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SHARING THE BURDEN OF GREENHOUSE GAS MITIGATION

**Final report of the joint CICERO-ECN project on the global differentiation of
emission mitigation targets among countries**

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This is the final report of the Burden Sharing study project that aims *to identify the most promising rules, applicable at the global level, for differentiation of greenhouse gas emission mitigation targets among countries*. The project is carried out jointly by CICERO (Oslo, Norway) and ECN (Petten/Amsterdam, the Netherlands) under ECN project number 7.7170. The project has run from October 1998 until late 2000. An interactive Multi-Sector Convergence tool will become available soon: Internet website http://www.ecn.nl/unit_bs/kyoto/burden/main.html

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Abstract

This report presents an overview of the major findings of the joint CICERO-ECN project on the issue of differentiation of greenhouse gas emission mitigation targets among countries after the so-called first budget period of the Kyoto Protocol (2008-2012). More particularly, the report provides (i) an analysis of the main principles of fairness relevant to the issue of differentiating emission mitigation targets among countries, (ii) a brief evaluation of several burden sharing proposals launched since the mid-1990s, (iii) a new, multi-sector convergence framework in support of future negotiations to reach agreement on national greenhouse gas emission mitigation targets (iv) an indication of its cost implications, and (v) some concluding remarks and suggestions for further research.

CONTENTS

SUMMARY	5
SAMENVATTING	7
1. INTRODUCTION	9
1.1 The issue of burden sharing	9
1.2 The joint CICERO-ECN project on Burden Sharing	11
1.3 Outline of the report	12
2. FAIRNESS PRINCIPLES	13
2.1 Introduction	13
2.2 Principles, formulas and indicators	13
2.3 The role of fairness principles in international negotiations	14
2.4 Principles of distributive fairness	15
2.5 Notions of ‘rights’	19
2.6 Summary	19
3. BRIEF REVIEW OF SOME EXISTING BURDEN SHARING RULES	23
3.1 Review of differentiation proposals from the AGBM negotiations	23
4. THE MULTI-SECTOR CONVERGENCE APPROACH	29
4.1 Introduction	29
4.2 Outline of the MSC framework	29
4.3 The distinction of different sectors	32
4.4 The setting of global sector emission standards	34
4.5 The determination of national emission mitigation targets	35
4.6 The inclusion of allowance factors	36
4.7 Graduation threshold and adjustment period	39
4.8 A numerical example	40
4.9 The participation of non-Annex I countries	41
5. COST IMPLICATIONS OF MULTISECTOR CONVERGENCE APPROACH	43
5.1 Introduction	43
5.2 Emission reduction requirements	44
5.3 Trade and costs effects	46
5.3.1 Main results	46

5.3.2 Disaggregated cost effects	48
5.4 Indicators of burden sharing: summary and conclusion	50
6. EVALUTION OF SOME BURDING SHARING APPROACHES	53
6.1 Introduction	53
6.2 Principles of fairness relevant to Burden Sharing	54
6.3 Operational requirements	55
6.4 Choice of promising burden sharing proposals	56
6.5 Evaluation of burden sharing approaches	57
7. CONCLUDING REMARKS AND SUGGESTIONS FOR FURTHER RESEARCH	59
7.1 Conclusions and major findings	59
7.2 Agenda for future research	62
REFERENCES	65

SUMMARY

This report presents the major findings of the joint CICERO-ECN research project on Burden Sharing. The aim of this project is *to identify the most promising rules, applicable at the global level, for differentiation of greenhouse gas emission mitigation targets among countries*. More specifically, by developing a framework for the differentiation of these targets, the research project aims to facilitate future policy negotiations on this issue.

However, in order to serve as a sound basis for international negotiations on differentiating emission limitations among a large variety of countries, a burden sharing scheme has to meet several criteria. Firstly, it should satisfy at least one of the three main principles of equity, notably ‘need’ – interpreted in terms of basic human needs – in order to be politically feasible. Most likely, however, it also has to meet one and, preferably, both other main principles of equity, i.e. ‘guilt’ and ‘capacity’. Moreover, a burden sharing rule relevant to international climate policy negotiations has to satisfy a number of operational requirements. In particular, it should (a) be universally applicable, (b) be easily made operational, (c) be simple to understand, (d) allow for future refinements, (e) allow for flexibility, and (f) allow to take country-specific circumstances into account.

The joint CICERO-ECN research project has developed a burden sharing rule – called the Multi-Sector Convergence approach (MSC) – that meets most of the above-mentioned criteria to a high extent. This approach:

- (i) is based on a comprehensive accounting framework of greenhouse gas emissions by different sectors within the national economy,
- (ii) takes as point of departure that, in principle, the amount of per capita emission assignments will have to ultimately converge to the same level for all countries, and
- (iii) accommodates for the possibility that additional allowances may be granted to countries facing specific circumstances.

The present report discusses the major characteristics of the MSC approach. Despite some limitations, the MSC approach has some attractive features, notably:

- The MSC approach satisfies the equity principles of ‘need’ and ‘capacity’.
- It meets the operational requirements of universal applicability and is comprehensive in terms of global coverage and coverage of the major greenhouse gas emissions as defined by the Kyoto Protocol.
- It allows for very flexible, user-defined parameter values in an interactive way and results in projections of atmospheric concentrations (expressed in ppm) on a CO₂ equivalent basis (including CH₄ and N₂O).
- It allows for rolling over from one budget period onto the next one with inclusion of newly evolving insights into the climate change issue, sectoral emission trends and infrastructural inertia. These evolving insights can be embedded in periodically negotiated adjustments of the framework parameter values.
- It allows for straightforward future refinements to the framework pending advances on the international climate change negotiation front and new sets of credible data becoming available.

The report provides a numerical example to illustrate the main features of the MSC approach. In addition, it gives an indication of its cost implication, notably for the so-called ‘second budget period’ (2013-2017). Furthermore, a comparison is made of some alternative burden sharing approaches, including MSC. The concluding chapter encompasses an agenda for future research on the burden sharing issue.

SAMENVATTING

Dit rapport presenteert de belangrijkste bevindingen van het gezamenlijke CICERO-ECN onderzoeksproject met betrekking tot “Burden Sharing”. Het doel van dit project is de meest veelbelovende mondiaal toepasbare regels te identificeren voor de differentiatie van broeikasgas mitigatie doelstellingen tussen landen. Door middel van het ontwikkelen van een raamwerk voor de differentiatie van deze doelstellingen hoopt het onderzoeksproject toekomstige politieke onderhandelingen over dit onderwerp te vergemakkelijken.

Echter, om als een gezonde basis te kunnen dienen voor internationale onderhandelingen over differentiatie van emissie limieten tussen verschillende landen, moet een burden sharing schema aan verschillende criteria voldoen. Ten eerste, het moet aan tenminste een van de drie gelijkheidsprincipes voldoen, namelijk ‘behoefte’ (geïnterpreteerd in termen van menselijke basisbehoeften), om politiek haalbaar te zijn. Waarschijnlijker is het dat aan nog één maar liever nog alle twee de hoofdcriteria van gelijkheid moet worden voldaan, namelijk ‘schuld’ en ‘capaciteit’. Verder moet een burden sharing regel aan een aantal operationele vereisten voldoen wil het relevant zijn voor internationale klimaatbeleid onderhandelingen. Ze moeten (a) universeel toepasbaar zijn, (b) gemakkelijk operationeel te maken zijn, (c) eenvoudig te begrijpen zijn, (d) ruimte laten voor toekomstige verfijningen, (e) ruimte voor flexibiliteit hebben en (f) ruimte laten om rekening te houden met landgebonden specifieke omstandigheden.

Het gezamenlijke ECN-CICERO onderzoeksproject heeft een burden sharing regel ontwikkeld, genaamd de Multi-Sector Convergence methode (Multi-Sector Convergence approach - MSC) dat aan de meeste van bovenstaande criteria grotendeels voldoet. Deze aanpak:

- (i) is gebaseerd op een veelomvattend raamwerk van broeikasgas emissies door verschillende sectoren binnen de nationale economie,
- (ii) heeft als uitgangspunt dat, in principe, de hoeveelheid per capita emissierechten uiteindelijk zullen moeten convergeren voor alle landen, en
- (iii) houdt rekening met de mogelijkheid dat additionele rechten toegewezen kunnen worden aan landen die met specifieke omstandigheden te maken hebben.

Het huidige rapport bespreekt de belangrijkste karakteristieken van de MSC aanpak en geeft een numeriek voorbeeld om de belangrijkste karakteristieken van deze aanpak toe te lichten. Verder geeft het een indicatie van het kostenplaatje, met name voor de zogenaamde ‘tweede budget periode’ (2013-2017).

Ondanks enkele beperkingen kan geconcludeerd worden dat de MSC methode een aantal aantrekkelijke karakteristieken heeft, namelijk:

- Aan de gelijkheidsprincipes “behoefte” en “draagkracht” wordt voldaan.
- De methode voldoet aan de operationele vereisten van universele toepasbaarheid en is veelomvattend in termen van mondiaal bereik en het omvatten van de belangrijkste broeikasgas emissies zoals gedefinieerd door het Kyoto Protocol.
- Er wordt ruimte gelaten voor zeer flexibele gebruikergedefinieerde parameter waarden op een interactieve manier en resulteert in voorspellingen over atmosferische concentraties (uitgedrukt in ppm) op een CO₂ equivalent basis (inclusief CH₄ en N₂O).
- De methodiek maakt het doorrollen van de ene budgetperiode naar de volgende mogelijk met aanpassingen aan toekomstige nieuwe inzichten in klimaatverandering, sectorale emissie trends en infrastructurele “inerties”. Deze inzichten kunnen ingebouwd worden in periodiek onderhandelde aanpassingen van de parameter waarden in het raamwerk.
- Verdere verfijningen aan het raamwerk zijn mogelijk, waarbij rekening kan worden gehouden met nieuwe ontwikkelingen op het internationale onderhandelingsfront aangaande klimaatverandering en nieuwe series data die beschikbaar komen.

1. INTRODUCTION

1.1 The issue of burden sharing

In both academic and policy circles, several connotations of the concept ‘burden sharing’ can be found. According to Ringius (1999), burden sharing refers generally to *the way in which a group of countries benefiting from a collective good agrees to share the costs of providing the collective good.*¹ In the context of this final report of the ECN-CICERO research project on Burden Sharing, the collective good in question concerns the protection of the global climate system by limiting human-induced greenhouse gas emissions. Hence, the concept ‘burden sharing’ – or ‘burden differentiation’ – in this report/project refers to the way a group of countries agrees to share - or differentiate – greenhouse gas emissions mitigation efforts and the associated cost consequences in order to protect the global climate system.²

The issue of burden sharing is possibly one of the most difficult topics to resolve under the UN Framework Convention on Climate Change (UNFCCC). Since the Kyoto Conference of December 1997, this issue has received little attention as quantified emission limits and reduction commitments have been agreed upon by Annex I countries with regard to the first budget period (2008-2012).³ Since Kyoto, a large part of the discussion has focused on guidelines, modalities, principles and rules for the flexible instruments, i.e. Emissions Trading, Joint Implementation and Clean Development Mechanism.

¹ It is noted that this definition explicitly refers to the cost implications of providing a collective good. Other definitions of burden sharing can be found in Ridgley (1996); see also Rose (1992) and Ringius (1999).

² *Mitigation* of greenhouse gas emissions refers to policy-induced emission reductions relative to the (whether or not fictitious) baseline situation that no specific climate change policies are in place in the country (countries) considered. In the customary climate change negotiations language an emission limitation target limits the growth of emissions per unit of time to a *lower* positive rate than the growth rate that would prevail in the baseline situation, whereas an emission reduction target caps the emissions by a *negative* growth rate per unit of time. Adhering to these connotations, emission mitigation encompasses both emission limitation and emission reduction.

³ In fact, the Kyoto Protocol speaks of ‘Annex B countries’ rather than ‘Annex I countries’. Whereas the former category refers to countries mentioned in Annex B of the Kyoto Protocol, the latter category concerns countries listed in Annex I of the UNFCCC. Annex B includes all countries recorded in Annex I, except Belarus and Turkey that did not accept an emission abatement target at the Kyoto Conference. Unless stated otherwise, this report will speak of Annex I countries, implying those countries – except Belarus and Turkey – that have accepted an official commitment to limit their GHG emissions. Czechoslovakia (Annex I) is split into Czech Republic and Slovakia (both Annex B). The following new countries are included in Annex B (not included in Annex I): Croatia, Slovenia, Liechtenstein and Monaco.

However, there are various arguments why the issue of burden differentiation will very likely return in the near future. First, under the Kyoto Protocol only the Annex I countries took commitments while most of the developing countries did not yet accept such commitments. Their participation is required at some moment in time in order to meet the ultimate objective of the UNFCCC.⁴ Second, the Kyoto Protocol only covers quantified emission limits and reduction commitments for the first budget period. In the longer term, further reductions are required. It is expected that differentiation of national greenhouse gas emission mitigation targets and the associated cost burdens will again get prime attention in the international climate negotiations within a few years.

Before Kyoto, various proposals were launched on how to differentiate emission burdens between countries (for an overview see Torvanger and Godal, 2000). At the Conference of the Parties meeting in Bonn (COP-5, November 1999) only one of these earlier proposals - the so-called Brazilian proposal - was briefly mentioned. At this occasion, various countries expressed their interest to further continue exploring rules and principles for burden sharing.

Since Kyoto, the set of elements to be considered in burden sharing has changed somewhat:

- The Kyoto Protocol also covers emissions of other greenhouse gases (CH₄, N₂O, HFCs, PFCs and SF₆) and part of the sinks of carbon dioxide that occur via land use changes. In most cases, the pre-Kyoto proposals on burden sharing covered only CO₂ emissions. New burden sharing proposals need to cover the other greenhouse gas emissions and sinks.
- Further, the Kyoto Protocol includes the three flexible instruments Emissions Trading (ET), Joint Implementation (JI) and Clean Development Mechanism (CDM). These instruments enable Annex I countries to reduce the costs of meeting their emission limitation commitments by means of transactions abroad. However, they also have burden sharing consequences. Such consequences need to be taken into account in the design of new burden sharing rules. While designing burden sharing rules one needs to have an idea how much the flexible instruments will be used and what their cost consequences might be.

⁴ The ultimate objective of the UNFCCC is: "...to achieve....stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system..." (art. 2).

