationally so market-based exchange rates may not reflect the relative values of such goods and services, even in theory. An alternative approach is based on estimates of the purchasing power of different currencies. The International Comparison Project compared prices for several hundred goods and services in a large number of countries. On the basis of this comparison, the relative values of local currencies are adjusted to reflect PPP (see UNDP, 1993). In effect, the PPP currency values reflect the number of units of a country's currency required to buy the same quantity of comparable goods and services in the local market as one US dollar would buy in an "average" country. The average country is based on a composite of all participating countries. In 1996 the World Bank initiated the ranking of countries by GDP converted at PPP rates; the effect was to reduce the income spread between the poorest and richest countries (WRI, 1997a).

UN Human Development Index

The UN has tried to address the shortcomings of GDP by developing *The Human Development Index* (UNDP, 1997). This index, produced since 1990, combines three factors to measure overall development:

- Income as measured by real GDP per capita at PPP to represent command over resources to enjoy a decent standard of living.
- Longevity as measured by life expectancy at birth.
- Educational attainment as measured by adult literacy and school enrolment.

The UN has also developed other measures, such as the Gender-related Development Index (GDI) and the Gender Empowerment Measure (GEM) to assess conditions such as gender equality.