



CICERO

Senter for
klimaforskning

Center for
International Climate
and Environmental
Research - Oslo

Report 1999:5

A survey of differentiation methods for national greenhouse gas reduction targets

Asbjørn Torvanger and Odd Godal



Universitetet i Oslo

University of Oslo

ISSN: 0804-4562

CICERO Report 1999:5

A survey of differentiation methods for national greenhouse gas reduction targets

Asbjørn Torvanger and Odd Godal

August 1999

Report to Nordic Council of Ministers

CICERO

Center for International Climate and
Environmental Research – Oslo

P.O. Box 1129 Blindern

N-0317 Oslo, Norway

Phone: (+47) 22 85 87 50

Fax: (+47) 22 85 87 51

E-mail: admin@cicero.uio.no

Web: www.cicero.uio.no

Foreword

This report presents an overview of differentiation methods for national greenhouse gas reduction targets. The main features of differentiation proposals from climate policy negotiations are presented in a catalogue style. The proposals are from the period 1995 to 1997. In 1995 the Berlin mandate was adopted, which initiated the negotiation process that ended up in the Kyoto Protocol to the United Nations Framework Convention on Climate Change in December 1997. In addition the European Community's Triptique approach for differentiation of targets within the union is included. Furthermore, some contributions from recent academic literature are reviewed.

The Kyoto Protocol has set a significant precedence for climate target negotiations in the future, and particularly with respect to differentiation of targets between countries. A provision is that a sufficient number of parties ratify the Kyoto Protocol to make it enter into force in the next few years. However, the approach taken to target differentiation in the Kyoto Protocol negotiations is likely to be insufficient for future negotiations. Thus a more systematic approach is deemed necessary to undertake future negotiations on climate targets after the present target period has ended in 2012. This argument can be strengthened if more ambitious future targets than the present targets are sought. Furthermore, a more systematic approach to target differentiation is essential for a later inclusion of developing countries in the group of countries with climate targets.

The most promising methods or proposals in terms of being potentially helpful for future negotiations on differentiation are extracted. Finally some numerical illustrations for the most promising proposals are given for the countries in the Baltic Sea region.

The present report is to some extent a follow-up to an earlier report to the Nordic Council of Ministers; "Climate Policy, Burden Sharing and the Nordic Countries – Present State of Analysis and Need for Further Analysis" (see Ringius et al., 1996).

Asbjørn Torvanger and Odd Godal from CICERO (Center for International Climate and Environmental Research – Oslo) produced the report in the period October 1998 to February 1999. The authors want to thank our colleague Lasse Ringius for valuable contributions.

The report was commissioned by the Nordic Council of Ministers' 'Samarbetsgrupp mellan energi- och miljösidan'. It is scheduled for printing in the Nordic Council of Ministers' Tema Nord report series.

Contents

EXECUTIVE SUMMARY.....	7
NORSK SAMANDRAG (NORWEGIAN ABSTRACT).....	10
1 INTRODUCTION	13
2 FRAMEWORK FOR REVIEW OF DIFFERENTIATION METHODS	15
3 REVIEW OF DIFFERENTIATION PROPOSALS FROM THE AGBM NEGOTIATIONS	17
4 REVIEW OF SELECTED LITERATURE	31
5 EVALUATION OF PROPOSALS	34
6 THE MOST PROMISING METHODS: CONSEQUENCES FOR COUNTRIES IN THE BALTIC SEA REGION	35
6.1 Data and base year	35
6.2 Numerical analysis.....	36
6.2.1 Proposal-specific results	36
6.2.2 Country-specific results	42
6.3 Summary.....	48
7 AN EVALUATION OF THE POLITICAL FEASIBILITY OF THE PROPOSALS	49
8 LITERATURE.....	51

Index of tables

Table 1. Grouping of burden sharing proposals from the AGBM process _____	17
Table 2. Summary of proposals for burden sharing methods made by parties in the Ad Hoc Group on the Berlin Mandate (AGBM) negotiations _____	18
Table 3. Selected fairness principles and related burden sharing rules _____	19
Table 4. The French convergence proposal _____	21
Table 5. Summary of proposals for burden sharing methods from recent literature _____	31
Table 6. The most promising proposals and score on evaluation criteria _____	34
Table 7. Data used in the analysis, 1990 _____	36
Table 8. Distribution of emissions according to all proposals and all countries. Changes compared to 1990 levels, percent _____	42
Table 9. The differentiation proposals' percentage deviation from the Kyoto Protocol outcome _____	49

Index of figures

Figure 1. Egalitarian distribution of emissions. Changes compared to 1990 levels, percent _____	37
Figure 2. Distribution of emissions according to the Ability to pay principle. Changes compared to 1990 levels, percent _____	38
Figure 3. Distribution of emissions according to the second Japanese proposal. Changes compared to 1990 levels, percent _____	39
Figure 4. Distribution of emissions according to the French proposal. Changes compared to 1990 levels, percent _____	40
Figure 5. Distribution of emissions according to the Norwegian proposal. Changes compared to 1990 levels, percent _____	41
Figure 6. Impacts on Danish emission reductions using different burden-sharing rules _____	44
Figure 7. Impacts on Finish emission reductions using different burden-sharing rules _____	44
Figure 8. Impacts on German emission reductions using different burden-sharing rules _____	44
Figure 9. Impacts on Icelandic emission reductions using different burden-sharing rules _____	45
Figure 10. Impacts on Norwegian emission reductions using different burden-sharing rules _____	45
Figure 11. Impacts on Swedish emission reductions using different burden-sharing rules _____	45
Figure 12. Impacts on Estonian emission reductions using different burden-sharing rules _____	46
Figure 13. Impacts on Russian emission reductions using different burden-sharing rules _____	46
Figure 14. Impacts on Polish emission reductions using different burden-sharing rules _____	47
Figure 15. Impacts on Latvian emission reductions using different burden-sharing rules _____	47
Figure 16. Impacts on Lithuanian emission reductions using different burden-sharing rules _____	47

Executive summary

The aim of this report is to contribute to exploring the potential of differentiation methods for national greenhouse gas reduction targets. Such methods can also be referred to as burden sharing methods or schemes. As a first step in this exploration project a survey of existing differentiation proposals is helpful. The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) from 1997 established differentiation of targets among countries, but not in any systematic manner. Our opinion is that a more systematic approach to differentiation will facilitate future negotiations. Future negotiations to determine national targets after 2012 are likely to occur, and sooner or later there will be a discussion of commitments for developing countries. More elaborated approaches and methods for differentiation will not solve all political differences and problems, but could be helpful and contribute a guiding framework for climate policy negotiations.

Three sources of methods or proposals are employed. The first are proposals from the Ad Hoc Group on the Berlin Mandate (AGBM) process from 1995 until the Kyoto Protocol was adopted in December 1997. From this negotiation process we identified and selected all proposals that implied some type of differentiation of targets. Altogether this came to 17 proposals made by a single party or groups of parties. The second source is the European Community's Triptique approach for differentiation of targets among its member states. The third source is recent academic literature, where we have included 8 contributions that we found interesting from the period 1992 to 1998. The proposals are presented in a catalogue style.

Based on 4 criteria on the usefulness of proposals or methods for future negotiations we have chosen 5 proposals as representing the most interesting and promising contributions. These criteria are political acceptability, feasibility related to negotiations, regional or global relevance of method, and the potential for developing the method further. The most promising contributions are the second proposal by Japan, the French proposal, the Norwegian proposal, the Brazilian proposal further developed by the Dutch RIVM research institute, and finally, EU's Triptique approach:

- ◆ *The second Japanese proposal*; where each party should reduce their emissions by 5% compared to 1990 levels. However, if emissions per unit of Gross Domestic Product (GDP), or emissions per capita, are lower than the average of all parties, the target is proportionally reduced. Likewise the target is proportionally reduced if population growth is higher than average.
- ◆ *The French proposal*; where targets are differentiated so that emission pathways converge to similar per capita or per unit of GDP levels by the end of the next century, with the aim of keeping atmospheric concentrations of CO₂ below 550 ppmv.
- ◆ *The Norwegian proposal*; where each party's percentage reduction target is distributed according to the weighted sum of the three indicators CO₂ equivalent emissions per unit of GDP, GDP per capita, and CO₂ equivalent emissions per capita, such that those parties that have higher than average values for these indicators also get a higher than average target, and vice versa.

- ◆ *The Brazil-RIVM proposal*; where targets are differentiated according to each party's historical responsibility for global warming, in terms of accumulated contribution to radiative forcing in the atmosphere since the industrial revolution.
- ◆ *EU's Triptique approach*; where the differences in emission-producing activities across the member states are accounted for through dividing each national economy into the three sectors electricity generation, energy-intensive industries, and other domestic sectors. In the electricity generation sector emissions are distributed according to minimum penetration of renewables, limits to fossil fuel use, and use of nuclear power. The energy-intensive industries are allowed to increase production at a constant rate based on the same energy-efficiency improvement rate. Finally, emissions from other domestic sectors are distributed on a per capita basis, to converge to the same future level.

For the purpose of showing differentiation consequences of the selected methods, we supply some numerical illustrations for the Baltic Sea region. The countries in this region are the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), the Baltic countries (Estonia, Latvia, and Lithuania), in addition to Germany, Poland, and the Russian Federation.