The differentiation scheme that came out of the Kyoto Protocol was not founded on a specific method, but rather based on negotiations given the various interests and national circumstances of the parties. Yet, a more systematic approach to differentiation may well facilitate negotiations on future commitments. However, in order to have good prospects to be used in climate negotiations, burden sharing rules need to meet several criteria referring to relevant differences between countries as well as to basic principles such as fairness, equity, efficiency and transparency.⁵

Sceptics may claim that the issue of burden sharing can not be solved by simple rules or equations. However, the point is that burden sharing rules are not intended to replace negotiations. The differentiation of emission limitations among countries will always be steered and ultimately finalised by political negotiations. Still, burden sharing rules can be of great value. They can support negotiations on differentiating emission limitations by adding structure to these negotiations. Moreover, they can be a tool to show the consequences in terms of quantitative emission limits and reduction objectives of different agreements. As such, burden sharing rules can facilitate actual negotiations.⁶

1.2 The joint CICERO-ECN project on Burden Sharing

In order to facilitate the expected international negotiations on differentiating GHG emission limitations among countries after the first budget period of the Kyoto Protocol, a research project on the issue of burden sharing has been conducted jointly by CICERO (Oslo, Norway) and ECN (Petten, the Netherlands). This project aims *to identify the most promising rules applicable for differentiation of national targets with respect to greenhouse gas emission mitigation*. It was carried out by a team of researchers of these institutions in the period running from October 1998 to late 2000.

⁵ We like to point out that, in the existing literature concerned, the notion of *burden sharing rules* refers to rules for determining national greenhouse gas mitigation targets. Yet it is evident, that the perceived allocation of the cost consequences of such rules are an important consideration in judgements of the attractiveness of alternative burden sharing rules. This issue of cost consequences is discussed further in Chapter 6 in connection with the Multi-Sector Convergence framework, an approach to burden sharing that was developed within the present project.

⁶ It is noted here that participation of parties in the negotiation process is an important factor to achieve an agreement. Therefore, consulting different kinds of actors during the design, selection and adjustment phases of burden sharing is considered crucial.

The joint CICERO-ECN research project on burden sharing has consisted of several phases and activities, including:

- Defining and analysing basic concepts and principles.
- Analysing earlier differentiation proposals.
- Designing a new sector-based framework for negotiating future emission mitigation targets.
- Indicating the potential cost implications of the newly designed burden sharing framework.
- Collecting and processing the necessary data concerned.
- Organising project meetings and workshops.

Besides the present final report, the CICERO-ECN research project on burden sharing has resulted in the publication of six working papers (see appendix A). In addition, the major research findings have been discussed at joint project meetings, a workshop with expert scientists (Oslo, May 2000) and, finally, a workshop with policy makers from a variety of countries (The Hague, November 2000).

1.3 Outline of the report

The present final report includes the major findings of the joint CICERO-ECN project on burden sharing. Its contents run as follows. First of all, the main principles of fairness relevant for burden differentiation are analysed in chapter 2. Subsequently, chapter 3 presents a brief overview of several burden sharing proposals launched since the mid-1990s as part of the negotiation process regarding the Kyoto Protocol. Chapter 4 launches a new, sector-based convergence framework for differentiating emission mitigation targets among countries after the first budget period of the Kyoto Protocol (2008-2012). Next, chapter 5 indicates the cost implications of this so-called ‘multi-sector convergence approach’, notably for the second budget period (presumably 2013-2017). Chapter 6 evaluates some burden sharing proposals, including the multi-sector convergence approach launched by the present project. Finally, some concluding remarks and suggestions for further research are presented in chapter 7.

2. FAIRNESS PRINCIPLES

2.1 Introduction

This chapter provides an analysis of fairness principles relevant for burden differentiation among countries, based on a survey and assessment of recent academic literature on this issue.⁷ The analysis focuses on two main questions. First, can any widely shared principles of fairness be identified, and – if so – which? Second, can these principles play a facilitative role in future climate policy negotiations?

2.2 Principles, formulas and indicators

When examining issues of justice and fairness in burden sharing, it is important that different concepts and notions are defined and used in a consistent and systematic manner. We propose to distinguish between three different levels of analysis: (i) general principles of fairness and justice, (ii) burden sharing formulae or rules, and (iii) criteria or operational indicators developed with specific reference to the particular problem at hand. These distinctions are based on different levels of normative content, levels of generality or specificity, and degree of formalisation and operationalisation.

By *principles* of fairness and justice, we refer to generally acknowledged norms of justice and fairness. Such principles are general in the sense that they are assumed to be valid across a wide range of areas and at different levels – from interpersonal to international relations. If translated into more specific burden sharing rules or formulas, these general principles can be brought to bear on particular policy problems, such as global climate change.

Burden sharing *formulas* or rules are operational functions that generate a specific burden sharing scheme given input from one or more criteria or indicators. A formula defines ‘national emissions entitlements, or changes from the status quo, on the basis of national characteristics such as population, GNP, current emissions, or factors plausibly

⁷ Some useful literature references are Ringius et al. (1998), Rose et al. (1997), Rose (1992), and Barrett (1992).

associated with national responsibility, sensitivity, or need for various emitting activities' (Parson and Zeckhauser, 1995). Burden sharing formulas and rules therefore reflect, more or less explicitly, one or more specific fairness principles and, moreover, identify and combine one or more specific indicators.

Operational criteria or indicators, finally, specify precisely the kind of 'hard' data used to determine allocations of environmental targets (e.g. a global emission cap) or estimate costs (burdens) and/or benefits in a given context.

2.3 The role of fairness principles in international negotiations

The interest in burden sharing formulas is premised on two basic assumptions. One is that the negotiating behaviour of at least some of the parties is to some degree based on normative considerations concerning distributive fairness or justice. To conclude that such norms provide important clues to understanding behaviour we must, however, demonstrate not only that they are sometimes *invoked* but also that they are *recognised* as important decision *premises* for a *critical mass* of significant actors even when their implications are *not* in one's own favour. The latter is a non-trivial and much stronger claim. Negotiation theory most often assumes that actor behaviour is motivated primarily by self-interest rather than norms. In this study we shall take a middle ground. More precisely, we assume that actor behaviour is based primarily, but not exclusively, on self-interest. Considerations of fairness will, we believe, serve (a) as a framework of *soft constraints* upon the pursuit of self-interest, and (b) as decision premises in situations where interests provide no clear guidance.

Notions of fairness can provide a basis for an international regime only if there is a certain minimum of *consensus* among its members about what is fair and what is unfair; a critical mass of actors must, in other words, subscribe to the *same* norms. For global regimes, meeting this latter requirement can be a tall order indeed. Again, we take an intermediate position. Studying international negotiations, we can observe that there are at least some rather general norms that are frequently invoked and very rarely disputed – at least on principled grounds. We shall assume that these do indeed constitute a soft core of widely, though probably not universally, accepted ideas about distributive fairness. Moreover, in most cases more than one principle can legitimately be invoked, and quite

often the implications of the most salient norms will diverge. To resolve such conflicts one could either work towards some differentiation of domains or assign relative ‘weights’ to various principles. Neither of these tools has in fact been developed in the context of international policy regimes. As a consequence, there will in most cases be ample scope for (interest-based) bargaining within a rather wide *zone* of legitimate arguments. It also follows that normative ‘clout’ will be generated particularly where salient principles *converge*. Our first priority should therefore be to search for burden sharing rules located at the *intersection* between two or more salient principles.

Which principles can serve as a basis for burden sharing agreements?

For a start, we propose to make a distinction between *norms of distributive fairness* and notions of *rights*. Both are relevant to a discussion of burden sharing, but the former play the more important role in the climate change negotiations.

2.4 Principles of distributive fairness

Some studies have identified a fairly large number of distributive fairness principles and rules for the distribution of costs or benefits. Some analysts (see e.g. Rose et al., 1998) in addition distinguish among different types of principles: principles concerned primarily with the initial allocation of burdens (allocation-based criteria), principles concerned primarily with the final costs of measures (outcome-based criteria), and principles primarily concerned with the fairness of the process of, or institution for, allocation as such (process-based criteria).

As some of these principles and rules seem to operate at different levels of generality, the overall picture can be somewhat confusing. The so-called sovereignty principle, for example, closely resembles the grandfathering principle. Essentially, based on entitlement theories of justice, the grandfathering principle considers current emissions as a claim established by usage and custom. In this section we will adopt a different approach. Instead of making another comprehensive inventory of principles or criteria for burden sharing, we will try to identify a few basic norms that seem – on the basis of the evidence we have from other similar instances – to constitute the core on which most of the discussion is focused.

We interpret available evidence as indicating that the norms of distributive fairness that actors relate to in international negotiations constitute a rather complex framework, *combining* at least three different notions: equality, equity and exemption. Let us first try to specify each of these notions and then explore how they are combined.

Equal obligations

The default option in international negotiations seems to be the norm that all parties should have *equal obligations*. In saying that this is the default option we do not imply that it is the one most frequently used. Rather, we suggest that this is where discussions will normally *start*, and that the burden of proof tends to rest with anyone who wants to argue for a different approach. The principle of equal obligations is open to different interpretations. One important question is whether obligations should be defined in *absolute* or *relative* terms. Given the range of variance in size and capabilities among countries, the former is hardly a serious option in negotiations on global regimes (except for procedural obligations and some commitments to ban completely the release of “non-essential” substances). Attention therefore tends to focus on obligations defined in terms of *relative* contributions. In the climate change negotiations many governments initially argued in favour of applying such a ‘flat rate’ or across-the-board approach to all industrialised countries.⁸

The principle of equal obligations has a firm normative basis if all parties involved are equal in all relevant respects. This condition is, however, never met in global negotiations. Even in a more narrow regional setting we will often find a substantial range of variance along important dimensions. When the range of variance exceeds a certain threshold (and the issue is not one of establishing a complete ban on certain activities), parties most often shift from the principle of equal obligations to some notion of *equity*.

⁸ Note, though, that the proponents of flat rate reductions did *not* necessarily argue that this principle would yield the fairest distribution of costs. For at least some parties, considerations of political feasibility seem to have been at least as important, one main argument being that bargaining over differentiated obligations would prove intractable and lead into prolonged deadlock.

Equity

The common denominator for equity norms is that costs and/or benefits be distributed in (rough) proportion to actor scores on some dimension considered to be important. A fairly large number of such dimensions can be identified, but in international negotiations attention seems to focus primarily on two. One is the role of each party in creating a problem or providing a good. If some parties have played a significantly or ‘disproportionally’ larger role than others have in causing a problem – e.g. through emissions – it seems fair that they should also take a corresponding responsibility for ‘cleaning up the mess’. Similarly, if some parties have contributed more to a particular good, it seems fair that they get a corresponding share of the benefits, everything else constant. The other dimension refers to the consequences that a particular obligation or project would have for the various parties. A common notion of fairness requires that burdens be shared in some proportion to capacity and that scarce goods be distributed in proportion to needs. This gives us a matrix with four key principles, summarised in Table 2.1.

Table 2.1 Key principles of equity

Focus on	Object to be distributed	
	<i>Costs (obligations)</i>	<i>Benefits (goods)</i>
↓		
<i>Cause of state of problem</i>	‘Guilt’, responsibility (for causing the problem)	Contribution (to solving problem or providing good)
<i>Consequences for actors</i>	Capacity (ability to pay) {Benefit derived from project}	Need

Burden sharing is, of course, a matter of distributing *costs*. However, as we shall see, criteria for distributing costs can be derived indirectly also from principles pertaining to the distribution of benefits. We therefore need to examine both columns.

The principle of ‘*guilt*’ says, in essence, that the costs of solving or alleviating a problem should be distributed in proportion to a party’s share of responsibility for causing that problem. This norm finds substantial support in previous conventions. Thus, in a somewhat different form it was one of the cornerstones of agreement concluded at the first global conference on the environment in Stockholm in 1972. It is also the backbone of the Polluter Pays Principle (although this principle was initially applied to international environmental problems primarily as a policy tool for enhancing efficiency rather

than as a norm of fairness). Applied to the climate change issue the principle of guilt would imply that countries with the largest emissions per capita would have to make the largest cutbacks (other things being equal). In the climate change negotiations the developing countries have based much of their argumentation upon this norm (see e.g. the Brazilian proposal, described in chapter 3).

The principle of *capacity* requires that costs be distributed in proportion to ‘ability to pay’. The conventional yardstick for determining capacity would be wealth measured in terms of GDP/cap.

If the benefits derived from a particular project vary substantially, the idea might come up that costs be distributed in proportion to (expected) benefits. Applied to problems of global environmental change, however, this notion would tend to run against other salient principles.

The corresponding equity norms for distributing *benefits* would be the principles of *contribution* and *need*, respectively. The former says that a party’s share of a certain good should be proportional to its contribution to ‘producing’ that good. Applied to pollution issues this norm most often translates into an argument that countries should be given *credit* for past achievements in terms of emission reductions.

In the climate change context the principle of *need* is the more salient and interesting of the two. It can be translated into somewhat different burden sharing rules, but a minimal requirement is that all human beings be granted the ‘pollution permits’ needed to secure basic human needs, including a decent standard of living. The most simple and ‘primitive’ rule building upon this requirement would be that all individuals be given equal pollution ‘permits’ (allowing for some period of adjustment). The norm that pollution ‘permits’ be based on needs has been invoked not only by developing countries; in somewhat different interpretations it is also the basic principle behind the early French proposal and the EU Triptych approach.⁹

⁹ In the Triptych approach the concept of ‘need’ is, though, given a rather liberal interpretation, extending far beyond basic human needs, including also what is considered necessary in order to sustain major economic activities on ‘reasonably equal’ terms.

Exemption

Particularly in a global setting, the range of variance in terms of the dimensions such as ‘guilt’ or ‘capacity’ is most often so great that even the notion of soft proportionality would lead to ‘unfair’ burdens upon the poorest ‘victims’. When the latter threshold is reached, attention tends to shift from norms of equity to the simple principle of *exemption*; more precisely, exemption from any substantive obligation for which a party is not (fully) compensated. We see this pattern clearly in the global climate change negotiations. Even those who argue that developing countries should make a commitment to contribute, at least in the future, do accept that exemptions are required for the poorest countries.

2.5 Notions of ‘rights’

There seems to be two basic notions of rights that are often invoked in international environmental negotiations. One refers to what might be called *inalienable human rights*, including the right to a ‘decent’ standard of living and to a ‘healthy’ environment. This kind of rights is rarely, if ever, explicitly challenged. On the other hand, there is no general consensus on precise specifications. It is clearly relevant to the global climate change negotiations, and often serves as a pillar of the principles of need and also the norm of exemption for the most disadvantaged parties. The other category may be referred to as *acquired rights*. Such notions play a prominent role in negotiations on resource management. For example, in international fisheries management ‘historic catch’ is often considered an important criterion for distributing quotas. Within OPEC ‘historic production volume’ serves a similar function.

2.6 Summary

Let us now try to summarise this analysis by addressing two key questions: First, what are the basic principles of fairness that a burden sharing rule will have to satisfy in order to serve as a basis for a global agreement? This is a question about *necessary* conditions; we are not suggesting that consistency with any one particular principle or combination of principles constitutes a *sufficient* condition. Second, assuming that no magic formula of fairness will by itself be sufficient to produce agreement, we have to ask

what are the *additional* criteria a specific burden sharing rule and formula will have to meet in order to be adopted.

The answer to the first of these questions can be summarised as follows: First, no burden sharing rule that is incompatible with *all* the three main principles of equity relevant to this particular case – the principles of ‘guilt’, ‘capacity’ and ‘need’ – will be accepted. More precisely, a burden sharing rule must be consistent with (a) the general pattern of differentiation outlined in Table 2.1, and (b) with at least one of the three main equity principles – probably with *more than one*. Second, no rule that is incompatible with the principle of ‘need’ – interpreted in terms of basic human needs – will be politically feasible. A rule may violate softer interpretations of ‘need’, but the demand that burden sharing rules respect basic human needs stands even if it runs into conflict with the principles of guilt and/or capacity. Beyond this, it is hard to establish – on ethical grounds – a clear hierarchical order of fairness norms.

Taken together, these propositions provide some guidance. However, even though the *range* of politically feasible burden sharing rules is reduced, we are still left with an uncomfortably large set of options (in fact, the number is infinite!). In this particular case we are in the fortunate situation that all the three equity principles to a large extent *point in the same general direction*. This means that different formulae may well yield similar substantive implications, applied to this particular case. To the extent that different formulae lead to similar conclusions, one may argue that in so far as actors are concerned with material consequences it does not matter much which of the formulae in question is adopted. This observation suggests that as we move on to develop specific rules, it will be a good idea to examine to what extent their practical implications converge. In the absence of a clear hierarchy of norms, a distribution that can be justified by reference to *multiple* principles or rules will, other things being equal, prevail in a contest with one that has a narrower normative basis.

In addition to these political constraints, there are a number of operational requirements to be considered as we move on to develop specific rules and criteria. Listed in decreasing order of importance, we suggest first of all that a formula should be universally *applicable*, i.e. refer to variables that can be applied to all prospective partners in the agreement. Second, it should be easy to *translate into operational indicators* and feed

with reliable data or at least data that are not seriously contested. Third, *simplicity* is desirable (although substantive validity must – in principle – have priority over operational costs). Fourth, the formula should be framed so that it allows for *future refinement* and adjustment. Fifth, a burden sharing rule should allow for some flexibility, for example if national circumstances change unexpectedly in the future. Finally, a burden sharing rule should allow to take country-specific circumstances in account. These are considerations that are dealt with in greater depth in chapters 4 and 6.

3. BRIEF REVIEW OF SOME EXISTING BURDEN SHARING RULES

In this chapter, seventeen specified proposals for burden sharing suggested by governments in the Kyoto Protocol negotiations are discussed briefly. Proposals advocating flat-rate (equal percentage) emission reductions are not included. As the range of the proposals is wide, we have tried to find a suitable organising principle for the survey. The first option was to try to identify one or more fairness principles supported by the proposals. However, since such principles rarely are explicitly formulated, identifying fairness principles that support specific proposals turned out to be a demanding task. Moreover, there is no simple one-to-one relation between fairness principles and equity formulae. Thus we ended up with 8 categories of proposals based on important common features, where the category name reflects the main feature.

We have employed two sources of methods or proposals for the survey. The first is proposals from the Ad Hoc Group on the Berlin Mandate (AGBM) process that was initiated by the Berlin Mandate at the first Conference of the Parties (CoP1) to the UNFCCC in the spring of 1995, and ended up in the Kyoto Protocol in December 1997.¹⁰ From this negotiation process we identified and selected all proposals that implied some type of differentiation of targets. Consequently, we left out all proposals for flat-rate targets (i.e. where parties should reduce their emissions by the same percentage). Altogether this came to 16 proposals made by a single party or groups of parties. The second source is the European Unity's Triptych approach for differentiation of targets among its member states. The proposals are presented in a catalogue style.

3.1 Review of differentiation proposals from the AGBM negotiations

Based on common features among the proposals, we have organised the 17 proposals from the AGBM process into 8 groups. In addition there were numerous proposals based on flat percentage reductions. These are, however, not examined further in this

¹⁰ An interesting survey of possible methods for differentiation from the early phase of the negotiations is found in UNFCCC (1996), FCCC/AGBM/1996/7. This document was prepared for the 4th AGBM meeting in Geneva in July 1996.

report. The grouping is shown in Table 3.1, where the proposals are given a reference number. The main common feature of a group of proposals is emphasised. One of the features to be considered is the explicit or implicit reference to one or more fairness principles. Furthermore, a more detailed summary of the reviewed proposals is shown in Table 3.2. Here we specify operational criteria as well as basic principles. We should like to point out that in some cases the arguments submitted or criteria proposed are compatible with more than one principle of fairness. In particular, it is often difficult to distinguish arguments pertaining to need from arguments invoking (basic) rights. Moreover, it is often hard to determine whether arguments in favour of convergence towards a common level of emissions per capita is based (only) on the notion of need or (also) on considerations pertaining to capacity. The overview below should be read with this caveat in mind. Having said that, we would like to add that we take some comfort in the fact that when such ambiguity occurs the principles in question will pull largely in the same direction, meaning that they can be expressed in similar (perhaps even identical) operational rules.

Table 3.1 Grouping of burden sharing proposals from the AGBM process

Group	Proposals
Convergence	1. France 2. Switzerland 3. EU
Historical responsibility	4. Brazil 5. Brazil-RIVM
Multi-criteria formula	6. Norway 7. Iceland
Fossil fuel dependency	8. Australia 9. Iran
Menu approach	10. Japan I 11. Japan II
Sectoral approach	12. EU's Triptych approach
Gross Domestic Product (GDP) per capita	13. Poland et al. 14. Estonia 15. Poland and Russia 16. Korea
Cost-effectiveness	17. New Zealand

From Table 3.2 we can see that at least 10 of the 17 proposals refer to the principle of *guilt* (polluter pays), at least 8 build on the principle of *capacity*, and at least 8 refer to the concept of *need* (or, in an alternative interpretation, some notion of 'rights'). Moreover, we can see that all proposals invoking the norm that burdens be distributed in

proportion to capacity also refer to the principle of guilt, and that at least 8 out of the 10 proposals invoking the principle of guilt also include the notion of capacity. At the level of basic principles, this indicates a fairly high degree of consensus, at least when we take into account that we are talking about negotiations with global participation. At the same time we can see, however, that different operational rules are in some cases ‘derived’ from the same principle. For example, the principle of guilt is sometimes related to emissions per capita, sometimes to emissions per unit of GDP, and in one proposal to emissions per unit of territory. Moreover, we can see that the pattern of divergence is not a random one; thus, it is hardly by accident that Japan refers to emissions per capita and per unit of GDP, while Russia finds the notion of emissions per unit of territory a more attractive option. This all suggests that it will be primarily at the level of more specific burden sharing rules that most of the really hard bargaining will occur.¹¹

¹¹ A detailed discussion of the 17 proposals is included in the second working paper of the CICERO-ECN research project on Burden Sharing (Ringius, et al. 1999).

Abbreviations in Table 3.2:

CDE:	Level of carbon dioxide equivalent emissions.
CDE/Pop:	Carbon dioxide equivalent emissions per capita.
CDE/GDP:	Carbon dioxide equivalent emissions per gross domestic product.
GDP/Pop:	Gross domestic product per capita.
Σ CDE:	The cumulative historical emissions contributing to global warming.
CDEexp/CDEtot:	The share of emissions resulting from production of goods for export (first of all the energy intensive industrial sector) relative to total national emissions.
dPop/dt:	Population growth.
EXP/FF:	Fossil fuel intensity of export.
CDE/km ² :	Carbon dioxide equivalent emissions per square kilometre of a country's territorial basis.
RE/TE:	A country's consumption of renewable energy compared to total energy consumption in the country.
(Proj):	Projected.
(X):	Subsidiary to X, i.e. X is the main criterion, but (X) could also be taken into consideration.
Horizontal:	Equalise net welfare change across countries.
Polluter Pays:	Share abatement costs across countries in proportion to emission levels.
Equal obligation.:	Reduce emissions proportionally across all countries.
Egalitarian:	Reduce emissions in proportion to population.
Ability to pay:	Net cost of abatement positive correlated with per person GDP.

Table 3.2 Summary of proposals for burden sharing methods made by parties in the Ad Hoc Group on the Berlin Mandate (AGBM) negotiations.

Ref. no.	Proposal	When proposed	Fairness principle	Main features	Indicators										
					CDE	CDE/Pop	CDE/GDP	GDP/Pop	ΣCDE	CDEexp/CDEtot	dPop/dt	EXP/FF	CDE/km ²	Other	
1	France	Dec. 96	Need (rights) (undifferentiated)	Progressive burdens compared to emissions. Convergence		X									
2	Switzerland	Dec. 96	Need (rights) (+ equal obligations within intervals)	Progressive burdens compared to emission. Convergence		X				(X)					
3	EU	Mar. 97	Need (rights)	Convergence		X	X								
4	Brazil	May 97	Guilt (polluter pays)	Burdens corresponds to cumulative emissions					X						
5	Brazil-RIVM	Nov. 98	Guilt (polluter pays)	Burdens corresponds to cumulative emissions					X						
6	Norway	Nov. 96	Need, guilt and capacity	Multi-criteria formula		X	X	X							
7	Iceland	Jan. 97	Need, guilt and capacity	Multi-criteria formula		X	X	X							RE/TE
8	Australia	Jan. 97	Need (rights), capacity, and guilt	Unweighted set of 5 indicators			X	X (Proj.)		X	X (Proj.)	X			
9	Iran	Mar. 97	Mixture; need + acquired rights incl.	Unweighted set of 8 indicators					X			X			More
10	Japan I	Dec. 96	Equal obligations	Parties can choose 1 of 2 indicators	X	X									
11	Japan II	Oct. 97	Equal obligations., modified by guilt	Parties can choose 1 out of 3 indicators	X	X	X				X				
12	Triptych	1997	Need, on a sector-specific basis	Multiple set of indicators											
13	Poland et al.	Mar. 97	Guilt and capacity	Unweighted set of 4 indicators	X	X	X	X							
14	Estonia	Mar. 96	Guilt and capacity	Two possible indicators				X	(X)						
15	Poland and the Russian Fed.	Aug. 95	Capacity and guilt	Unweighted set of 7 indicators		X		X					X		More
16	Korea	Feb. 97	Guilt and capacity	Unweighted set of 3 indicators			X	X	X						
17	New Zealand	Nov. 96	Not specified	Global least cost (equal marginal costs)											Eq. marg. abatement costs

4. THE MULTI-SECTOR CONVERGENCE APPROACH

4.1 Introduction

In this chapter, a flexible sector-based approach will be introduced for setting national targets regarding GHG emission mitigation. This approach is called the *Multi-Sector Convergence* (MSC) framework approach as its major distinguishing characteristics are that (i) it is based on the distinction of different sectors within the national economy, (ii) the amount of per capita emission assignments will ultimately converge to the same level for all countries, and (iii) additional allowances may be conceded to countries facing specific circumstances that warrant higher emission needs than countries with more favourable specific emission mitigating circumstances, all other factors remaining the same.

4.2 Outline of the MSC framework

The MSC approach outlined in this chapter includes the following stages:

1. The distinction of different sectors.
2. The setting of global sector emission norms.
3. The determination of national emission mitigation targets.
4. The inclusion of allowance factors.

These stages will be further explained below in sections 4.3 up to 4.6. The final result of this process contains the national emission (mitigation) targets after adjustment for allowance factors. Section 4.7 will discuss the graduation and adjustment period for the so-called ‘low-per-capita-emission countries’. A numerical example to illustrate the MSC approach will be presented in section 4.8. Finally, section 4.9 will discuss the participation of non-Annex I countries within the framework of the MSC approach.

An overview of the MSC framework by means of a ‘flow chart’ is presented in Figure 4.1. In order to make this chart not overly complicated, it only pertains to the so-called ‘high-per-capita-emission countries’ (countries with per capita emissions above a certain, pre-defined graduation threshold), presumably having committed themselves to the MSC mitigation regime as proposed here. Figure 4.1. depicts most steps to be taken and

indicates the iterative character of the MSC approach. It is assumed that the low-per-capita-emission countries will be exempted from taking on emission mitigation commitments.

Let us further explain the flow chart in Figure 4.1. The flow chart assumes that the determination of the sectors to be included (stage 1) has already taken place. Steps 1-6 will have to be taken in stage 2, the setting of global sector emission standards. The following steps (to be further elaborated in sections 4.3-4.6) have to be taken:

- Establish (total) sector emissions at national level in the base year for all countries (step 1: see Section 4.3).
- Establish sector emissions at the global level in the base year (step 2).
- Establish per capita sector emissions at the global level in the base year (step 3).
- Set the per capita sector emission limitation rates that determine non-binding sector emission standards at the global level given projected sectoral emission trends at an assumed global level of climate change mitigation policy efforts (step 4).
- Set the convergence year and the per capita sector emission standards in the convergence year (step 5).

Stage 3, the determination of national emission mitigation targets, involves the following steps:

- Determine the national per capita sector emissions in the base year (step 6).
- Determine the implied per capita sector emission limitation rates at the national level (step 7).
- Determine the (non-binding) per capita sector emission standards in the target year at the national level (step 8).
- Aggregate the per capita sector emission standards and multiply them by the projected population number in the target year, resulting in the proposed pre-adjustment national assignments in the target year (step 9).