Given the joint Kyoto Protocol reduction target for the countries in the Baltic Sea region we compare the burden sharing consequences for one proposal or method across countries, and for one country across the methods or proposals. The comparison is based on the distribution of percentage emission reduction targets across the countries in the region. For the illustrations we employ the following fairness principles as differentiation methods:

- *The Sovereignty principle*; interpreted as reduction of emissions proportionally across all countries to maintain the relative emission level between them;
- *The Egalitarian principle*; interpreted as reduction of emissions in proportion to population (i.e. equal per capita emission); and
- *The Ability to pay principle*; interpreted as differentiation of climate targets such that the net abatement cost is positively correlated with per capita GDP.

Furthermore, illustrations are given for the second Japanese proposal, the French proposal, and the Norwegian proposal. No illustrations are given for the Brazil-RIVM proposal and EU's Triptique approach, since the required calculations would be outside the scope of this report. The results should only be taken as illustrations to illuminate differences between differentiation methods.

Comparing the distribution of commitments across countries generated by the differentiation proposals we find that the span between the largest and smallest targets is much larger for the single fairness principles 'Egalitarian' and 'Ability to pay' than for the three proposals from the climate negotiations. In the latter three proposals Estonia and the Russian Federation have to reduce their emissions by much more than the average reduction for the Baltic Sea region countries of 6%. In the Norwegian proposal the heaviest burden falls on Poland. According to the French proposal Sweden and Iceland are allowed to increase their emissions due to a relatively low present emission level. The Nordic countries and Germany are allowed to increase their emissions substantially given the Egalitarian principle. However, given the Ability to pay principle these countries would get a much larger burden than the other

countries. The results for proposals from the climate negotiations all lie between these extremes; that is between +9% (the French proposal for Sweden) and -12% (the French proposal for Estonia).

With the aim to evaluate the political feasibility of the various differentiation methods we compare the results from chapter 6 across the countries in the Baltic Sea region, and divide them into OECD and EIT countries. Furthermore, we interpret the outcome of the Kyoto Protocol (and the internal differentiation scheme within the European Community) as an example of a politically feasible differentiation scheme, which may then serve as a benchmark for comparison with the differentiation methods evaluated here.

On the basis of these observations we find that the Sovereignty and Egalitarian methods seem less interesting. The first method yields no differentiation, and the latter is too extreme in the short run since it equalises per capita emissions. Second, the Ability to pay method puts the largest burden on the OECD countries, whereas the Japan II proposal, the French proposal, and to some the degree the Norwegian proposal, put the largest burden on EIT countries. Third, all the methods explored provide Russia with a stricter target than the Kyoto Protocol, while the opposite situation is the case for Denmark and Germany. And finally, fourth, Japan II is the proposal that yields targets closest to the Kyoto Protocol, followed by the French and the Norwegian proposal. The three fairness principles based methods cause larger deviations from the Kyoto Protocol outcome.

Consequently one might argue that a ranking of the differentiation methods according to political feasibility should be: 1. Japan II, 2. French, 3. Norwegian, 4. Ability to pay, 5. Sovereignty, and 6. Egalitarian. However, putting more emphasis on the second conclusion above, one might claim that the Ability to pay based method should have a higher ranking, and maybe be ranked in first place. The argument for this would be that it is unfair, and consequently also less politically feasible, to demand that the relatively poorer EIT countries should reduce their emissions by a larger percentage than the OECD countries.

Among the countries in the Baltic Sea region Poland might be taken as proxy of a developing country due to its relatively low per capita GDP and its average per capita emissions of greenhouse gases. With this provision the most promising methods for involving developing countries seem to be based on the Ability to pay principle and the French proposal, since these methods are likely to yield relatively softer targets for developing countries.

Norsk samandrag (Norwegian abstract)

Føremålet med denne rapporten er å undersøkje potensialet til metodar for differensiering av nasjonale mål for å redusere utslepp av klimagassar. Slike metodar blir også referert til som byrdefordelingsmetodar. Eit fyrste skritt er å få oversikt over metodar for differensiering som er foreslått. Kyotoprotokollen til FN sin Klimakonvensjon frå 1997 etablerte prinsippet om differensiering av mål mellom land, men utan å leggje ein systematisk metode til grunn. Vår oppfatning er at ei meir systematisk tilnærming til differensiering vil kunne forenkle framtidige klimaforhandlingar. Framtidige forhandlingar for å fastsetje nasjonale mål etter 2012 er sannsynlege, og før eller sidan må det bli ein diskusjon om forpliktingar for utviklingsland. Meir sofistikerte tilnærmingar og metodar vil kunne vere hjelpsame og vil kunne gje eit nyttig rammeverk for framtidige klimaforhandlingar.

Tre kjelder til metodar og framlegg er brukt. Den første er framlegg frå "Ad Hoc Group on the Berlin Mandate" (AGBM) prosessen som enda opp med Kyotoprotokollen i desember 1997. Frå denne forhandlingsprosessen har vi identifisert og valt ut alle framlegg som innebar ein eller anna type differensiering av reduksjonsmål. I alt vart det 17 framlegg frå einsskilte partar eller grupper av partar. Den andre kjelda er Triptique-tilnærminga for å differensiere mål mellom medlemsstatane i EU. Den tredje kjelda er nyare akademisk litteratur, der vi har plukka ut 8 artiklar frå perioden 1992 til 1998 som vi fann interessante. Alle metodar og framlegg er presenterte i eit katalogformat.

Basert på 4 kriterium på kor nyttige framlegg eller metodar kan vere for framtidige forhandlingar har vi valt ut 5 framlegg som dei mest interessant og lovande. Desse kriteria er politisk aksept, i kva grad kan metoden brukast i ein forhandlingssituasjon, regional eller global relevans, og potensialet for å utvikle metoden vidare. Dette er det andre framlegget til Japan, the franske framlegget, det norske framlegget, det brasilianske framlegget vidareutvikla av det nederlandske RIVM forskingsinstituttet, og til sist, EU si Triptique-tilnærming:

- ◆ *Det andre japanske forslaget;* der kvart land skal redusere utsleppa sine med 5% samanlikna med nivået i 1990. Dersom utsleppa per eining BNP eller utslepp per capita er lavare enn gjennomsnittet for alle land i gruppa blir målet redusert frå 5% i same proporsjon. På same måte blir målet redusert dersom veksten i folketalet er høgare enn gjennomsnittet i gruppa av land.
- ◆ *Det franske forslaget;* der måla blir differensiert slik at utsleppsbanane konvergerer mot same per capita nivå eller mot same utsleppsnivå per eining BNP mot slutten av neste hundreår, der siktemålet er å halde konsentrasjonen i atmosfæren under 550 ppmv.
- ◆ *Det norske forslaget;* der kvart land sin prosentvise reduksjon blir fordelt etter den vektla summen av dei tre indikatorane CO₂ ekvivalente utslepp per eining BNP, BNP per capita, og CO₂ ekvivalente utslepp per capita, slik at dei landa som har høgare verdiar enn gjennomsnittet for desse indikatorane i gruppa av landa får eit høgare mål, og vice versa.
- ◆ *Forslaget til Brasil-RIVM;* der måla blir differensierte etter kvart land sitt historiske ansvar for global oppvarming, målt etter akkumulerte utslepp av klimagassar i atmosfæren og gjennom det påverknad på strålingspådrivet sidan den industrielle revolusjonen.

- ◆ *EU si Triptique tilnærming*; der ein tek utgangspunkt i forskjellane i utsleppsgenererande aktivitetar mellom landa ved å dele økonomien i eit land inn i tre hovudsektorar: produksjon av straum, energi-intensive sektorar, og andre innanlandske sektorar. I sektoren for produksjon av straum blir utsleppa fordelt etter eit minimumsnivå for bruken av vedvarande energikjelder, skrankar på bruken av fossile energivarer, og bruken av kjernekraft. Dei energi-intensive industriane får lov å auke sin produksjon etter ein konstant rate basert på same rate for forbedringar i energieffektiviteten. Utsleppa frå andre innanlandske sektorar blir fordelt på per capita basis, slik at dei konvergerer mot same nivå i framtida.

For å samanlikne differensieringskonsekvensane av dei valde framlegga har vi produsert nokre numeriske illustrasjonar for land i Austersjø-området. Landa i denne regionen er dei Nordiske landa Danmark, Finland, Island, Noreg og Sverige, dei baltiske landa Estland, Latvia og Litauen, i tillegg til Tyskland, Polen og Russland.

Med utgangspunkt i reduksjonsmåla frå Kyotoprotokollen for landa i Austersjø-regionen har vi samanlikna byrdefordelingskonsekvensane av eit framlegg mellom alle landa, og for kvart land mellom alle framlegga. Samanlikninga er basert på fordelinga av prosentvise reduksjonsmål mellom landa i regionen. I illustrasjonane blir desse rettferdsprinsippa brukte for å differensiere utsleppmåla mellom landa:

- ◆ *Suverenitetsprinsippet*; tolka som ein proporsjonal reduksjon i utsleppa over alle land slik at det relative utsleppsnivået ligg fast;
- ◆ *Egalitærprinsippet*; tolka som ein proporsjonal utsleppsreduksjon etter folketalet (d.v.s. like per capita utslepp); og
- ◆ *Betalingssevneprinsippet*; tolka som differensiering av reduksjonsmål slik at netto kostnad ved klimatiltaka er positivt korrelert med BNP per capita.