Stage 4, the inclusion of allowance factors, runs as follows:

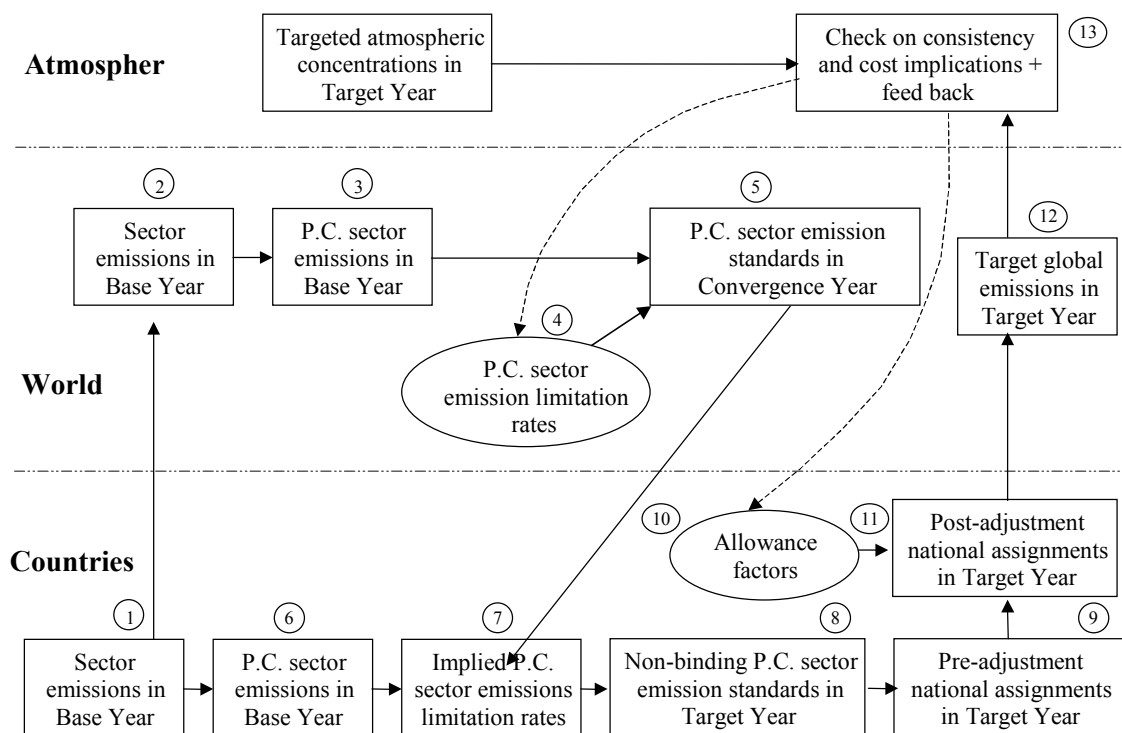
- Determine the allowance factors to be included, and for each factor its indicator, the country indicator values of the allowance indicators concerned and the rule to determine the level of additional allowances per country (step 10).

- Determine the post-adjustment national assignments in the target year (step 11).

For assessing the impact on climate change and the national economy, further steps need to be made:

- Based on the target national assignments (for countries with mitigation commitments) and baseline emission projections (for countries without commitments), target global emissions can be obtained by aggregation (step 12).
- Results generated by steps 11 and 12 have to be weighted on their potential impact on climate change (e.g. by projecting atmospheric carbon-equivalent concentrations in ppm) and macroeconomic impacts at the national level (“Are the national mitigation cost burdens and other macroeconomic impacts ‘politically feasible?’”).

Figure 4.1 A flow chart of the main steps and feedback loops in the Multi-Sector Convergence framework approach



Note: P.C. = Per Capita

If the outcomes of a certain run with the MSC framework model are not considered satisfactory from the climate change perspective (or, alternatively, from the perspective of the expected economic impacts), negotiators can iteratively define new input parameter values considered fair and mutually consistent. The iterations are to be continued until

results are obtained on which broad-based agreement about a comprehensive set of national mitigation targets can be reached. Given agreement on the distinction of sectors, notably the following negotiation parameters may be reconsidered for plugging in alternative values:

- The convergence year.
- Per capita sector emission mitigation rates at global level (assuming more/less climate change mitigation policy efforts).
- Allowance factors: deletion or inclusion of more factors, or changing the rules for determining allowance additions for each factor.
- The graduation threshold.
- The adjustment period towards graduation.
- The accounting rule for possible surplus emission credits of low-emission countries.

The list above shows the main negotiation parameters but is not exhaustive. Yet it brings out the great flexibility of the MSC framework. Section 4.8 presents a numerical example that may provide further insight into the MSC approach.

4.3 The distinction of different sectors

The first stage in designing a flexible, sector-based framework for negotiating burden sharing rules is to distinguish a relevant set of socio-economic sectors. The precise division between sectors should be an appropriate compromise between various concerns, i.e.:

- Distinct sectors should account for a significant share in total, human-induced GHG emissions.
- The sectors should not be overly heterogeneous with respect to intra-sector GHG-emission characteristics.
- Reliable data should be available on indicators of the distinct sectors for a large number of countries.
- The number of sectors should be large enough to guarantee nearly comprehensiveness, but small enough to preserve simplicity and clarity.

In line with the above-mentioned considerations, the following sectors – and related GHG emissions - have been distinguished for the time being, given the present state of data availability:

1. Power

- GHG emissions related to power generation, excluding power use in industry.

2. Households

- All energy-related GHG emissions by households, except for emissions related to (generation for) electricity use by households.

3. Transport

- All energy-related GHG emissions by the transportation sector, with the exception of emissions related to (generation for) electricity use for transportation purposes.

4. Industry

- GHG emissions brought about by power use in industry.
- Other energy-related GHG emissions by the industrial sector.
- Non-energy GHG emissions of high GWP gases in industrial processes (notably in the cement industry).

5. Services

- All energy-related GHG emissions by services and agriculture, except for emissions related to (generation for) electricity use by the services sector.

6. Agriculture

- Non-energy-related GHG emissions from crop production (mainly methane from paddy growing).
- Non-energy-related GHG emissions from livestock (notably methane, some nitrous oxide).

7. Waste

- Non-energy related GHG emissions from waste treatment (mainly from landfills: especially methane, some nitrous oxide).

All energy-related GHG emissions are encompassed by the first five sectors. Data availability problems necessitated the inclusion of GHG emissions from electricity (generation for) use in the sectors Households and Services in the sector Power. As factors determining GHG emissions from industrial processes are similar to the ones determining energy-related industrial GHG emissions, emissions from industrial processes have been categorised under *Industry*. The sector *Services* in fact encompasses energy-related GHG emissions by services and agriculture, except for emissions related to electricity use. As services accounts for the lion's share of these emissions, we have labelled the sector concerned as *Services*. The last two sectors – Agriculture and Waste - account for (the bulk of) non-energy-related GHG emissions.

Together, the seven sectors distinguished above account for the vast majority of GHGs covered by the Kyoto Protocol. The main exceptions are GHG emissions due to land use changes and emissions of HFCs, SF₆ and PFCs. The major reason for these exceptions is lack of available, reliable data at the sector and/or national level for a large number of countries. Improvement in the availability of data may give rise to the introduction of an alternative choice of sectors and further improvement in the coverage of total global GHG emissions. In principle, net emissions from *land use changes* (net reductions in “sinks”) can be added later as a separate sector pending advances in climate change negotiations on this issue and the production of statistics that will be deemed credible by a critical mass of scientists and negotiators.

4.4 The setting of global sector emission standards

For each sector, several aspects have been considered in order to establish non-binding sector emission standards – expressed in per capita terms – in both a base year, a convergence year and intermediate target years (see below). These aspects or considerations include:

- a. Main subsectors or end uses and major sector-related GHGs.

- b. Considerations at subsector level, including the character of the needs met in association with the emissions ('basic needs' versus 'non-basic' needs).
- c. Main factors explaining variances in sector emission levels among countries.
- d. Global activity and non-policy-induced decarbonisation trends, and other major driving factors for global emissions at the sector level.
- e. Typical turnover periods of capital goods of the sector considered, which 'lock in' emission reduction potentials for a certain period.
- f. Impact of the assumed level of climate change policy efforts on decarbonisation trends.
- g. Major allowance factors, i.e. country-specific circumstances resulting in variances of sector emissions among countries that are virtually impossible to influence by the governments concerned.

As noted, these aspects have been considered in order to establish global sector emission standards. For the base year (2010), these standards have been set equal to the world average sector GHG emissions per capita in that year. Subsequently, an annual reduction or limitation norm per sector has been set – expressed in a percentage per year – in order to derive sector emission standards in the years thereafter, notably in a convergence year (e.g. 2100) and in some intermediate, target years (for instance, 2015, representing the second budget period). Finally, per capita emission standards at the sector level have been added up to obtain the global per capita emission standard at the aggregated level.

Countries with emission levels in a certain base year higher than the global per capita total emission standard (GTES) in that year will be designated as *high-emission countries*, while countries with lower emissions than this standard will be called *low-emission countries*. We assume that international agreement will be reached that signatory countries to the UNFCCC exceeding the GTES will have to graduate into the league of countries accepting future emission mitigation targets.

4.5 The determination of national emission mitigation targets

The third stage in designing a sector-based burden sharing framework concerns the determination of emission limitation targets for each country in certain target years such as

2015 or 2050. Starting point for each country is its sector levels of per capita emissions in the base year (2010).¹² In the years thereafter, these levels are supposed to converge to the global sector emission standards of the convergence year derived in the previous section. Non-binding sector emission levels for each country in intermediate target years are obtained by geometric interpolation between the actual sector emission levels in the base year and the global sector emission standards of the convergence year.¹³ Finally, these non-binding sector emission levels are added up and multiplied by total population in order to determine national emission limitation targets for the countries and years concerned. These commitments can be expressed either in absolute terms – i.e. in amounts of emission assignments for a certain budget period – or as a reduction/limitation rate, i.e. as a percentage by which emissions in a certain budget period has to be reduced/limited compared to a base year or a previous budget period.

4.6 The inclusion of allowance factors

The framework for negotiating national GHG emission limitation targets can be fine-tuned by including so-called allowance factors. These factors can be defined as country-specific circumstances resulting in variances of sector emissions among countries that are virtually impossible to influence by the governments concerned, at least in the short and medium run. Hence, under certain conditions such allowance factors may provide grounds for justification and agreement at the international negotiation table to concede certain *allowance additions* – expressed as a certain amount of GHG emission assignments – to the national emission limitation targets derived in the previous section for countries that are faced with less favourable country-specific circumstances.¹⁴ Allowance additions may be either temporary – i.e. only for specific target years – or for all

¹² For Annex-I countries, the sector levels of per capita emissions in the year 2010 are based on the actual sector emission levels in the year 1990 adjusted by the (national) emission limitation rates laid down in the Kyoto Protocol. For non-Annex-I countries, the sector levels of per capita emissions in the year 2010 are based on the actual sector emission levels in the year 1990 adjusted by the (national) projected growth rates according to the A1 SRES-scenario of the IPCC.

¹³ It should be noted that whereas the normative, sector emission standards of the convergence year are, in principle, the same for each country, the actual sector emission levels in the base year – and, hence, in intermediate target years – are different for each country (see numerical examples included in section 4.8).

¹⁴ From a negotiation strategy perspective we have opted to include only allowance *additions*. Alternatively, inclusion of allowance *deductions* may be considered as well so as to achieve carbon budget neutrality. Inclusion of allowance additions only implies that feedback iterations with a view to achieving desired global emission limits will be quite essential.

target years, including the convergence year. Some examples of possible allowance factors include:

- *Local climate.* Due to climate factors and resulting differences in in-doors heating and cooling conditioning, emission levels between countries may vary significantly, notably in the power, household and other sectors of the economy. These factors may be accounted for by granting countries concerned an additional amount of emission assignments according to their number of heating or cooling degree-days.
- *Population density.* A low population density compared to some world standard will, on average, result in a higher level of per capita GHG emissions, mainly because of higher efficiency losses in the power sector, higher transport needs, and higher energy needs in the household sector (for instance, to warm houses in scarcely populated areas), if differences in other circumstances would be negligible. Therefore, it seems justified to assign an extra amount of GHG emissions to scarcely populated countries.
- *Agriculture.* Some countries are highly dependent on *rice cropping* in order to meet the basic food needs of their population. Rice cropping by means of irrigation or natural flooding, however, is the most important source of GHG emissions – notably of CH₄ – in the food crop sector). Hence, rice cropping may be included as an allowance factor for the countries concerned, according to the area of their irrigated paddy fields. To a certain extent, *animal husbandry* also provides basic food needs. An alternative way of making allowance for the basic needs character of certain products of the agricultural sector and the required non-energy GHG emissions to produce these products is to introduce relatively lenient GHG emission standards for agriculture.
- *Transition economies.* Some countries are facing specific problematic circumstances because their economy is in a state of transition, either from a communist, centralised state to a capitalist, market-led economy or from a rapidly developing, industrialising state to a more developed and moderately growing services economy. These circumstances may justify *temporary*, additional amounts of emission assignments during the transition period. The same – evidently also on a temporary basis - might

be considered for *fossil-fuel exporting countries*, i.e. countries that face the difficult transition towards a more diversified economic base with reduced dependence on fossil fuel exports and use. However, this kind of compensation would only be useful if oil exporting countries would accept an emission limitation commitment and if they would be allowed to sell a possible surplus of emission assignments to deficit countries (which is at present not the case for non-Annex I, oil exporting countries). Moreover, as recently recommended by a joint study of ECN and Clingendael, it could be considered to compensate oil exporting countries by creating a special fund managed by the IMF and World Bank (Van der Linden et al. 1999). Resources on behalf of this fund can be generated by raising taxes on oil consumption of Annex I or by providing other financial means to this fund. These resources can be used as balance-of-payments support (IMF) or to restructure oil exporting economies during their transition period.

- *Renewable energy resources.* Some countries are poorly endowed with renewable energy resources (hydro power potential, wind resources, solar energy), whereas other countries possess vast resources of renewable energy. These differences in renewable energy resources – resulting in large variances in GHG emissions of power generation – may justify country-specific additional allowances for the former renewable-energy-recourse-poor group of countries.

In addition, other allowance factors may be considered. For instance, the above-average presence of export-oriented industries is sometimes suggested as an allowance factor as countries concerned are faced by additional amounts of GHG emissions (in favour of import-oriented countries). However, as the flexible mechanisms of the Kyoto Protocol may enable the Annex I countries to meet their domestic emission commitments by means of foreign transactions, it seems more obvious that export-oriented countries use part of their foreign revenues to obtain additional amounts of emission assignments by means of the flexible instruments (Emission Trading, Joint Implementation and/or the Clean Development Mechanism). Hence, whether an allowance factor is justified depends not only on the incidence of country-specific circumstances but also on the institutional setting of granting and trading emission assignments.

4.7 Graduation threshold and adjustment period

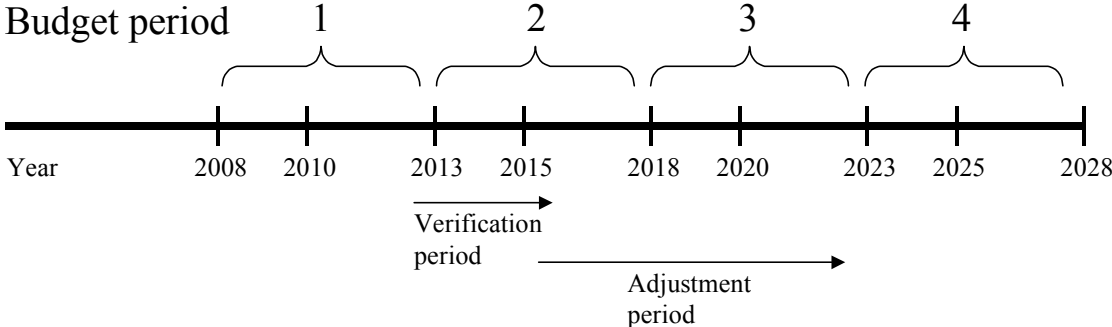
In section 4.2, the assumption has been set out that so-called low-per-capita-emission countries will be exempted from taking on emission mitigation commitments. In the MSC framework, it is assumed that such countries will eventually graduate towards taking on emission mitigation commitments when exceeding a certain per capita emission threshold. This *graduation threshold* indicates the – to be negotiated - per capita realised emission level at which non-Annex-I countries, signatory to the FCCC, will have to assume mitigation commitments. In the numerical example to be explained in the next section, the graduation threshold will be put at the GTES level (global total emission standard on a per capita basis, already explained in section 4.4).

Granted five-year budget periods with reference years 2010, 2015, 2020, etc. as mid-years, we may assume that for each country that is signatory to the FCCC realised emissions in a certain budget period will be determined and verified ex post by the following reference year at the latest. Hence, the national emissions in the first budget period, 2008-2012, are assumed to be determined and verified by the year 2015 at the latest.

Now assume a certain non-Annex-I country has generated average annual (per capita) emissions during the first budget period exceeding the graduation threshold. Assuming this country will be notified to take on emission mitigation commitments in year 2015, the earliest budget period in which this country can conceivably take on emission limitation commitments is the third budget period, 2018-2023. Yet it is conceivable that a longer adjustment period will be agreed upon, e.g. an additional five year adjustment period. This is depicted in Figure 4.2

In conclusion, in the MSC approach the *adjustment period* after which a signatory non-Annex I country exceeding the graduation threshold, will have to adopt the targeted emission mitigation is an additional flexible parameter which value is to be determined by international negotiations.

Figure 4.2 Example of an adjustment period, including verification and notification, of 15 years



4.8 A numerical example

Results of the procedure outlined above are summarised in Table 4.5 for a selected sample of countries in the years 2010, 2015, 2020, 2050 and 2100. This table shows, for instance, that Tanzania is allowed to increase its total GHG emissions from 21 Mt in 1990 to 67 Mt in 2010 and even to 397 Mt in 2050. This significant increase is due to the combination of two effects, i.e. (i) a substantial rise in allowable emissions per capita – up to the world average standards – is multiplied by (ii) a rapidly growing population. On the other hand, Russia is obliged to reduce its total GHG emissions from almost 3,000 Mt in 1990 to some 350 Mt in 2100 as a result of (i) a substantial lower emission assignment per capita in 2050, combined by (ii) a steadily declining population.

Table 4.5 Emission limitation targets for selected countries (2015-2100)^a

Unit	Year/period	Tanzania	India	China	Iran	Russia	Brazil	EU-15	USA	Japan	World
GHG/cap	1990	813	1741	3027	4236	20163	3437	11431	23230	9511	5027
[kgCO ₂ eq/cap]	2010	1514	3263	6504	8214	21198	8627	10259	18368	8693	5700
	2015	1520	3240	6216	7651	18890	8109	9599	16680	8155	5394
	2020	1530	3220	5947	7154	16857	7630	8989	15156	7657	5132
	2050	1737	3181	4689	5129	8824	5431	6177	8633	5383	4173
	2100	3606	3606	3606	3606	3606	3606	3606	3606	3606	3606
Total GHG	1990	21	1481	3497	251	2990	509	4175	5903	1175	26552
[MtCO ₂ eq]	2010	67	3760	8878	807	2990	1637	3852	5490	1104	39275
	2015	76	3926	8759	838	2610	1619	3588	5185	1026	39301
	2020	86	4095	8616	857	2272	1591	3340	4884	948	39372
	2050	152	4923	7026	804	1032	1369	2054	3090	731	38950
	2100	397	5839	4897	619	346	986	989	1277	536	35908
Change	1990-2010	221.8	153.8	153.8	221.8	0.0	221.8	-7.7	-7.0	-6.0	47.9
[%]	2010-2015	13.9	4.4	-1.3	3.8	-12.7	-1.1	-6.8	-5.6	-7.1	0.1
	2015-2020	13.2	4.3	-1.6	2.3	-13.0	-1.7	-6.9	-5.8	-7.6	0.2
	2010-2050	128.7	30.9	-20.9	-0.4	-65.5	-16.4	-46.7	-43.7	-33.8	-0.8
	2010-2100	495.3	55.3	-44.8	-23.3	-88.4	-39.8	-74.5	-76.7	-51.5	-8.6

a) Including CO₂, CH₄ and N₂O but excluding estimated emissions from land use changes.

4.9 The participation of non-Annex I countries

A major point of discussion is whether and how non-Annex I countries should participate in the burden sharing approach outlined above. The present, post-Kyoto situation is that non-Annex I countries are not subject to an official commitment to limit their GHG emissions. However, they are involved in international climate policies to control the greenhouse effect by means of the Clean Development Mechanism (CDM). The main objectives of this mechanism are (a) to encourage the sustainable development of non-Annex I countries by means of institutional capacity building and technology transfers, and (b) to enable Annex I countries to meet part of their Kyoto commitments cost-effectively by means of abatement projects in non-Annex I countries.

Although the specific guidelines, rules and procedures of CDM still have to be defined by ongoing policy negotiations as part of the annual Conference of the Parties (CoP), the post-Kyoto situation offers the following advantages:¹⁵

- It encourages the sustainable development of all interested non-Annex I countries as it implies a transfer from Annex I to non-Annex I countries of investment funds, knowledge and technologies regarding GHG mitigation.
- It offers net gains to non-Annex I countries by selling CDM emission credits to Annex I countries.
- It encourages particularly the participation in international GHG mitigation efforts of those non-Annex I countries that possess a large abatement potential at relatively low costs (such as China and India).
- It contributes to mitigating GHG emissions at low costs and, hence, to accepting more ambitious, higher emission limitation targets by Annex I countries.
- It does not require a reliable system of monitoring and evaluating GHG emissions at the national level, but only at the project level.

Emissions trading between countries requires a reliable system of monitoring and evaluating GHG emissions at the national level. At present, such systems are hardly available in non-Annex I countries.¹⁶ Therefore, regarding the participation of low-emission non-Annex I countries in global emission limitation efforts, the present (post-Kyoto) situation seems to be more preferable than the alternative option discussed above. However, with regard to the higher emission non-Annex-I countries that are signatories to the UNFCCC, it is assumed that they will have to accept future emission mitigation targets as part of the international negotiations on this issue.

For negotiating a comprehensive MSC approach with participation of the present non-Annex-I countries, the introduction of an adjustment period of acceding countries appears warranted. Reference is made to section 4.7 in which recommendations for the design of a graduation procedure for high-emission non-Annex-I countries have been presented.

¹⁵ For details, see Sijm et al. (2000a). See also Working Paper No. 6 of the present research project (Sijm et al., 2000b).

¹⁶ Even the emission statistics of some non-Annex I countries included in the database of the present research project are questionable.

5. COST IMPLICATIONS OF MULTISECTOR CONVERGENCE APPROACH

5.1 Introduction

The previous chapter has resulted in a set of emission limitation targets for a large sample of countries with regard to the years following the first budget period of the Kyoto Protocol. These targets give an impression of burden sharing among countries in terms of reduction percentages or amounts of emissions to be mitigated. However, they do not provide an indication of burden sharing in terms of costs involved. The latter, i.e. indicating the cost implications of the multi-sector convergence approach is the main intention of the present chapter.

The cost analyses included in this chapter are based on a model previously developed by ECN to study the impact of the Kyoto Mechanisms in meeting the commitments of Annex I countries to limit their GHG emissions. One of the opportunities of this model is to estimate the costs of emission limitation commitments of the Annex I countries with regard to the so-called first budget period of the Kyoto Protocol (2008-2012).¹⁷ By adding some small adjustments to this model, it can also be used to estimate the cost effects of the multi-sector convergence approach of burden sharing for the subsequent, second budget period (2013-2017). Because of data and model simplicity considerations, these effects will be indicated only for all major individual countries of the western Annex I region and for the Annex I countries of Central and Eastern Europe and the Former Soviet Union as a whole (CEE/FSU Annex I region). Cost implications will not be indicated for non-Annex I countries as (i) most of these countries are not obliged to limit their GHG emissions during the second budget period, and (ii) necessary data are lacking at the individual country level.¹⁸

¹⁷ A brief outline of this model and some research findings are included in Sijm, et al. (2000a).

¹⁸ In fact, non-Annex I countries have been grouped in six sub-regions, i.e. Africa, Asia, the Former Soviet Union (FSU non-Annex I), Latin America, the Middle East and Oceania. It has been assumed that each sub-region as a whole is not subject to a GHG abatement commitment.

The structure of this chapter runs as follows. First of all, emission reduction requirements of Annex I countries/regions with regard to the second budget period are discussed in section 5.2. Subsequently, section 5.3 analyses the trade and cost effects of the multi-sector convergence approach for the second budget period (including and excluding the use of Kyoto Mechanisms). Finally, a comparative summary and conclusion of this chapter is provided in section 5.4.¹⁹

5.2 Emission reduction requirements

Emission reduction requirements are defined as the difference between the expected (baseline) emissions in a certain period and the so-called ‘emission limitation target’, i.e. the assigned amount of GHG emissions in that period, based on a certain percentage – for instance, 90 or 95 percent – of the emission level in the reference period. Table 5.1 summarises the estimated GHG emission levels in 1990, 2010 and 2015, as well as the emission limitation targets and the resulting emission reduction requirements for each western Annex I country and for the Annex I countries of the CEE/FSU region as a whole in the years 2010 and 2015 (where 1990 represents the reference period and the years 2010 and 2015 stand for the first and second budget periods, respectively).

Table 5.1 shows that the emission limitation targets of the Annex I countries are, on average, lower with regard to the first budget period (-5.2 percent) than regarding the second budget period (-7.7 percent). However, as the projected increase in baseline emissions is more significant in the years 1990-2010 (11.4 percent) than between 2010 and 2015 (6.2 percent), the emission reduction requirements in absolute amounts are higher for the first budget period (2.9 billion tonnes CO₂ eq.) than for the second budget period (2.5 billion tonnes CO₂ eq.). Moreover, these aggregated figures hide major differences at the disaggregated level of individual countries and regions. For instance, emission reduction requirements for the USA decrease from almost 2.0 billion tonnes in the first budget period to less than 0.8 billion tonnes in the second budget period, whereas they increase for the CEE/FSU Annex I region as a whole from, on average, 0 to more than 1.0 billion tonnes CO₂ eq. Note that the emission reduction targets of columns 5 and 6

¹⁹ It should be noted that the construction of GHG abatement cost curves for the countries/regions concerned is not discussed in this final report. For information on this subject, see Sijm, et al. (2000a and 2000b).

in Table 5.1. have a relative meaning as an indicator of burden sharing among countries as real emission reduction requirements are not only (or mainly) determined by these targets and emissions levels of the base year, but also – sometimes even predominantly – by emission levels in the year 2010 or 2015 as determined by population and economic growth as well as other autonomous trends affecting baseline emission levels.

Table 5.1 Emission levels, limitation targets and reduction requirements of Annex I countries (first and second budget period)^a

Country/region	GHG baseline emissions ^b			Emission limitation targets				Emission reduction requirements			
	[MtCO ₂ eq.]			(as reduction percentage) ^c		(as assigned amounts, MtCO ₂ eq.)		[MtCO ₂ eq.]		(as reduction percentage) ^d	
	1990	2010	2015	2010	2015	2010	2015	2010	2015	2010	2015
Australia	423	496	517	-8	5.2	456	433	40	44	8	9
Austria	79	86	88	13	6.0	69	65	17	6	20	9
Belgium	130	144	148	7.5	7.8	120	111	24	13	16	11
Canada	340	402	419	6	5.3	320	303	82	34	20	10
Denmark	73	79	80	21	6.0	58	54	21	5	27	8
Finland	64	83	89	0	7.6	64	59	19	11	23	16
France	501	515	518	0	5.3	501	474	14	30	3	6
Germany	1203	976	1005	21	7.7	951	877	25	103	3	11
Greece	101	147	162	-25	8.5	126	116	22	24	15	18
Iceland	3	4	5	-10	4.3	3	3	1	1	29	22
Ireland	53	69	74	-13	7.8	60	55	9	10	13	15
Italy	511	592	614	6.5	7.8	478	441	113	60	19	12
Japan	1333	1587	1658	6	7.2	1253	1162	334	162	21	12
Luxembourg	16	12	12	28	13.8	12	10	0	2	0	17
Netherlands	225	258	267	6	7.2	212	196	47	24	18	11
New Zealand	69	105	117	0	5.1	69	65	36	16	34	20
Norway	43	52	55	-1	6.4	44	41	8	6	16	14
Portugal	68	86	91	-23.9	6.4	84	79	2	10	3	11
Spain	294	358	375	-15	6.3	338	317	19	39	5	11
Sweden	67	76	79	-4	3.5	69	67	7	5	9	7
Switzerland	53	66	70	8	5.6	49	46	17	7	26	13
United Kingdom	752	699	720	12.5	6.4	658	616	42	62	6	9
USA	6187	7751	8200	7	5.6	5754	5434	1997	769	26	13
<i>Western Annex I</i>	<i>12588</i>	<i>14645</i>	<i>15363</i>	<i>6.7</i>	<i>6.2</i>	<i>11748</i>	<i>11024</i>	<i>2898</i>	<i>1441</i>	<i>20</i>	<i>12</i>
CEE/FSU Annex I	4885	4813	5295	1.5	11.5	4813	4258	0	1037	0	20
<i>Total Annex I</i>	<i>17473</i>	<i>19458</i>	<i>20658</i>	<i>5.2</i>	<i>7.7</i>	<i>16561</i>	<i>15282</i>	<i>2898</i>	<i>2478</i>	<i>15</i>	<i>14</i>

a) The year 2010 represents the first budget period (2008-2012) and the year 2015 the second budget period (2013-2017).

b) For an explanation of baseline emissions in 2010 and 2015, see Sijm et al (2000a and 2000b).

c) A positive figure means that emissions should decrease by the percentage indicated, whereas a negative sign implies that they are allowed to increase by the percentage recorded. For 2010, the limitation rates – as agreed in the Kyoto Protocol - refer to the reference year 1990. For 2015, these rates refer to the previous period – 2010, i.e. the first budget period – as derived by the multi-sector convergence approach described in WP no. 5 (Jansen et al., 2000).

d) For 2010, the reduction requirements are calculated as a percentage of baseline emissions in 2010. For 2015, these requirements are calculated as a percentage of baseline emissions in 2015 corrected for the emissions limitations that have been implemented during the first budget period as part of the Kyoto Protocol.