Vidare har vi teke med illustrasjonar for det andre japanske forslaget, det franske forslaget, og the norske forslaget. Vi har ingen illustrasjonar for det brasilianske framlegget og Triptique ettersom dette ville krevje utrekningar som ligg utanfor rammene for denne rapporten. Resultata bør berre oppfattast som illustrasjonar som kan vise forskjellar mellom metodane og framlegga til differensiering.

Når vi samanliknar byrdefordelingskonsekvensane mellom land som følgjer av framlegga finn vi at spennet mellom dei største og minste reduksjonsmåla er mykje større for dei enkle rettferdsprinsippa 'Egalitær' og 'Betalingssevne' enn for dei tre framlegga frå klimaforhandlingane. I dei tre framlegga frå klimaforhandlingane må Estland og Russland redusere sine utslepp mykje meir enn gjennomsnittet for alle landa Austersjø-regionen, som er på 6%. I den norske framlegget fell den største byrden på Polen. Ut frå det franske framlegget vil Sverige og Island kunne auke sine utslepp fordi dei per i dag har lave utslepp per capita. Dei nordiske landa og Tyskland kan auke sine utslepp monaleg ut frå det Egalitære prinsippet. Men skulle Betalingssevneprinsippet bli lagt til grunn vil desse landa få ei større byrde enn dei andre landa. Byrdefordelingskonsekvensane av framlegg frå klimaforhandlingsprosessen ligg alle mellom desse ytterverdiane; det vil seie mellom +9% (det franske framlegget for Sverige) og -12% (det franske framlegget for Estland).

For å vurdere i kva grad differensieringsmetodane kan gjennomførast politisk sett samanliknar vi resultatane frå kapittel 6 for landa i Austersjø-området og grupperer dei i OECD- og EIT-land (omstillingsøkonomiar). Vidare ser vi på dei nasjonale måla i Kyotoprotokollen (og den interne byrdefordelinga i EU) som eit døme på eit politisk akseptabelt differensieringsutfall. Dei nasjonale måla frå Kyotoprotokollen kan såleis brukast som ein målestokk på i kva grad metodane politisk sett kan gjennomførast når vi samanliknar med resultatane frå dei differensieringsmetodane vi drøftar her.

På bakgrunn av desse observasjonane finn vi at 'Suverenitet' og 'Egalitær' metodane er mindre interessante. Den fyrste av desse metodane gjev ingen differensiering, og den andre er for ekstrem på kort sikt fordi den krev like per capita utslepp. Den andre konklusjonen er at 'Betalingsevne' vil leggje størst byrde OECD landa, medan Japan II, det franske framlegget, og til ein viss grad det norske framlegget, legg størst byrde på omstillingsøkonomiane. For det tredje fører alle metodane til ein større byrde for Russland enn Kyotoprotokollen, medan det motsette er tilfelle for Danmark og Tyskland. Og, for det fjerde er Japan II det framlegget som gjev mål som ligg nærast Kyotoprotokollen, følgd av det franske framlegget og the norske framlegget. Dei tre metodane som byggjer på rettferdsprinsipp medfører alle relativt større avvik frå Kyotoprotokollen. På denne bakgrunn kan vi setje opp følgjande liste med metodar, der metodane som politisk sett sannsynlegvis lettast kan bli gjennomført står først: 1. Japan II, 2. Det franske framlegget, 3. Det norske framlegget, 4. 'Betalingsevne', 5. 'Suverenitet', og 6. 'Egalitær'. Dersom ein derimot legg meir vekt på den andre konklusjonen ovanfor kan ein argumentere for at 'Betalingsevne' bør ha ei høgare plassering på lista, og kanskje til og med få førsteplassen. Argumentet for dette er at det er urettferdig, og dermed også mindre politisk akseptabelt, å krevje at relativt fattige omstillingsøkonomiar skal redusere sine utslepp meir enn OECD land.

Mellom landa i Austersjø-området kan Polen brukast som eit "tilnærma utviklingsland" på grunn av relativt lavt brutto nasjonalprodukt per capita og gjennomsnittlege utslepp av klimagassar per capita. I eit slikt perspektiv kan dei mest lovande metodane for å involvere utviklingsland vere 'Betalingsevne' og det franske framlegget, sidan desse metodane sannsynlegvis vil medføre relativt mjukare mål for utviklingsland enn dei andre metodane.

1 Introduction

The aim of this study is to contribute to exploring the potential of differentiation methods for national greenhouse gas reduction targets. Such methods can also be referred to as burden sharing methods or schemes. As a first step in such an exploration project a survey of existing proposals is helpful. One of the important principles included in the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) from 1997 is differentiation of targets among countries. However, 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.¹ Our opinion is that a more systematic approach to differentiation will facilitate future negotiations. Assuming that the Kyoto Protocol will be ratified by enough Parties and enter into force, future negotiations will be needed to determine targets after 2012.² Sooner or later there will also be a discussion on commitments for developing countries, and what criteria and burden sharing arrangements that should apply in such cases.³ Finally, there is a possibility that EU will need to re-negotiate its present differentiation of targets according to the Triptique approach, if the present commitments turn out to be much more challenging than anticipated for some of the member states.⁴ More elaborated approaches and methods for differentiation will not solve all political differences and problems, but could be helpful and contribute a guiding framework for climate policy negotiations, confer Ringius et al. (1998) and Torvanger et al. (1996).

We employ three levels or concepts for describing differentiation methods in the analysis. The first level relates to one or more fairness or justice principles that might be supported by the proposal. Second, a proposal's main feature is the formula or rule specified. Finally, the methods require operational indicators (i.e. data or criteria), see Ringius et al. (1998).

Three sources of methods or proposals are employed. 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 1997.⁵ 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 17 proposals made by a single party or groups of parties. The second source is the European Community's Triptique approach for

¹ The final targets in the Kyoto Protocol vary from a Party being allowed to increase its greenhouse gas emissions by 10% in the target period 2008-2012 compared to 1990, to parties having to reduce their emissions by 8%.

² The first 5-year target period of the Kyoto Protocol is 2008-12. By year 2005 the Parties should show demonstrable progress in achieving their commitments.

³ Developing countries, the so-called non-Annex I countries, do not have any commitments to reduce their emissions of greenhouse gases in the Kyoto Protocol. However, due to the fast increase of emissions from this group of countries, their share of annual global emissions may reach 50% by the middle of the next century. One possibility is to agree that a country should take on commitments to reduce its emissions as soon as its level of development reaches a specific level, such as the gross domestic product per capita of the poorest group of OECD countries. Annex I countries are industrialized countries, as defined in an annex to the United Nations Framework Convention on Climate Change.

⁴ The present scale of differentiation within the European Community is from an increase in emissions by 27% compared to 1990, to reduction of emissions by 28%.

⁵ 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.

differentiation of targets among its member states. The third source is recent academic literature, where we have included 8 contributions in the period 1992 to 1998 that we find interesting. The proposals are presented in a catalogue style. We have not included other Parties' reactions to these proposals during the negotiations, since this would require a more extensive analysis of the negotiations than has been possible in this study.

For the purpose of showing differentiation consequences of some of the proposed methods, we supply some numerical illustrations for the Baltic Sea region. The countries in this region are the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), the Baltic countries (Estonia, Latvia, and Lithuania), in addition to Germany, Poland, and the Russian Federation. Within this geographical region the variation in national resource bases and level of development is large enough to give a good test of the proposed methods.

In chapter two the framework for reviewing differentiation methods is discussed, where a number of organising principles are mentioned. The next chapter of the report presents the catalogue review of proposals from the AGBM negotiation process, where the 17 proposals are divided into 8 groups according to common features. In chapter four a review of selected recent literature is presented. This is followed by an evaluation of the proposals in chapter 5, where the 5 most promising methods are selected according to four criteria. In chapter 6 the same 5 proposals are explored through numerical illustrations. Given the joint Kyoto Protocol reduction target for the countries in the Baltic Sea region we compare the burden sharing consequences for one proposal or method across countries, and for one country across the methods or proposals. Finally, in chapter 7, the political feasibility of the methods is evaluated. This evaluation is based on the results from chapter 6, and a comparison to the Kyoto Protocol outcome and the internal differentiation scheme of the European Community.

2 Framework for review of differentiation methods

One or more organising principles or dimensions is useful in a survey of burden sharing proposals to make the survey more accessible and facilitate comparison of proposals. The challenge is to choose a principle that is helpful for this purpose given the heterogeneous features of the proposals. Some possible dimensions are:

1. Allocation, outcome- or process-based⁶
2. Dynamic or static
3. Based on single base year (e.g. 1990) (or period) emissions or accumulated historic emissions
4. Supported fairness or justice principle
5. Global or regional relevance (where regional relevance could mean suitable for Annex I countries only)
6. Reduction based or emissions allowance based targets

Dimension 1 refers to three main categories of rules, where the allocation-based focus is on the initial allocation of emission allowances among countries. The outcome-based proposals, on the other hand, focus on welfare effects generated by the proposals, whereas the common feature of the process-based proposals is a focus on the process of allocating allowances to emit greenhouse gases, confer Rose et al. (1998).