5.3 Trade and costs effects

5.3.1 Main results

Table 5.2 presents the main trade and cost effects of the Kyoto Mechanisms during the first budget period (Kyoto Protocol) versus the second budget period (multi-sector convergence approach). Two cases are distinguished. In case A, reduction options at negative marginal costs in non-Annex I and CEE/FSU Annex I countries are excluded from the analysis, whereas this ‘profitable potential’ is included in case B. For reasons of convenience, case A during the first budget period is indicated as A1 and during the second budget period as A2. The same indication applies to case B (i.e. B1 versus B2).

Table 5.2 Main trade and cost effects of the Kyoto Mechanisms during the first and second budget period

	First budget period (Kyoto Protocol)		Second budget period (Multi-sector approach)	
	Case A1	Case B1	Case A2	Case B2
Reduction requirements Annex I [Mt]	2898	2898	2478	2478
Equilibrium price of emission credits [US\$/t]	8	3	24	10
Reduction requirements achieved domestically [Mt]	1040	543	1410	1070
Total trade in emission credits [Mt]	1858	2355	1068	1408
<i>As % of Annex I reduction requirements</i>	<i>64%</i>	<i>81%</i>	<i>43%</i>	<i>57%</i>
ET within western Annex I region [Mt]	70	8	126	3
JI export CEE/FSU Annex I region [Mt]	254	900	0	0
CDM export non-Annex I region [Mt]	1534	1447	942	1406
Total reduction costs before trade [mUS\$95]	75753	75753	133270	133270
Total reduction costs after trade [mUS\$95]	10321	1578	35100	15953
Average costs per tonne before trade [US\$95/t]	26.1	26.1	53.8	53.8
Average costs per tonne after trade [US\$95/t]	3.6	0.5	14.2	6.4
Average costs per capita before trade [US\$95/t]	14.0	14.0	18.4	18.4
Average costs per capita after trade [US\$95/t]	1.5	0.2	4.8	2.2

The first row of Table 5.2 provides the estimated reduction requirements of the Annex I countries as derived in Table 5.1. In case of free trade (i.e. unrestricted use of all Kyoto Mechanisms), these requirements will be met at an international equilibrium price of emission credits equal to 8 US\$ per tonne CO₂ eq. in case A1 and 3 US\$ in case B1 as far as the first budget period is concerned. In the second budget period, on the contrary, this price level will be much higher – i.e. 24 and 10 US\$, respectively – as the cheapest reduction options have already been used during the first budget period.

Depending on the equilibrium price of emission credits, countries will determine the optimal level of both their domestic emission reductions and their foreign trade transactions in emission credits. For instance, in case A2 (i.e. an equilibrium price of 24 US\$ per tonne), the Annex I countries will reduce 1410 Mt GHG emissions at home and import emission credits equal to an amount of 1068 Mt (Table 5.2). In case B2, however, the equilibrium price of emission credits will be lower (10 US\$ per tonne). As a result, Annex I countries will reduce less GHG emissions at home (1070 Mt) and import more emission credits abroad (1408 Mt). In both cases, imported emission credits are predominantly achieved through CDM transactions with non-Annex I countries and hardly by ET transactions within the western Annex I region. JI transactions with countries in the CEE/FSU Annex I region are estimated to be 0 during the second budget period in contrast to the first budget period when they account for a substantial part of total trade in emission credits.²⁰

In addition to the above-mentioned trade effects, Table 5.2 also presents the main cost effects of the decision to enable Annex I countries to meet their reduction requirements by means of Kyoto Mechanisms. It shows that, in case A1, global abatement costs are estimated to tumble from almost 76 billion US\$ ‘before trade’ to 10 billion US\$ after trade’ (i.e. after relying on the Kyoto Mechanisms). Including no-regret options in the non-Annex I and CEE/FSU Annex I regions (case B1) results in a further decrease of total abatement costs to 1.6 billion US\$. In the latter case, the average reduction costs per tonne will be only 0.5 US\$ compared to 26 US\$ ‘before trade’. Similar, although slightly less spectacular cost savings will be realised during the second budget period (cases A2 and B2). Hence, it may be concluded that the decision to introduce JI, CDM and ET may result in tremendous global savings of total abatement costs, particularly if no-regret options in non-Annex I and CEE/FSU Annex I regions are included in global abatement strategies.

²⁰ It is assumed that Emissions Trading (ET) will mainly occur within the western Annex I region, and Joint Implementation (JI) between this region and the CEE/FSU Annex I region.

5.3.2 Disaggregated cost effects

A more detailed picture of the above-mentioned cost effects is presented in Table 5.3.²¹ It shows that, before trade, abatement costs in absolute terms are mainly born by major western Annex I countries such as Italy, Japan and the US due to either high reduction requirements or relatively high domestic reduction costs (or a combination of both factors). Total abatement costs of these three countries amount to 109 billion US\$, i.e. some 82 percent of all cost to meet the reduction requirements of the western Annex I countries with regard to the second budget period.

After trade, however, total abatement costs of the western Annex I countries fall from 132 billion US\$ to 23 billion US\$ (case A2). Although, in absolute terms, the US, Japan and Italy benefit most from using the Kyoto Mechanisms to meet their reduction requirements, they still account for the major share (i.e. 15 billion US\$ or almost 66 percent) of total abatement costs born by western Annex I countries. Moreover, whereas most western Annex I countries benefit from trade in the sense that they have to make less costs to meet their reduction requirements, non-Annex I countries will benefit in the sense that they can make real profits by exporting emission credits to Annex I countries. In case A2, such profits will be mainly realised by countries in Asia (7.5 billion US\$) and in Latin America (0.8 billion US\$).

The distribution of net gains owing to the use of Kyoto Mechanisms will show some significant changes, however, if no-regret options are included (case B2). Total abatement costs of all western Annex I countries will fall to 11 billion US\$. Again, the US, Japan and Italy will benefit most in absolute terms, but still they account for some 68 percent (i.e. 7.8 billion US\$) of all costs born by the western Annex I countries. Net real profits of exporting countries in the non-Annex I region will decrease from 9.7 billion US\$ in case A2 to 5.1 billion US\$ in case B2. This decrease is explained by the fact that, due to the inclusion of no-regret options, the quantity of emission credits exported by these regions indeed increases, but this effect is more than offset by the resulting decrease in the equilibrium price of these credits.

²¹ For a more detailed discussion of the trade effects of the Kyoto Mechanisms at the disaggregated level of individual countries/regions during the second budget period, see Sijm et al. (2000b).

Table 5.3 Second budget period: costs effects of using Kyoto Mechanisms (Multi-sector convergence approach)^a

	Costs before trade [M USD95]	Costs after trade [M USD95]		Costs as % of GDP 2015			Net gains as % of GDP 2015	
		Case A2	Case B 2	Before Trade	After trade		Case A2	Case B2
					Case A2	Case B2		
Australia	2987	947	393	0.60	0.19	0.08	0.41	0.52
Austria	1351	114	54	0.39	0.03	0.02	0.36	0.37
Belgium	742	204	109	0.19	0.05	0.03	0.13	0.16
Canada	2317	499	276	0.27	0.06	0.03	0.21	0.24
Denmark	605	88	42	0.24	0.03	0.02	0.20	0.22
Finland	702	172	84	0.38	0.09	0.05	0.28	0.33
France	179	475	201	0.01	0.02	0.01	-0.01	0.00
Germany	1805	2110	878	0.05	0.06	0.02	-0.01	0.03
Greece	774	460	228	0.57	0.34	0.17	0.23	0.40
Iceland	331	0	5	3.18	0.00	0.04	3.18	3.13
Ireland	664	179	78	0.73	0.20	0.09	0.53	0.65
Italy	14900	1187	523	0.92	0.07	0.03	0.85	0.89
Japan	49085	3408	1595	0.67	0.05	0.02	0.63	0.65
Luxembourg	166	36	16	0.74	0.16	0.07	0.59	0.68
Netherlands	1779	368	197	0.30	0.06	0.03	0.24	0.27
New Zealand	858	201	89	1.18	0.28	0.12	0.90	1.05
Norway	670	112	50	0.31	0.05	0.02	0.26	0.29
Portugal	103	182	91	0.07	0.12	0.06	-0.05	0.01
Spain	461	606	321	0.06	0.07	0.04	-0.02	0.02
Sweden	257	99	47	0.08	0.03	0.01	0.05	0.06
Switzerland	1279	124	63	0.29	0.03	0.01	0.26	0.27
United Kingdom	4965	881	368	0.30	0.05	0.02	0.25	0.28
USA	45442	10697	5653	0.43	0.10	0.05	0.33	0.38
Tot. western Annex I	132425	23148	11361	0.41	0.07	0.04	0.34	0.37
CEE+ FSU Annex I	845	21632	9726	0.06	1.62	0.73	-1.56	-0.66
Total Annex I	133270	44780	21087	0.39	0.13	0.06	0.26	0.33
Africa	0	-543	-379	0.00	-0.07	-0.05	0.07	0.05
Asia	0	-7549	-3731	0.00	-0.12	-0.06	0.12	0.06
FSU non-Annex I	0	-470	-325	0.00	-0.18	-0.13	0.18	0.13
Latin America	0	-811	-505	0.00	-0.02	-0.02	0.02	0.02
Middle East	0	-287	-186	0.00	-0.02	-0.01	0.02	0.01
Oceania	0	-21	-8	0.00	-0.19	-0.07	0.19	0.07
Total non-Annex I	0	-9680	-5134	0.00	-0.08	-0.04	0.08	0.04
World	133270	35100	15953	0.29	0.08	0.03	0.21	0.26

a) The case 'before trade' concerns the situation where emission reduction requirements are met fully by only domestic actions in both the first and second budget periods. Case A2 (B2) refers to the situation where no-regret options are excluded (included) in both the first and second budget periods.

The last two columns of Table 5.3 express net gains of using Kyoto Mechanisms as a share of the estimated GDP in 2015. In these terms, the countries that benefit most include Italy, Japan, Iceland and Luxembourg, mainly due to their relatively high domestic reduction costs.

5.4 Indicators of burden sharing: summary and conclusion

The analysis in the previous sections can be summarised by comparing some indicators of burden sharing among Annex I countries. In Table 5.4 five indicators are recorded:

1. Emission limitation targets for the year 2015, expressed as a reduction percentage of emission levels in the year 2010 (where 2010 and 2015 represent the first and second budget periods, respectively). These targets originate from the multi-sector convergence approach outlined in chapter 4.
2. Emission reduction requirements in 2015, expressed as an abatement percentage of emissions levels in the year 2015.
3. Reduction costs as a percentage of GDP in 2015, excluding both no-regret options and the use of Kyoto Mechanisms.
4. Reduction costs as a percentage of GDP in 2015, excluding no-regret options but including the use of Kyoto Mechanisms.
5. Reduction costs as a percentage of GDP in 2015, including both no-regret options and the use of Kyoto Mechanisms.

For each indicator, countries have been ranked to descending order of burden sharing. Table 5.4 reveals that the ranking of countries may differ significantly depending on the indicator used. This applies particularly for countries such as Iceland, New Zealand, Australia, Germany, Italy or the CEE/FSU Annex I region.

Table 5.4 Second budget period: Indicators of burden sharing (Multi-sector Convergence Approach)

Emission limitation targets for 2015		Emission reduction requirements in 2015		Costs as % of GDP 2015 ^b					
(as reduction % of 2010 emissions) ^a		(as reduction % of 2015 emissions)		Before trade		After trade			
						Case A2		Case B2	
Luxembourg	13.8	Iceland	22	Iceland	3.18	CEE/FSU	1.62	CEE/FSU	0.73
CEE/FSU	11.5	New Zealand	20	New Zealand	1.18	Greece	0.34	Greece	0.17
Greece	8.5	CEE/FSU	20	Italy	0.92	New Zealand	0.28	New Zealand	0.12
Ireland	7.8	Greece	18	Luxembourg	0.74	Ireland	0.20	Ireland	0.09
Belgium	7.8	Luxembourg	17	Ireland	0.73	Australia	0.19	Australia	0.08
Italy	7.8	Finland	16	Japan	0.67	Luxembourg	0.16	Luxembourg	0.07
Germany	7.7	Ireland	15	Australia	0.60	Portugal	0.12	Portugal	0.06
Finland	7.6	Norway	14	Greece	0.57	USA	0.10	Finland	0.05
Japan	7.2	Switzerland	13	USA	0.43	Finland	0.09	USA	0.05
Netherlands	7.2	USA	13	Austria	0.39	Italy	0.07	Iceland	0.04
Norway	6.4	Japan	12	Finland	0.38	Spain	0.07	Spain	0.04
Portugal	6.4	Italy	12	Norway	0.31	Canada	0.06	Belgium	0.03
UK	6.4	Portugal	11	Netherlands	0.30	Germany	0.06	Canada	0.03
Spain	6.3	Spain	11	UK	0.30	Netherlands	0.06	Italy	0.03
Austria	6.0	Netherlands	11	Switzerland	0.29	Belgium	0.05	Netherlands	0.03
Denmark	6.0	Belgium	11	Canada	0.27	Japan	0.05	Austria	0.02
Switzerland	5.6	Germany	11	Denmark	0.24	Norway	0.05	Denmark	0.02
USA	5.6	Canada	10	Belgium	0.19	UK	0.05	Germany	0.02
France	5.3	Australia	9	Sweden	0.08	Austria	0.03	Japan	0.02
Canada	5.3	UK	9	Portugal	0.07	Denmark	0.03	Norway	0.02
Australia	5.2	Austria	9	Spain	0.06	Sweden	0.03	UK	0.02
New Zealand	5.1	Denmark	8	CEE/FSU	0.06	Switzerland	0.03	France	0.01
Iceland	4.3	Sweden	7	Germany	0.05	France	0.02	Sweden	0.01
Sweden	3.5	France	6	France	0.01	Iceland	0.00	Switzerland	0.01

- a) A positive figure means that emissions in the first budget year should decrease by the percentage indicated compared to the level of GHG emissions in 2010, whereas a negative sign implies that they are allowed to increase by the percentage recorded.
- b) The case 'before trade' concerns the situation where emission reduction requirements are met fully by only domestic actions in both the first and second budget periods. Case A2 (B2) refers to the situation where no-regret options are excluded (included) in both the first and second budget periods.

The major lesson or conclusion from the above-mentioned shifts in country rankings is that allocation based burden sharing rules in terms of indicator 1 have only a relative meaning compared to other burden sharing indicators included in Table 5.4. The main reason for this finding is that the burden of emission mitigation is not only determined by the setting of emission limitation targets for the year 2015 (expressed as a reduction percentage relative to emission levels in 2010) but also by other factors such as:

- Trends in GHG emissions between 1990 and 2015 as determined by population/economic growth and other autonomous (technology) trends regarding GHG emissions.
- Major differences in abatement potentials and costs among countries and regions.
- Including or excluding the (unrestricted/limited) use of the Kyoto Mechanisms.

- Including or excluding no-regret options in (inter)national abatement strategies.

Hence, these factors have to be accounted for when designing and negotiating allocation based burden sharing rules for the years following the first budget period of the Kyoto Protocol.

6. EVALUATION OF SOME BURDING SHARING APPROACHES

6.1 Introduction

This chapter focuses attention on the policy feasibility and political acceptability of burden sharing rules (BSRs). In particular, it aims to identify a number of criteria that should be applied in evaluating the policy feasibility and political acceptability of proposals for BRSs that might be introduced into the global climate negotiations. Such criteria may be used when evaluating existing BSRs as well as proposals for new BSRs.

After a summary of fairness principles relevant to burden sharing, this chapter discusses to what extent individual BSRs (a) have universal applicability, (b) could easily be made operational, (c) are simple or complex, (d) could undergo future refinements, (e) would give room for flexibility, and, finally, (f) would allow to take country-specific circumstances into account. These criteria all seem relevant to consider when assessing the feasibility and acceptability of individual BSRs. The proposed evaluation criteria are summarised in the first two columns of Table 6.1.

Table 6.1 Types of burden sharing rules (BSRs) and evaluation of such rules with respect to fairness principles and operational requirements^a

	Criteria	Weight	<i>France</i>	<i>Japan II</i>	<i>Norway</i>	<i>Brazil/ RIVM</i>	<i>Triptych</i>	<i>Multi-sector convergence approach</i>
BSR type	Top-down (T) Bottom-up (B)		T	T	T	T	B	B
Fairness principles	i) 'need'	4	+	+	+	+	+	+
	ii) 'capacity'	4	0	0	+	+	+	+
	iii) 'guilt'	2	-	-	-	+	-	-
Sum: principles			2	2	6	10	6	6
Operational requirements	a) Universal applicability	2	+	0	-	+	0	+
	b) Easy to make operational	2	+	+	+	0	0	-
	c) Simplicity	1	+	+	0	-	0	0
	d) Allow for future refinements	1	+	0	0	+	+	+
	e) Allow for flexibility	1	0	+	+	0	+	+
	f) Allowance for country-specific circumstances	2	-	+	+	-	+	+
Sum: operational requirements			4	6	3	0	4	4
Total evaluation: principles/operational requirements			2/4	2/6	6/3	10/0	6/4	6/4

^{a)} Where + means criterion satisfied, - means criterion not satisfied, and 0 means inconclusive. The total evaluation or score is the sum of the weighted score for each criterion. Note that a '- ' means that the score on this criterion is subtracted from the total score. Thus a '- ' with weight 2 contributes minus 2 in the total score.

6.2 Principles of fairness relevant to Burden Sharing

It seems appropriate to construct BSRs that are based on at least one of the three principles of fairness stressing need, guilt, or capacity (see chapter 2 and references cited there). According to the guilt principle, the costs of undertaking measures to alleviate the climate problem – i.e. the abatement costs – should be distributed in some proportion to the degree to which actors are responsible for the climate problem. The other two principles are concerned with the impact of measures on actors (as opposed to their impact on the problem). The first principle would distribute the costs in accordance with actors' legitimate need for economic development, whereas the second principle would distribute the cost in accordance with actors' ability or capacity to solve the climate problem. Individual BSRs might build on one or more of these key principles of equity. However, in order to receive widespread support, any BSR intended to have an impact on international negotiations concerned with the environment and natural resources would probably need to combine at least two, and preferably three, of these principles.

6.3 Operational requirements

The first operational requirement is that a BSR should be universally applicable. Rules that can be applied to all, or almost all countries, are clearly more attractive than rules that are only partially applicable because the latter raise thorny questions about supplementary rules, exemptions, or both. In those situations it would be necessary to distinguish between those actors that should be bound by a rule and those who should not.

The degree to which individual BSRs can be made operational is another important issue to consider when assessing their policy feasibility. In some cases it will be possible to identify empirical indicators and quantitative data that can be coupled to individual BSRs in a straightforward manner. It is likely that these rules would be widely supported. Reliable and comparable data will be important. Indicators and statistics that are internationally approved might be more readily accepted than those that are not approved internationally. Even an otherwise promising BSR – e.g. one that combines several key principles of fairness – might receive insufficient support in case there is scarcity of relevant data for operational purposes.

It should be expected that BSRs that are relatively simple to make operational would be superior to those that are more complex. Basically, both the depth and the breadth of the data needed increase complexity.

It would seem self-evident that a possibility for adjusting and refining the operationalisation of burden sharing rules would be advantageous. Because the knowledge base regarding global warming is still evolving, it seems certain that new issues (as e.g. the cooling effect of particles) could have an impact on our understanding of the global climate system and accordingly on the operationalisation of BSRs and the need for refinement of their operationalisation (e.g. refinement of GWP-values). But although built-in possibility for refinement is advantageous, it would be unattractive if it reduces the extent to which BSRs could be made operational in order to address more current issues in global climate negotiations.

Yet another issue is concerned with flexibility. A BSR that allows for flexibility seems relatively more attractive, for example if national circumstances change unexpectedly at

some point in the future. One flexibility feature is to allow for rolling over from one budget period (such as the Kyoto target period 2008-12) to the next budget period.

A final issue concerns inclusion of country-specific circumstances. These might include criteria (e.g. inertia factors) like structure of national energy supply system, structure of the national economy, dependence on fossil fuel exports, population density, and population growth.

6.4 Choice of promising burden sharing proposals

Based on the survey of BSRs from the climate policy negotiations discussed in chapter 3 of this report, we have chosen the proposals from France, Japan II, Norway, Brazil/RIVM and Triptych as the first candidates for testing the evaluation criteria discussed in this study.²² These proposals are singled out in two steps from a large number of proposals that came up during the negotiations leading up to the Kyoto Protocol in December 1997. In the first step proposals that advocated a non-differentiated approach – that is equal percentage reductions of greenhouse gas emissions across countries – were left out together with proposals that were not specified enough to be made operational and thus enable us to quantify their consequences. In the second step the proposals that seemed most promising in future negotiations were singled out based on criteria like political feasibility, simplicity and reliability, regional or global relevance, and the potential for developing the method further. Consequently, we ended up with the same proposals as Torvanger and Godal (2000). This selection of proposals also constitutes a good overlap with the proposals that got most attention from the parties during the negotiations.

In addition we have included the multi-sector convergence approach developed in the joint ECN/CICERO project (Jansen et al. 2000) This BSR has some similarities with Triptych. The most important difference is the global coverage of the multi-sector convergence approach as compared to Triptych's regional coverage. Furthermore the multi-sector convergence approach contains more sectors than Triptych, which makes the

²² A more detailed description of the four proposals from the climate negotiations and Triptych can be found in Ringius et al. (1999). See also chapter 3 of this report.

former BSR more flexible and allows for more country-specific circumstances. The BSRs are shown in the first row of Table 6.1.

A BSR can be categorised as a top-down or bottom-up approach. Table 6.1 includes a classification of proposals into these two categories. Top-down methods tend to apply more aggregate indicators, for example emissions per capita and GDP per capita. Weighting of indicators may be used, even rather explicit, in mathematically phrased formulae. Bottom-up approaches, on the other hand, take into account sectoral contributions of greenhouse gases, cluster economic sectors together (e.g. domestic sector; export-oriented sector), and develop allowances at sector level. According to this classification the Triptych approach and the multi-sector convergence approach are the only bottom-up methods among the six proposals. The other proposals are top-down.

6.5 Evaluation of burden sharing approaches

We are now in a position to evaluate the six proposals from the climate policy negotiations according to our criteria a) to i). In Table 6.1 the proposals are given a score on each criterion, either ‘+’ for criterion satisfied, ‘-’ for criterion not satisfied, or ‘0’ for inconclusive. Each criterion is given a weight, after which the total score of the BSRs is calculated by adding up the weighted scores from the criteria. Note that a ‘-’ means that the score on this criterion is subtracted from the total score. There are separate total scores for fairness principles and for operational requirements. To reflect the importance of the two fairness principles ‘need’ and ‘capacity’ they are each given weight 4. The sum of all weights is 19, implying that the maximum score for a BSR is 19.²³ The third fairness principle ‘guilt’ is given only weight 2 since we believe that too much weight on ‘guilt’, especially in historical terms (that is responsibility for historical greenhouse gas emissions), will be less acceptable for industrialised countries. In terms of historical guilt there is likely to be data and methodological uncertainties related to such calculations. The operational criteria d), e) and i) are given double weight (2) compared to the other operational criteria. This is due to the importance of a BSR being able to handle both industrialised and developing countries in future climate policy negotiations. Criterion e) is important since reliance on uncertain or contentious data would make a BSR

²³ The maximum score may not be attainable in practice since there can be a trade-off between some criteria, i.e. between ‘simplicity’ and ‘allowance for country-specific circumstances’.

less feasible and undermine the credibility of the approach. Finally, in terms of criterion i), a BSR must allow considerations for country-specific circumstances to play a useful role in burden sharing negotiations among countries with largely different circumstances with regard to economic development and economic structure. The sum of all weights is 19, implying that the maximum score can be represented by 10/9 (score on fairness principles/score on operational requirements).

According to the simple evaluation procedure summarised in Table 6.1, the multi-sector convergence method and Triptych get the highest total score, owing to being supported by two fairness principles and a relative good score on operational requirements. This indicates that sector-based BSRs could play a useful role in climate policy negotiations among a larger group of countries, and could potentially also be helpful to incite developing countries to take on greenhouse gas abatement targets.

Since the maximum score is 10/9 we find that no single BSR is really capable of meeting all or even the large majority of criteria. Next are the Brazil/RIVM and Norwegian proposals. Brazil/RIVM has the largest score on fairness principles and Norway the largest score on operational requirements. The score on fairness principles is at least as high as the two sectoral approaches, but the score on operational requirements is lower. Japan II is next, followed by France. They have the same score on fairness principles, but France has the lowest score on operational requirements. Obviously these results are dependent on the weights of the criteria, and other possible criteria would yield different results. Nonetheless, the results give an indication of the proposed BSRs that seem most promising in future climate policy negotiations according to the criteria selected in this study.

7. CONCLUDING REMARKS AND SUGGESTIONS FOR FURTHER RESEARCH

7.1 Conclusions and major findings

The aim of the joint CICERO-ECN research project on burden sharing has been *to identify the most promising rules, applicable at the global level, for differentiation of greenhouse gas emission mitigation targets among countries*. First and foremost, however, it has to be stressed that the complex issue of sharing the burden of global emission mitigation can not be solved by a simple set of rules or equations, and that the design of a burden sharing rule is not intended to replace negotiations. Differentiation of emission mitigation commitments among countries will always be steered and ultimately finalised by political negotiations. Still, burden sharing rules can be of great value. They can support negotiations on differentiating emission mitigation targets by adding structure to these negotiations. Moreover, they can be a tool to provide insight into the consequences of alternative negotiation premises in terms of the allocation of global emission allowances. As such, burden sharing rules can facilitate actual negotiations.

However, in order to serve as a sound basis for international negotiations on differentiating emission limitations among a large variety of countries, a burden sharing scheme has to meet several criteria. Firstly, it should satisfy at least one of the three main principles of equity, notably ‘need’ – interpreted in terms of basic human needs – in order to be politically feasible. Most likely, however, it also has to meet one and, preferably, both other main principles of equity, i.e. ‘guilt’ and ‘capacity’. Moreover, a burden sharing rule relevant to international climate policy negotiations has to satisfy a number of operational requirements. In particular, it should (a) be universally applicable, (b) be easily made operational, (c) be simple to understand, (d) allow for future refinements, (e) allow for flexibility, and (f) allow to take country-specific circumstances into account.

The joint CICERO-ECN research project has developed a burden sharing rule – called the Multi-Sector Convergence approach (MSC) – that meets most of the above-mentioned criteria to a high extent. This approach:

- i. is based on a comprehensive accounting framework of greenhouse gas emissions by different sectors within the national economy,
- ii. takes as point of departure that, in principle, the amount of per capita emission assignments will have to ultimately converge to the same level for all countries, and
- iii. accommodates for the possibility that additional allowances may be granted to countries facing specific circumstances.