The second dimension refers to the framework of the proposal or method being static or dynamic. An example of a static approach is the Norwegian proposal (no. 6). The Triptique approach is an example of a dynamic method, where the base year and the growth projections, etc., can be easily updated over time.

Next, the issue at hand is the historical responsibility for increased greenhouse gas concentrations in the atmosphere. If historical responsibility is accepted the relevant emission data could be accumulated emissions from a country since the industrial revolution around 1750 up till e.g. 1990. If historical responsibility is rejected we are left with emissions from a single year or period as the reference data.

A number of fairness or justice principles exist, confer Rose et al. (1998), Ringius et al. (1998) and Barrett (1992). One difficulty is that there is no simple one-to-one relation between a fairness principle and a specific formula, meaning that one formula can be supported by more than one principle, and one principle can support more than one formula. Another difficulty with the proposals from the AGBM negotiation process is that fairness principles seldom are clearly specified. In some cases one might be able to infer a principle (or two or three principles) from the proposal text, however.

The fifth dimension refers to the flexibility of the proposals. Given that structural differences increases as one moves from e.g. Nordic countries to OECD countries, and even more to non-Annex I countries, a proposal of global relevance must be able to handle larger structural differences than a more limited, regional proposal. Obviously, some of the proposals from the AGBM negotiations seem to be more flexible than other proposals, confer Table.

⁶ See Rose et al. (1998), Table 1.

Finally, the sixth dimension relates to the burden sharing scheme being based on allowances to emit greenhouse gases, like the French convergence proposal, or if it is based on the determination of reductions among the countries of a group, like the Norwegian proposal.

3 Review of differentiation proposals from the AGBM negotiations

Based on the six dimensions in Chapter 2 and common features among the proposals we have organised the 17 proposals from the AGBM process into 8 groups. The grouping is shown in Table, 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 2. There are numerous proposals that are based on flat percentage reductions. These are, however, not examined further in this study.

Table 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
Triptique	12. EU's Triptique approach
Gross Domestic Product (GDP) per capita	13. Poland et al. 14. Estonia 15. Poland and Russia 16. Korea
Cost-effectiveness	17. New Zealand

Table 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	Egalitarian	Progressive burdens compared to emissions. Convergence		x									
2	Switzerland	Dec. 96	Egalitarian	Progressive burdens compared to emission Convergence		x					(x)				
3	EU	Mar. 97	Egalitarian	Convergence		x	x								
4	Brazil	May 97	Polluter pays	Burdens corresponds to cumulative emissions						x					
5	Brazil-RIVM	Nov. 98	Polluter pays	Burdens corresponds to cumulative emissions						x					
6	Norway	Nov. 96	Egalitarian, Ability to pay	Multi-criteria formula		x	x	x							
7	Iceland	Jan. 97	Egalitarian, Ability to pay	Multi-criteria formula		x	x	x							RE/TE
8	Australia	Jan. 97	Mixture	Unweighted set of 5 indicators			x	x (Proj.)			x	x (Proj.)	x		
9	Iran	Mar. 97	Mixture	Unweighted set of 8 indicators						x			x		More
10	Japan I	Dec. 96	Sovereignty, Egalitarian	Parties can choose 1 of 2 indicators	x	x									
11	Japan II	Oct. 97	Sovereignty, Egalitarian	Parties can choose 1 out of 3 indicators	x	x	x					x			
12	Triptique	1997	Horizontal, Ability to pay	Multiple set of indicators											
13	Poland et al.	Mar. 97	Polluter pays, Ability to pay, Egalitarian	Unweighted set of 4 indicators	x	x	x	x							
14	Estonia	Mar. 96	Ability to pay, polluter pays	Two possible indicators				x		(x)					
15	Poland and the Russian Fed.	Aug. 95	Mixture	Unweighted set of 7 indicators		x		x						x	More
16	Korea	Feb. 97	Ability to pay, Polluter pays	Unweighted set of 3 indicators			x	x		x					
17	New Zealand	Nov. 96	None	Global least cost											Eq. marg. abatement costs

Abbreviations in table 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.
ΣCDE:	The cumulative historical emissions contributing to global warming.
CDE _{exp} /CDE _{tot} :	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 kilometer 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.

An explanation of the fairness principles used in table 2 follows below in table 3.

Table 3: Selected fairness principles and related burden sharing rules.

Fairness principle	Interpretation	Example of implied burden sharing rule
Egalitarian	Equal rights of people to use the atmospheric resources	Reduce emissions in proportion to population or equal per capita emissions
Sovereignty	Current rate of emissions constitutes a status quo right now	Reduce emissions proportionally across all countries to maintain relative emission levels between them
Horizontal	Similar economic circumstances have similar emission rights and burden sharing responsibilities	Equalise net welfare change across countries (net cost of abatement as a proportion of GDP is the same for each country)
Ability to Pay/ Vertical	The greater the ability to pay the greater the economic burden	Net cost of abatement is positively correlated with per person GDP
Polluter pays	Carry abatement burden corresponding to emissions (eventually including historical emissions)	Share abatement costs across countries in proportion to emission levels

Sources: Rose (1992), ABARE and DFAT (1995), Bureau of Industry Economics (1995), Burtraw and Toman (1992).

The catalogue format chosen for the review of differentiation methods proposed during the AGBM negotiation process is the following:

- a. Name and reference of proposal.
- b. Who made the proposal, when, and on what occasion.

- c. The main features of the proposal.
- d. Summary. Could the method potentially be helpful for future negotiations, possibly in a further developed version.

In addition EU's Triptique approach is included.

Group: Convergence

The principal common feature of proposal 1 (France), 2 (Switzerland), and 3 (EU) is convergence of per capita emissions over time. This means that those countries that have high 1990 per capita emissions must reduce their emissions more than countries that have relatively low per capita emissions. In the long run, by year 2100 according to the French proposal, all countries would meet at the same per capita emission level.

1 France

- a. French contribution to the AGBM before EU developed a joint position.
Source: FCCC/AGBM/1997/MISC.1, p. 25
- b. France prepared the following proposal in December 1996 for the 6th session of the AGBM, Bonn, 3-7 March 1997.
- c. The French proposal is based on a reduction in emissions to reach an atmospheric concentration of 550 ppmv of CO₂ as a future goal, and has a "per capita" approach as the main element for burden sharing. According to IPCC's second assessment report, this concentration level can be obtained if average per capita level of CO₂ and other GHGs emissions are in the range of 1 to 2.7 tons of carbon equivalent within the Annex I Group by the end of the next century. On this basis, France proposes that burdens should be distributed so that the emission pathways converge to similar per capita or per unit of GDP levels by the end of the next century. Numerically, the proposal is designed as follows:

$$E_{i,2010} = E_{i,2000}^{9/10} \times X^{1/10}$$

Where:

$E_{i,2010}$ = carbon dioxide equivalent emissions in year 2010 for country i

$E_{i,2000}$ = carbon dioxide equivalent emissions in year 2000 for country i

X = Emission goal per capita for all countries in 2100

The resulting commitments in 2010 given some levels of per capita emissions in year 2000 are shown in

Table 4: The French convergence proposal.

Per capita emission in 2000	Per capita emission objective for 2010	Average percentage reduction 2000-2010
3 teC/cap	2.8-2.9 teC/cap	5,0%
4 teC/cap	3.7-3.8 teC/cap	6,3%
5 teC/cap	4.5-4.6 teC/cap	9,0%
6 teC/cap	5.3-5.4 teC/cap	10,8%

The burdens are in other words defined so that countries with high per capita emissions must undertake a larger percentage reduction in emissions.

- d. The French proposal is interesting as a method of implementing a long-term atmospheric stabilisation target, and due to its focus on convergence of per capita emissions in all countries. But, even with 100 years time horizon the proposal might seem idealistic when aiming for complete convergence.

2 Switzerland

- a. Switzerland. Source: FCCC/AGBM/1997/MISC.1.
- b. The Swiss proposal was prepared in December 1996 for the 5th session of the AGBM in December 1996.
- c. The Swiss proposal addresses the emissions of CO₂, CH₄ and N₂O and targets a 10% reduction of the total GHG emissions of Annex I Parties by the year 2010 compared to the 1990 levels. It states that countries should be grouped in categories differentiated by increments of 5 tons of annual CO₂-equivalent emissions per capita. Burdens should then be distributed so that countries with the highest CO₂-emissions would be obliged to achieve the biggest emission reduction. The proposal opens for adjustments to this rule if a Party has a large energy-intensive exporting industrial sector.
- d. The Swiss proposal is in general simple to handle. It shows some similarities to the French proposal. Exactly how the different groups of emitters shall be treated is however not explicitly defined.

3 EU

- a. Framework compilation of proposals from Parties for the elements of a protocol or another legal instrument. Source: FCCC/AGBM/1997/2, p. 31.
- b. France and Spain made the proposal, in submission by the EU. The proposal was prepared for the 6th session of the AGBM, Bonn, 3-7 March 1997.
- c. Annex I Parties would adopt greenhouse gas emissions paths converging eventually to similar levels of emissions per capita or per unit of GDP leading to an overall emissions reduction within specified time-frames.