Some attractive features of the MSC approach are:

- It satisfies the equity principles of ‘need’ and ‘capacity’.
- The need principle is operationalised in a bottom-up sectoral fashion, which may improve the insight into the feasibility of global environmental goals and the reconciliation of these goals with concerns at the sector level.
- It meets the operational requirements of universal applicability and is comprehensive in terms of global coverage and coverage of the major greenhouse gas emissions as defined by the Kyoto Protocol.
- The MSC model tool allows for very flexible, user-defined parameter values in an interactive way and results in projections of atmospheric concentrations (expressed in ppm) on a CO₂ *equivalent* basis (including CH₄ and N₂O).
- The possibility of setting parameter values in an iterative way allows for reconciliation of concerns about mitigating potentially dangerous human-induced climate change, equity, and major country-specific factors accounting for variation in per capita emissions.
- It allows for rolling over from one budget period onto the next one with inclusion of newly evolving insights into the climate change issue, sectoral emission trends and infrastructural inertia. These evolving insights can be embedded in periodically negotiated adjustments of the framework parameter values.
- It allows for straightforward future refinements to the framework pending advances on the international climate change negotiation front and new sets of credible data becoming available.

In its present state, the MSC approach is still marked by some limitations. Firstly, because of its many variables and data needs, it is not always simple to understand or easy to make operational. Secondly, the necessary data – notably at the sector level – are not always readily available or fully reliable, particularly with regard to those GHGs – i.e. PFC, HFC and SF₆ – or those (non-Annex I) countries not covered by the present study. Thirdly, the annual sectoral emission mitigation rates of the multi-sector convergence approach are as yet largely based on intuitive, expert guesses and, hence, need further empirical underpinning. Fourthly, the operationalisation of the so-called ‘allowance factors’ – i.e. factors allowing or accounting for country-specific circumstances – is still in its initial stage and needs to be further developed.

In a strict sense, the MSC approach does not provide an indication of burden differentiation in terms of costs involved. Yet, as part of the CICERO-ECN project on burden sharing, the impact of the multi-sector convergence approach in terms of cost differentiation among Annex I countries has been estimated with regard to the so-called ‘second’ budget period (2013-2017). This exercise clearly demonstrated that allocation based burden sharing rules in terms of reduction percentages – or amounts of emissions to be mitigated – cannot be equated straightaway with other burden sharing indicators such as, notably, cost differentiation among countries. The main reason is that the cost burden of emission mitigation is not only determined by the setting of emission limitation targets for the year 2015 (expressed as a reduction percentage relative to emission levels in 2010) but also by other factors such as:

- Trends in GHG emissions between 1990 and 2015 as determined by population/economic growth and other autonomous (technology) trends regarding GHG emissions.
- Major differences in abatement potentials and costs among countries and regions.
- Including or excluding the (unrestricted/limited) use of the Kyoto Mechanisms.
- Including or excluding no-regret options in (inter)national abatement strategies.

Hence, these factors have to be accounted for when designing and negotiating allocation based burden sharing rules for the years following the first budget period of the Kyoto Protocol. In practice, this may imply that an iterative process of adjustments in terms of allowance factors and abatement targets may be introduced as part of the international

negotiations on burden sharing until a satisfying agreement is reached among all parties concerned.

Nevertheless, even when due allowance is made for these limitations, the joint CICERO-ECN research project on burden sharing has shown that, at least in principle, a multi-sector convergence framework can be developed that highly meets most of the key criteria to permit facilitation of future international policy negotiations on differentiating emission mitigation commitments among a large variety of countries.

7.2 Agenda for future research

The aforementioned limitations of the present study translate into suggestions for additional research:

- (i) One priority area concerns improving the availability, reliability, and comprehensiveness of data, notably with regard to the “sector” land use changes (sinks) as well as GHGs and countries not covered by the present study.
- (ii) Second, additional research is needed to improve the empirical underpinning of the annual sectoral emission mitigation rates of the multi-sector convergence approach.
- (iii) Further analysis and reflection is needed on what should be the per capita standard emission level in the convergence year: at what level – and in which year – does this standard satisfy the twin objectives of (a) favourable socio-economic development leading to the satisfaction of basic needs, improving living standards and the quality of life, and (b) a sustainable climate system?
- (iv) A fourth field of additional research is related to the further operationalisation – and, perhaps, the further extension of the number – of factors accounting for country-specific circumstances, i.e. the so-called ‘allowance factors’.
- (v) Finally, further study is needed regarding the cost implications of alternative allocations of global emission allowances. In doing so, special attention should be paid to individual non-Annex I countries in the second budget period as well as for all relevant countries in the third and subsequent budget periods (2018-2022 and so on). This research requires the construction of a large set of ‘dynamic’ cost curves covering a wide variety of individual countries and budget periods. Moreover, it requires an iterative interaction with the further fine-tuning of the

multi-sector approach – including allowance factors – in order to serve as an improved basis for international policy negotiations on sharing the burden of greenhouse gas mitigation.

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ANNEX 1 PROJECTDESCRIPTION

Background

The official project title is *Rules for burden differentiation of green house gas reduction*. The project started in October 1988 and the research was concluded by the end of 2000.

Study objective

The overall objective of this study is to identify the most promising rules applicable for differentiation of greenhouse gas emission reduction burdens. The expected results are: the development of the basic concepts behind emission differences between countries; an overview of the most relevant criteria to evaluate burden sharing rules; development of burden sharing rules; and evaluation and estimation of the consequences of different burden sharing rules.

Study rationale

In the context of reaching international agreements on reduction of greenhouse gas (GHG) emissions, burden differentiation plays an important role, as has recently been shown by the preliminary burden sharing agreement reached in the European Union in March 1997 and by the differentiated emission limits in the Kyoto protocol. The arguments for burden differentiation are the differences between countries regarding, among others, costs of emission reduction, economic development, implemented policies to reduce GHG emissions, existing energy configuration, geographical and climatic conditions, economic trade relations, etc.

In one instance a specific burden sharing formula has been instrumental in reaching an agreement (the 'trptych' approach, developed by K. Blok e.a. (*The Triptique approach: burden differentiation of CO₂ emission reduction amongst EU member states*, 1997), which has been the basis for the negotiation of the EU burden sharing agreement). Another example of a burden differentiation formula is the so-called 'Norwegian formula', developed by the CICERO research group in Norway. It should be noted that the role of burden sharing rules is that they are likely to provide an important starting point in the

process to reach agreements, a key analytical step in the negotiation process. Burden sharing rules will never take the place of negotiations between countries, but they can contribute to the reaching of an agreement, especially if the use of burden differentiation rules is incorporated in the design of negotiation processes. Apart from the 'tritych approach' and the 'Norwegian formula' mentioned above, there have been other publications in which burden sharing rules have been developed, such as Ridgley (*Fair sharing of greenhouse gas burdens*, 1996), who uses multicriteria decision making methods to develop rules on the basis of a number of different equity indicators, different contributions to Paterson and Grubb (*Sharing the Effort: options for differentiating commitments on Climate Change* 1996) and the report by Grubb and Collier (*Developing indices for differentiating CO₂ emissions in the European Union: issues and proposals* 1997) for DG XI on indices for differentiating CO₂ emissions in the European Union. However, burden sharing in climate agreements is a relatively new field of study; consequently the body of literature dealing specifically with this problem is therefore limited.

The simple guidelines or ethical principles on which such burden differentiation rules are based, such as, for example, emissions per capita, emission per unit of GDP, cumulative emissions etc., have been extensively researched, both in political science, economics and ethics (see, for example, Ringius (*Leaders, Differentiation and Fairness: Negotiating Climate Commitments in the European Community*, 1997), Ringius and Asbjørn Torvanger, *Can Multi-Criteria Rules Fairly Distribute Climate Burdens? OECD Results from Three Burden Sharing Rules*, Rose (*equity considerations of tradeable carbon emission entitlements* 1992)). However, less attention has been paid to identifying those fairness and equity principles which have played a significant role in the analysis of international environmental negotiations and to the question why these principles mattered.

Information is available, although to a varying extent, on the differences between countries which might play a role in formulating burden sharing formulas, such as sectoral energy use, industrial structure, economic development, potential for emission reduction and abatement costs. However, this information is not necessarily available at the level of detail, quality and comparability needed for defining burden sharing formulas which are useful as a basis for negotiating climate agreements. Moreover, the available information focuses almost exclusively on CO₂ emissions from energy use. Data with respect to other greenhouse gases (GHGs) and land use changes use which are included in the

Kyoto protocol are much less available. After Kyoto, some tentative overviews have recently been prepared for the countries of the EU (see e.g. Gielen, Koutstaal et al, *Post Kyoto - effecten op het klimaatbeleid van de Europese Unie*). The quality and availability of data is also less for countries other than the OECD countries.

The purpose of this study is to further develop the principle of burden sharing, to formulate burden sharing rules for GHG reduction including all the six GHGs (carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O), and the industrial trace gasses HFCs, PFCs and SF₆) and including those countries which are expected to accept emission limits in the next protocols. Furthermore, a user-friendly computer programme has been developed which can be used in negotiations and the first application of this tool will be part of the study. This study includes the Annex I countries, and selected Newly Industrialized Countries, selected oil exporting countries in the Middle East and selected developing countries (in particular China and India). The period considered is the first budget period of the protocol (2008-2012) and the subsequent period through the year 2100, with emphasis put on the period 2013-2017, presumably the second budget period.

Important questions set out to be answered in the present study included:

- what are relevant differences between countries on which burden sharing rules should be based?
- which information is missing or lacking in quality or comparability?
- which simple guidelines or ethical principles are relevant?
- which criteria should be applied to burden sharing rules (fairness, equity, political acceptability, acceptability of data quality, lucidity, allocative effectiveness, feasibility)?
- what are the results in terms of emission reduction targets, abatement costs and (as far as possible) economic consequences and with respect to other criteria?
- how should differentiation processes be designed in order to facilitate agreements between countries?
- what are the estimated consequences of emission trading and CDM/JI for the results of burden sharing rules?
- to what extent should allocation rules be different for different groups of countries and in different periods?

- how and how much will negotiators change their views on burden sharing rules, once someone is confronted with the consequences thereof?

Phasing and outputs of the study

The present project has been carried out in four phases:

Phase 1 consisted of an analysis of differences between countries relevant for greenhouse gas emission levels, especially existing energy configuration and economic development and an analysis of equity principles. Phase 1 also included an analysis of the experience from existing international agreements relevant for burden sharing. The emphasis was put on those fairness and equity principles that play a significant role in international agreements.

Phase 2 covered listings the most important criteria that burden sharing rules have to meet and the actual design of a diverse set of burden sharing rules.

Phase 3 included the calculation of the emission targets for countries and the analysis of the consequences of applying burden sharing rule. The consequences to be analysed also included estimates of the cost for emission reduction per capita per country and the marginal cost of emission reduction with and without instruments such as emission trading, JI and CDM.

Phase 4 dealt with dissemination. Firstly, the interactive, user-friendly Multi-Sector Convergence spreadsheet model was developed within the framework of the present project which allows policy makers to calculate the consequences of his/her preferred burdens sharing rules as structured by the so-called Multi-Sector Convergence approach designed within the present project. Second, two dissemination workshops were organised, one scientists' workshop in Oslo, 1-2 May 2000, and another in the form of a side event of CoP-6, The Hague, 18 November 2000, targeted at policy makers. The latter event was jointly organised by CICERO, ECN, RIVM, and Utrecht University.

ANNEX 2 LIST OF PROJECT PUBLICATIONS

- Berk, M.M., J. Gupta and J.C. Jansen: *Options for Differentiation of Future Commitments under the Climate Convention - examples of a comprehensive approach*. Contribution to upcoming NRP book. Forthcoming.
- Bruggink, J.J.C: *The Multi-ector convergence approach of burden sharing*. HDP Conference on Institutions and Instruments to Control Global Environmental Change, Maastricht, June 21-22 ,2001.
- Jansen, J. C., J. J. Battjes, J. P. M. Sijm, C. Volkers and J. R. Ybema (2000): *The Multi-ector convergence approach of burden sharing – A flexible sector-based framework for negotiating global rules for national greenhouse gas emission mitigation targets*. ECN Report ECN-C--01-007, Petten, and CICERO Working Paper No. 5, CICERO, Oslo.
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Ybema, J.R., J.C. Jansen, F.T. Ormel,(2000a): *Project definition and introduction to some key concepts and issues – The joint CICERO-ECN project on sharing the burden of greenhouse gas reduction among countries* ECN-C--00-010 / CICERO WP 1999: 12

Ybema, J.R., J.J. Battjes, J.C. Jansen, F.T. Ormel,(2000b): *Burden differentiation: GHG emissions, undercurrents and mitigation costs - The joint CICERO-ECN project on sharing the burden of greenhouse gas reduction among countries.* ECN-C--00-012 / CICERO WP 1999: 14

Websites

The following websites refer to an interactive model tool of the Multi-Sector Convergence approach and a side event during the sixth Conference of the Parties (The Hague, 18 November 2000) co-organised with RIVM and the University of Utrecht in the framework of the present project:

http://www.ecn.nl/unit_bs/kyoto/mechanism/burden.html

<http://www.iisd.ca/csd.html>

ANNEX 3 COORDINATION WITH OTHER PROJECTS AND PROGRAMMES

In the course of the present study project fairly intensive contacts were maintained with RIVM, leading party in the COOL project, especially with Messrs Marcel Berk and Michel den Elzen, and with Utrecht University, especially with Ms Heleen Groenenberg. The project team was represented in two COOL dialogue workshops taking place in Bilthoven on 4-6 July, 1999 and in Zeist on 6-7 July, 2000, respectively. RIVM and Utrecht University were represented at a project scientist workshop in Oslo on 1-2 May 2000. CICERO, ECN, RIVM and Utrecht University have jointly organised a side-event on the Burden Sharing issue at CoP-6 in The Hague on November 18th, 2000 that was quite successful in terms of (large) attendance and response.

ANNEX 4 ATTENDANCE AT NATIONAL AND INTERNATIONAL MEETINGS

Project workshop in Petten, November 1999. Presentation of three draft working papers. Ybema et al. (2000a), Ybema et al. (2000b), and Ringius, Torvanger and Underdal (1999).

Participation in two dialogue workshops of the COOL project (see Appendix 3).

Participation in the side event at CoP-6 on Burden Sharing, The Hague, 18th November 2000. Presentations by, among others, Asbjørn Torvanger (CICERO), Jaap Jansen (ECN), and Jos Sijm (ECN).