- d. This proposal is difficult to evaluate since the level of specification is low.

Group: Historical responsibility

The main common feature of proposal 4 (Brazil) and 5 (Brazil-RIVM) is the emphasis on historical responsibility for global warming, in terms of accumulated contribution to radiative forcing or temperature increase in the atmosphere since the industrial revolution.

4 Brazil

- a. The Brazilian contribution to the AGBM.
Source: FCCC/AGBM/1997/MISC.1/Add.3, p. 3.
- b. Brazil prepared the following proposal in May 1997 for the 7th session of the AGBM, Bonn, 31 July-7 August 1997.
- c. The proposal for burden sharing is designed so that Parties receive a burden that corresponds to the same Party's responsibility for contributing to climate change. In order to quantify this contribution, cumulative historical emissions needs to be estimated, which together with the state of the art knowledge in the natural science field can produce relevant information for this criterion. The proposal is designed in order to be applied to all Parties, including developing countries.
- d. This proposal is interesting since it includes accumulated historical emissions by a country and calculates the its responsibility in terms of atmospheric warming. One limitation is that only fossil fuel based CO₂, CH₄ and N₂O is included. Responsibility of the present generation for past emissions when global warming was unknown, is a disputable principle.

5 Brazil-RIVM

- a. The Brazilian proposal and other options for international burden sharing. Source: Berk and Elzen, (1998).
- b. The proposal was presented by the Netherlands National Institute for Public Health and the Environment (RIVM) at the COP-4 in Buenos Aires, November 1998. The proposal is in general a technical revision of the previous Brazilian proposal, giving suggestions for elements that could be improved.
- c. After the proposal was presented at the AGBM in August 1997, Berk and Elzen (1998) at the RIVM, carried out a more in depth study of the technical parts of the proposal, which was presented as a discussion paper in Buenos Aires, 1998. Among the conclusions it is worth mentioning that the technical methodology in the original Brazilian proposal was incorrect and needed to be improved. It overestimated the contribution of the Annex I to temperature change relative to non-Annex I. It would be preferable to use a multi-gas approach, including all sources and sinks. Furthermore, it seemed preferable to estimate the contribution to concentrations or radiative forcing rather than temperature changes.

Finally they considered it more equitable to use the per capita contribution rather than using the absolute contribution to temperature or concentration increase.

- d. This is an improved version of the Brazilian proposal under number 4. Some weaknesses are reduced due to new data and better models, making the method preferable to the original Brazilian proposal.

Group: Multi-criteria formula

The Norwegian (no. 6) and Icelandic (no. 7) proposals are to a large extent overlapping. They are multi-criteria rules containing indicators for Ability to pay (GDP per capita), Egalitarian (emissions per capita), and 'energy efficiency' (emissions per unit of GDP). Deviations from average value (of the group of countries) of one or more of these indicators generate a burden above the average percentage emission reduction required in the group.

6 Norway

- a. Norwegian contribution to the AGBM negotiation process.
Source: FCCC/AGBM/1996/MISC.2/Add.2, p. 25. The formula was developed through a research project documented in Torvanger et al. (1996).
- b. Norway prepared the following proposal in November 1996 for the 5th AGBM session in Geneva in December 1996.
- c. A formula considers a Party's percentage reductions of greenhouse gas emissions based on the three indicators: CO₂ equivalent emissions per unit of GDP (indicator for emission intensity), and GDP per capita and CO₂ equivalent emissions per capita are included to induce an equitable outcome⁷. The formula is:

$$Y_i = A[x(B_i/B)+y(C_i/C)+z(D_i/D)]$$

Where Y_i is percentage reduction of emissions for Party i . B_i is CO₂ equivalent emissions per unit of GDP for country i , and B is the equivalent average for the group of countries (i.e. the Annex I countries). Likewise C_i and C are GDP per capita for country i and for the average of the group, and D_i and D are CO₂ equivalent emissions per capita for country i and the average of the group. x , y and z are weights that add up to one. A is a scale factor to ensure that the desired overall reduction in emissions for the group of countries is achieved.

- d. The Norwegian multi-criteria formula is relatively simple, but has quite some capacity built into it to handle countries with different emission, population and economic development structures, in particular due to its multi-criteria nature. However, it is a relatively static top-down approach and consequently not sensitive to differences between economic sectors as driving forces for emissions.

⁷ According to previous proposals submitted by Norway, emission figures were to be based on a country's future emissions, following the business as usual scenario. However, according to FCCC/AGBM/1996/MISC.2/Add.2, p. 25, this is no longer explicitly stated.

7. Iceland

- a. Submission made by the Government of Iceland to the UNFCCC, AGBM.
Source: FCCC/AGBM/1997/MISC.1, p. 28.
- b. Iceland prepared the following proposal in January 1997 for the 6th session of the AGBM, Bonn, 3-7 March 1997.
- c. The Icelandic proposal is expressed as a formula consisting of the following four elements.
 - GHG emission intensity (measured per capita) (+)⁸
 - GDP per capita (+)
 - Level of GHG emissions (+)
 - Share of renewable energy sources (-)

All GHGs should be included; counting both sources and sinks. The proposal does not specify the weights of each element, nor the aggregate reduction in emissions for all Parties. In a later proposal by Iceland dated October 1997 the criteria “level of GHG emissions” is replaced by “CO₂ emissions in industrial processing as a share of party’s total CO₂-emissions (-)”.

- d. This proposal is very similar to the Norwegian proposal, the main difference being inclusion of the share of renewable energy sources as a fourth component.

Group: Fossil fuel dependency

The most important common feature of proposal 8 (Australia) and 9 (Iran) is dependency of income on fossil fuel exports. In addition both proposals include economic growth and population growth.

8 Australia

- a. Further submission by Australia, dated 15 January 1997.
FCCC/AGBM/1996/MISC.2/Add.2, p. 3.
- b. The Australian paper is dated 15 January 1997.
- c. The Australian proposal for burden differentiation is to be applied to all Annex B countries and includes all GHGs, all sources and sinks. The following set of criteria should be used in order to ensure equal percentage changes in per capita economic welfare across Annex B Parties from mitigation action:
 - Projected population growth. (-)

⁸ The following notation is used throughout the document. (+) indicates that the criteria is positively correlated to the size of the burden. E.g. in the Icelandic proposal, the higher the emissions per capita are, the larger should the Party’s burden become.

- Projected real GDP per capita growth (-)
 - Emission intensity of GDP (+)
 - Emission intensity of exports (-)
 - Fossil fuel intensity of exports (-)
- d. The Australian proposal is relatively complex since there are 5 criteria that need to be quantified, and since two of them deals with projected figures. The method is not specified in detail, however, it is only meant to function as a framework for negotiations.

9 Iran

- a. Main elements for inclusion in a protocol or another legal instrument. Submitted by the Islamic Republic of Iran. Source: FCCC/AGBM/1997/MISC.1, p. 30
- b. Iran prepared the following proposal for the 6th session of the AGBM, Bonn, 3-7 March 1997
- c. The proposal contains a list of criteria that could be considered when differentiating burdens. These criteria are:
- Economic growth
 - Historical share
 - Dependency on income from fossil fuels
 - Access to sources of renewable energy
 - Defence budget
 - Population growth
 - Special circumstances
 - Share in international trade
- There are no specifications on how each element should count.
- d. The proposal is vague. It contains some unique indicators, such as defence budget.

Group: Menu-approach

Even if there are a number of differences between the two Japanese proposals 10 (Japan I) and 11 (Japan II), they have one important common feature, namely the menu-approach. According to these proposals a country may choose one of two or three options that make its emission reduction commitment smallest. The proposals also imply a well-defined upper constraint on commitments.

10 Japan I

- a. Japan; Proposals on the elements to be included in the Draft Protocol to the UNFCCC. Source: FCCC/AGBM/1996/MISC.2/Add.4, p. 3
- b. The Japanese proposal was prepared 9 December 1996 for the 5th session of the AGBM in December 1996.

- c. The Japanese proposal is to be applied to all Annex I countries, other Parties are to take voluntary measures. The proposal gives an Annex I Party the possibility to choose one out of two paths.
 - To maintain its anthropogenic emissions of carbon dioxide over a five year period at an average yearly level not more than p tonnes of carbon per capita, or
 - To reduce its anthropogenic emissions of carbon dioxide over a five year period at an average yearly level of not less than q per cent below the level of the year 1990.
- d. The Japanese proposal is original in the way that Parties can choose between two completely different criteria. Although the values of the parameters p and q not are specified, it seems that Parties with high per capita emissions could benefit using the second strategy, were as low per capita emitters could benefit from the first strategy.

11 Japan II

- a. Japanese proposal as presented in FCCC/AGBM/1997/MISC.1/Add.6, p. 13.
- b. This Japanese proposal was submitted in October 1997 for the 8th session of the AGBM, Bonn, 22-31 October 1997.
- c. The Japanese proposal covers the gases CO₂, CH₄ and N₂O. In general, each Annex I country shall reduce emissions by 5% in the first budget period (2008-2012) compared to 1990 levels. However, countries with the following conditions may apply any one of the following alternative reduction rates:
 - (a) For a country of which emissions per GDP in 1990 (A) are less than the emissions per GDP of all Annex I countries in 1990 (B):
Alternative reduction rate (%) = $5\% \times (A/B)$
 - (b) For a country of which emissions per capita in 1990 (C) are less than the emissions per capita of all Annex I countries in 1990 (D):
Alternative reduction rate (%) = $5\% \times (C/D)$
 - (c) Similar alternative reduction rate for countries with high population growth must be developed.

Under no circumstance shall any country's emissions exceed its 1990 levels.

- d. This Japanese proposal would effectively reduce emissions from Annex I to less than 5% as many countries by definition have lower than average emissions with respect to one of the two variables described above or population growth. Hence, there will be extensive use of the alternative reduction rate options.

Group: Triptique

Among the proposals we have listed, EU's Triptique approach is unique due to the bottom-up approach, where the economy is divided into three sectors. Thus there are no other proposals in this group.

12 EU's Triptique approach

- a. The Triptique approach was developed by Block et al. (1997) at the University of Utrecht.
- b. The methodology for this burden-sharing key was developed on the request of the Netherlands Presidency. The motivation for the request was to develop a method for distributing emission commitments across members of the European Community.
- c. The main motivation for the approach was to develop a method that would take into account the differences in emission-producing activities across the member states. It is important to note that the approach not only determines the distribution of commitments but also the aggregate level of emissions from the member states. As a first step in the Triptique approach, emissions were divided in three groups.
 - Emissions from electricity generation
 - Emissions from the internationally oriented energy-intensive industries
 - Emissions from other domestic sectors

Emissions are in general treated differently across the groups, but equally across the member states. No other greenhouse gas (GHG) than carbon dioxide is included in the analysis.

The electricity-generating sector showed large variation across the states regarding emissions of CO₂. First of all, the total consumption (and production) of electricity in the EU was set to be limited to a growth rate of 1% per year, instead of the 1.5% that was used as the conventional wisdom projection. Some extra allowance was given the cohesion countries.⁹ Carbon dioxide emissions were then to be distributed taking into account;

- minimum percentages for the penetration of renewable energies and combined heat and power (CHP)
- limitation of oil and coal use
- use of nuclear power according to national preferences
- remainder to be supplied using natural gas

The energy-intensive part of the industrial sector was allowed to increase production at a constant rate across all countries.¹⁰ The same energy efficient improvement rate was also applied across the member states for this sector, leading to a fixed reduction factor for CO₂ emissions for all countries.

⁹ Consisting of Greece, Spain, Portugal and Ireland.

¹⁰ Consisting of the following industries: building materials, chemical, iron and steel, non-ferrous metals, pulp and paper, refineries, coke ovens (if they were not a part of the iron and steel industry), gasworks and other energy transformation branches, where electricity generation is excluded.

Emissions from the domestic sectors were distributed on a per capita base.¹¹ The main rule was that emissions per capita should converge to the same level across all countries at a certain point in the future (e.g. 2030) that is 20 or 30% lower than in 1990. The allowance in 2010 was then calculated using linear interpolation between actual figures in 1990 and desired level in 2030. The emission levels were only corrected for variations in natural climate across the countries.

- d. It is important to remember that the above method is only applied in order to calculate a particular distribution of burdens. How a country satisfies commitments is entirely up to the country itself. This method is one of the few that has actually been used in practice in this field, and should therefore be considered as a possible tool for future burden sharing. However, it is also important to be aware of the relative homogeneity across the members of the European Community in terms of economic structure and output, historical and present responsibility for possible climatic changes, abatement costs and vulnerability to climate changes. For this reason, it is difficult to predict how well this method can be adapted to a broader group of countries.

Group: GDP per capita

The common feature of proposal 13 (Poland et al.), 14 (Estonia), 15 (Poland and the Russian Federation), and 16 (Korea) is the focus on the GDP per capita as an important indicator for distributing commitments. GDP per capita can be interpreted as a proxy variable for Ability to pay. In addition some of these proposals, but not all, have a reference to emissions per capita and/or contribution to global emissions.

13 Poland et al.

- a. Framework compilation of proposals from Parties for the elements of a protocol or another legal instrument. Source: FCCC/AGBM/1997/MISC.1, p. 75.
- b. The proposal was prepared on behalf of Bulgaria, Estonia, Latvia, Poland and Slovenia for the 6th session of the AGBM, Bonn, 3-7 March 1997.
- c. Each Annex I Party should have some flexibility in adopting emission reduction objectives. The following criteria should be used for this purpose:
 - GDP per capita;
 - Contribution to global emissions;
 - Emissions per capita and/or emission intensity of GDP.
- d. This proposal is difficult to evaluate due to a low level of specification.

¹¹ Consisting of households, services, light industry, agriculture and transportation.

14 Estonia

- a. Possible features of a protocol or another legal instrument. Estonia.
Source: FCCC/AGBM/1996/7, p. 15.
- b. The Estonian proposal was prepared 15 January 1996 for the 3rd session of the AGBM, Geneva, 5-8 March 1996.
- c. The Estonian proposal should be applied to a “basket” of gases including sinks. The main criteria for differentiation could be GDP per capita. In addition it opens for the incorporating of a Party’s contribution to global warming.
- d. This proposal is difficult to evaluate due to a low level of specification.

15 Poland and the Russian Federation

- a. UNFCCC, Implementation of the Berlin Mandate, Poland and Russia.
Source: FCCC/AGBM/1995/MISC.1/Add.1, p. 54.
- b. The proposal was prepared by Poland and the Russian Federation in August 1995 for the 2nd session of the AGBM in Geneva 30 October-3 November 1995.
- c. The proposal states that the criteria used to distribute reduction commitments should reflect social, economic and some climatic parameters relevant in the context of sustainable development. The following criteria were mentioned:
 - GDP per capita;
 - Amount of anthropogenic emissions, first of all of carbon dioxide and methane, per capita and per unit of territory;
 - Amount of sinks and net emissions per capita and per unit of territory;
 - Levels of production and consumption of energy per capita.
- d. The proposal contains similar elements to the ones described above, except for the consideration of a country’s territorial area.

16 Korea

- a. A proposal on the Elements in a Draft Protocol or Amendment of the United Nations Framework Convention on Climate Change (UNFCCC) by the Government of the Republic of Korea. Source: FCCC/AGBM/1997/MISC.1/Add.1, p. 13.
- b. The following proposal was prepared by Korea in February 1997, for the 6th session of the Ad Hoc Group on the Berlin Mandate (AGBM), Bonn, 3-7 March 1997.
- c. The Korean proposal focuses on three principles that all should be considered when distributing emission reduction commitments: burden sharing based on equity and common but differentiated responsibilities and respective capabilities, cost effectiveness

and harmony with economic development and an open international economic system. The equity principle is to be taken care of by distributing emission allowances across Annex I Parties according to cumulative emissions of GHGs since the industrial revolution to a certain target year. The burdens should also be connected to a country's capability measured in terms of gross domestic product (GDP) per capita and based on the elasticity of emissions of GHG in terms of GDP.

- d. The method contains elements that are common to other proposals, but does not define the exact key for burden sharing.

Group: Cost-effectiveness

New Zealand (no. 17) has supplied the only proposal in this group. The special feature of this proposal is the emphasis on cost-effectiveness. According to the proposal commitments should be distributed so as to equalise marginal abatement costs across countries.

17 New Zealand

- a. Greenhouse gas stabilisation: Principles to guide the formulation of possible targets & policies and measures. Source: FCCC/AGBM/1996/MISC.2/Add.4, p. 15.
- b. New Zealand prepared the following proposal in November 1996 for the 5th session of the AGBM in December 1996.
- c. The key element of the New Zealand position is that emissions reductions should be achieved at global least cost. A least cost approach does not neglect equity; rather, a least cost approach improves the prospects of finding an equitable outcome acceptable to all. If differentiated commitments are considered it is important that this is on the basis of a simple principle that reduces the disparity between Parties in terms of abatement costs implied by uniform targets. One possible option would be to aim to share commitments in a manner consistent with the outcome expected if marginal costs were equalised. Clearly there are a range of options which could reduce cost disparities.
- d. The New Zealand proposal focuses on designing a protocol that ensures a global least cost solution, but not on burden sharing as an issue separated from cost-effectiveness.

4 Review of selected literature

The literature on burden sharing in the context of international climate policy agreements is of a rather recent date. The first studies have addressed the burden sharing issue in the context of allocating carbon quotas or allowances among countries, whereas more recent contributions analyse differentiation of targets. In this chapter we review recent contributions from the academic literature. The studies are shown in Table 5 together with supported fairness principles and main features.

Table 5: Summary of proposals for burden sharing methods from recent literature.

Ref. no.	Proposal	When proposed	Fairness principle	Main features
18	Claussen and McNeilly	1998	Horizontal Vertical Polluter pays	Countries divided into three tiers according to standard of living, responsibility, and opportunity
19	Rose et al.	1998	Sovereignty Egalitarian Horizontal Vertical Consensus equity	Welfare implications for world regions; non-linear programming model
20	Rose & Stevens	1998	Egalitarian Sovereignty 'No harm'	Emissions trading in dynamic model; extend Kyoto Protocol to DCs
21	Rose	1992	Horizontal Vertical Ability to pay Rawls' maximin Egalitarian Other principles	Tradable emission quotas; calculate welfare changes for large countries
22	Rowlands	1997	Reactive historical Proactive historical Ahistorical Equality or efficiency	Emission targets for OECD countries given each rule
23	Ridgley	1996	Egalitarian Ability to pay Other principles	Multiple criteria methodology; lexicographic optimisation
24	Kawashima	1996	Egalitarian Ability to pay	'Emissions needs' to set targets for Annex I countries; tests single-criterion and multi-criteria rules
25	Barrett	1992	Sovereignty Egalitarian Ability to pay Kantian allocation rule Other principles	Tradable emission quotas; game-theoretic analysis of outcomes for large countries

18 Claussen and McNeilly (1998) noting that the non-systematic differentiation approach of the Kyoto Protocol negotiation outcome is not sufficient as a basis for future negotiations, explore important elements for a fair differentiation scheme at the global level. They propose to build on three criteria, responsibility for present and past emissions of carbon dioxide, standard of living (or ability to pay), and opportunity to reduce emissions. On this basis they come up with a division of countries into three tiers. The first tier is "Must act now", containing most current Annex I countries (among them Denmark, Germany, and Norway)

and some developing countries. The third tier “Could act now”, contains developing countries of extremely low income. Finally, the second tier, “Should act now, but differently”, lies between the two other tiers and contains mostly developing countries (but also the Baltic Sea region countries Estonia, Finland, Iceland, Latvia, Lithuania, Poland, Russia, and Sweden).

19. Rose et al. (1998) study alternative equity criteria for global warming policy. The criteria are divided into allocation-based, outcome-based and process-based criteria. By employing a non-linear programming model they examine the welfare implications of the alternative criteria for major world regions. The results indicate that the net abatement cost is almost the same for several criteria. However, criteria such as the Egalitarian principle and consensus equity show rather extreme results.

20. Rose and Stevens (1998) analyse fairness aspects of the current Kyoto Protocol and its development into a global treaty where also developing countries get reduction targets. They employ a tradable emission quota framework and a dynamic model of emissions trading among countries. Developing countries are divided into two groups according to per capita income being higher or lower than USD 1000, where in one scenario the first group take on commitments in 2010 and the other in 2020. They find particularly large gains from interregional trading when developing countries participate with quotas based on their 2010 (and subsequent years) projected emissions. For quota distributions according to the Sovereignty or Egalitarian principle there is also a large global gain, primarily because developing countries make earlier commitments than otherwise likely.

21. Rose (1992) presents a thorough analysis of ten international equity principles. The principles are used to allocate carbon entitlements with and without trading to eight major countries and world regions. Both static reference and dynamic reference bases are employed. The dynamic reference bases take into account cumulative emissions. Alternative equity principles are shown to lead to widely different welfare implications for the world regions. Trading reduces these differences to a large extent.

22. Rowlands (1997) examines rules for the allocation of GHG emissions among OECD countries. The rules are divided into six categories according to the relevance of historical emissions (i.e. reactive historical, proactive historical, and ahistorical) and emphasis on equality or efficiency. He calculates the emission reductions generated for each country and rule, and then concludes that the rules produce very different results for the various OECD countries. Finally he proposes a twin-track strategy, consisting of flat-rate targets in the short term and differentiated targets in the longer term.

23. Ridgley (1996) describes an approach to find the ‘relative accountability’ of multinational regions for reducing GHG emissions. Various approaches are discussed and divided into equity based approaches, on the one hand, and indices and target based approaches, on the other hand. Next, a survey of multi-criteria decision methods is presented in which the methods are divided into principle or performance based methods, and interactive or non-interactive methods. He argues that such methods have a high potential for developing compromise burden sharing schemes. The author illustrates the multiple criteria methodology by defining eleven equity indicators and combining them by employing a lexicographic optimisation method. He shows that the resulting accountability profile over the eleven multinational regions produces a high degree of fairness.

24. Kawashima (1996) starts out with differentiation of targets for the Annex I countries in the FCCC. As the first step she determines CO₂ 'emission needs' based on the three countries with lowest emissions. A population-based rule, a GDP-based rule, and a multi-criteria rule (population, GDP, carbon intensity, temperature and area) are examined, where five sectors are specified. In the second step the emission baselines developed in the first step are employed to set targets. One alternative is to set targets in proportion to the emission baselines. Another alternative is to set targets in proportion to the difference between actual emissions and the baseline. The main finding is that the multi-criteria rule yields less difference between the smallest and largest target for a country than single-criterion rules.

25. Barrett (1992) observes that ethical rules often serve as focal points when negotiating international agreements. He proceeds to present a brief overview of thirteen allocation rules for tradable carbon emission entitlements. Next, he undertakes an analysis in a game-theoretic framework of outcomes for the United States, the Soviet Union, China and rest of the world. A 'Kantian' rule is explored. From this rule countries choose abatement levels at least as high as the uniform abatement level they would like all countries to observe. This rule outperforms all other rules, and the outcomes come close to the co-operative solution, and with the 'Kantian' rule all countries are better off than in the case of no agreement.

All these studies are interesting contributions to the analysis of burden sharing methods applied to climate politics, for instance in terms of rules for initial allocation of emission quotas in a trading system. However, the methods employed are not easily applicable to actual negotiations since they often are complex and depend on specific economic models. All parties would have to accept a single model framework to use these methods, which seems less realistic. The three-tier approach by Claussen and McReilly (1998) has a higher score on political feasibility, but needs further refinements to become operational. Thus the contributions from the literature in general get a low score on criteria 1 and 2 in chapter 5. We have therefore chosen not to evaluate these methods further in chapter 5, but concentrate the evaluation of methods on proposals from the AGBM negotiation process.

5 Evaluation of proposals

The main criteria used for the evaluation of the proposed differentiation methods is the usefulness for future climate policy negotiations, either in its present form or based on a modified version of the proposal. More specifically the four criteria are:

1. Political acceptability (e.g. support from major Parties).
2. Feasibility related to the negotiations (simplicity and reliability).
3. Is the method of regional or global relevance (i.e. Annex B or also non-Annex B countries)?
4. The potential for developing the method further.

In addition to these criteria our choice has been constrained by the extent to which specific methods are operational. For some proposals both the formula and indicators are well defined, and can be supported by easily available data. Other proposals are not fully specified. In the literature there are also methods that assume that a specific economic model is available to calculate welfare changes. Furthermore it is assumed that the model and its results are acceptable to all parties, which seems to be less realistic. Given the four criteria above and these additional considerations we ended up with a list of 5 proposals that seem most promising and potentially helpful for future negotiations under the Kyoto Protocol for target periods after 2012, such as 2013-17. The list is shown in Table together with the score on the four criteria.

Table 6: The most promising proposals and score on evaluation criteria.

PROPOSAL	Political acceptability H: high M: medium L: low	Feasibility H: high M: medium L: low	Global (G) or regional (R) relevance	Future potential H: high M: medium L: low
a. Japan II	M	H	G	M/H
b. France	M	H	G	M/H
c. Norway	M	H	R	M/H
d. Brazil-RIVM	M	M	G	M/H
e. Triptique	H	M	R	M/H

This list does not imply any ranking of the proposals with respect to helpfulness for future negotiations. In our opinion such a ranking would be premature at this point. In the next chapter some numerical illustrations for the proposals are given.

6 The most promising methods: Consequences for countries in the Baltic Sea Region

Numerical illustrations are given for the first three proposals in Table . With regard to the last two proposals, Brazil-RIVM and Triptique, they require more data and calculations than what is feasible in this study. Consequently, the numerical illustrations in this section are limited to Japan II, France and Norway. In addition we include methods based on the fairness principles Sovereignty, Egalitarian, and Ability to pay, (as explained in Table) confer e.g. Rose et al. (1998). Other methods from recent literature are not further explored since they are based on economic models and relatively complex formulae, or are not fully specified, thus giving a low score on criteria 1 and 2 in chapter 5.

6.1 Data and base year

More sophisticated methods for burden sharing are relevant for the negotiations for the second target period 2013-17. To provide numerical illustrations of the proposals chosen we need data, which depend on the base year chosen. On this background one could assume that the Kyoto Protocol targets are achieved in 2010, and then negotiate a common target and differentiation of targets among the Parties for 2013-17. In this case year 2010 could be referred to as the new base year. If 2010 is chosen as a new base year we would need projections for gross domestic product (GDP) and population. However, to limit data uncertainty we have chosen to employ 1990 data and implement the Kyoto targets in the group of countries. Consequently we frame the problem at hand as testing implications of the burden sharing proposals for the countries in the Baltic Sea region. We compare the burden sharing consequences of one proposal across the countries, and then the burden sharing consequences for one country across the proposals. We furthermore assume that the Kyoto Protocol target for the group of countries is met, and that all six gases and groups of gases are included. If data on the three industrial gases are missing, we still treat the data as complete, thus containing all gases. For our purpose this should be acceptable, and in particular since the share of the three industrial gases is likely to be small for most countries.

In order to carry out a numerical analysis on the chosen proposals and general methods, four kinds of data were needed for all countries. Emission data are taken from FCCC/CP/1998/11/Add.2. Estonia, Finland, Latvia, Lithuania and Poland have not reported emissions of the industrial gases, HFC, PFC and SF₆ for year 1990, and only CO₂, CH₄ and N₂O are included for these countries. For all other countries, all six gases are reported¹². The other three kinds of data were taken from the United Nations Statistical Yearbook, (UN, 1997) contributing with 1990 data for population size, population growth and GDP per capita.¹³ When calculating the overall target for the group as stated in the Kyoto Protocol, we have, for the member countries of the European Community (EU), chosen the reduction rates agreed upon internally within the EU. A summary of the input data used in the analysis is

¹² The emission figure for Denmark is the actual 1990 emissions of 71 837 kt CO₂ equivalents. However, according to Jørgen Abildgaard at the Danish Energy Agency, Denmark's commitment to a 21% reduction in the period 2008-2012 is based on a 1990 level of about 80 million tonnes corrected CO₂-equivalents (J. Abildgaard, personal communication 15 April 1999).

¹³ Population growth was based on changes in population in the period 1990-1995. GDP per capita data were not corrected for purchasing power parities.

presented in table 6. The reduction rates are presented in the column ‘Kyoto Target’, and are given as an emission factor to be multiplied with the 1990 emissions in order to achieve the commitment.

Table 7: Data used in the analysis, 1990.

Country	Population 1000	Annual Pop. growth, %	GDP/capita USD/capita	GHG emiss. kt CO2 eq.	Kyoto Target Index
Denmark	5 140	0.3 %	25 122	71 837	0.79
Estonia	1 571	-1.2 %	7 605	40 719	0.92
Finland	4 986	0.5 %	27 037	64 546	1.00
Germany	79 365	0.6 %	21 533	1 212 467	0.79
Iceland	255	1.1 %	24 480	2 889	1.10
Latvia	2 671	-1.2 %	7 020	35 669	0.92
Lithuania	3 722	0.0 %	5 218	51 548	0.92
Norway	4 241	0.5 %	24 882	54 011	1.01
Poland	38 119	0.3 %	1 547	546 286	0.94
Russia	148 292	0.0 %	6 539	3 040 332	1.00
Sweden	8 559	0.6 %	26 844	66 457	1.04
Total	296 921			5 186 761	
Weighted Average		0.22 %	11 428		0.94

The overall emission reduction required in this group of countries in order to fulfil the Kyoto Protocol is calculated to be 6.0 percent.

6.2 Numerical analysis

6.2.1 Proposal-specific results

In this section we describe the methodology used to quantify burden shares and present the results according to the proposals.

Sovereignty

When burdens are allocated so that relative emission levels between all countries are to remain constant, all countries will have to reduce emissions by the same percentage. Formally we have:

$$R_i = \frac{CDE_{tot,KP}}{CDE_{tot,1990}} - 1$$

Where:

R_i = Reduction rate applied to country i

$CDE_{tot,KP}$ = Total carbon dioxide equivalent emissions for the group of countries required to fulfil the Kyoto Protocol

$CDE_{tot,1990}$ = Total carbon dioxide equivalent emissions for the group of countries in 1990

This rule implies that the reduction rate of all countries becomes 6.0 percent.

Egalitarian

When calculating the distribution of emission reductions that could occur if burdens were to follow the Egalitarian principle, the required average per capita emissions needed to fulfil the Kyoto Protocol were applied to all countries. The country-specific reduction rates are hence calculated by applying the following formula.

$$R_i = \frac{CDE_{i,1990} / Pop_{i,1990}}{CDE_{tot,KP} / Pop_{tot,1990}} - 1$$

Where:

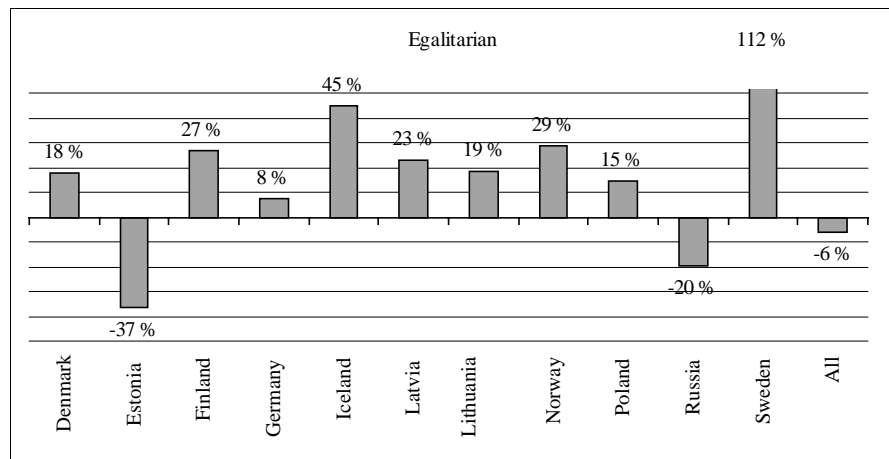
$CDE_{i,1990} / Pop_{i,1990}$ = Carbon dioxide equivalent emissions per capita by country *i* in 1990

$CDE_{tot,KP}$ = Total carbon dioxide equivalent emissions for the group of countries required to fulfil the Kyoto Protocol

$Pop_{tot,1990}$ = Total population in the group of countries

The results are presented in Figure 1.

Figure 1: Egalitarian distribution of emissions. Changes compared to 1990 levels, percent.”



As Figure 1 indicates, Russia and Estonia will need to reduce emissions, all other countries can increase. Sweden could more than double emissions, as their per capita level today is relatively low.

Ability to pay

We consider a simple rule that can be interpreted as based on the Ability to pay fairness principle. In our example, we consider the per capita GDP in a country, and assume that no country is allowed to increase emissions. The distribution of burdens follows the relative GDP per capita compared to the average of the group, scaled in order to achieve the overall reduction level.

$$R_i = \alpha \times \left[\frac{GDP_i / Pop_i}{GDP_a / Pop_a} \right]$$

Where:

R_i = required reduction rate by country i ,

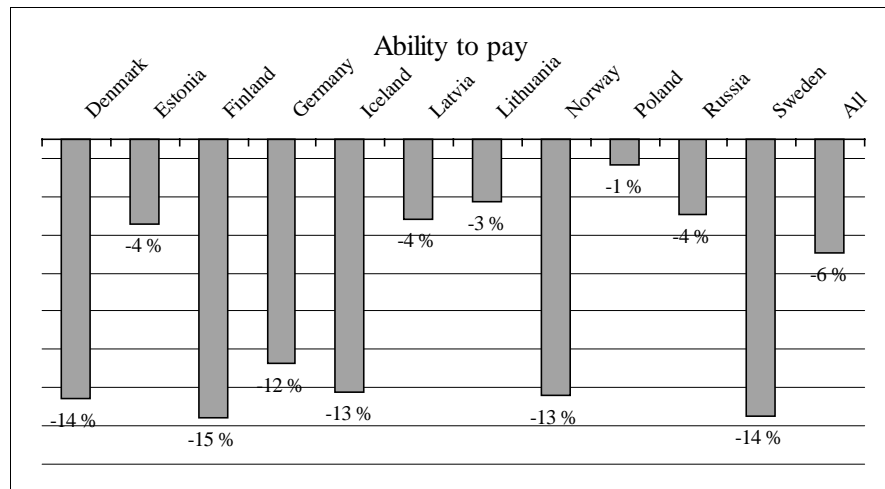
GDP_i/Pop_i = Gross domestic product per capita in country i ,

GDP_a/Pop_a = Average gross domestic product per capita in the group of countries,

α = Scale factor multiplied to reduce emissions to the required level (calculated to be -0.065)

The results are presented in Figure 2.

Figure 2: Distribution of emissions according to the Ability to pay principle. Changes compared to 1990 levels, percent.



The distribution of emissions in this case follows directly from the GDP per capita figures. As indicated by Table 6, Finland has the highest production per capita and will hence share the largest burden per capita. Poland, earning only about 15% of the average of all countries is assigned the smallest reduction rate. The formula used to illustrate consequences if the Ability to pay approach is followed, is not the only Ability to pay approach that could be used to quantify the distribution of burdens. Another approach could be to let relatively poor countries increase their emissions, while the wealthier take on larger reductions. In that case it would be necessary to introduce a scalar that defines the boundaries of the emission changes.

The second Japanese proposal

The second Japanese proposal enable countries to choose the most favourable of three criteria with the restriction that each country shall reduce emissions in the range of zero to five percent. However, the criterion that favours countries with high population growth was not explicitly defined in the Japanese paper. In lack of this definition we have made a suggestion of how this could be accomplished. Countries with a lower population growth than the average (which is 0.22% per year) cannot choose this criterion. However, countries with a higher population growth than 0.22 % per year, can divide the average population growth by its own growth, multiply this value by the default reduction rate and choose this approach. This method seems reasonable for the data set we are dealing with in our analysis. It is however, important to note that this method can produce peculiar results if for instance the average growth is negative.

The proposal defines the overall reduction, which in our case turned out to be -3.9 percent. To make the analysis comparable to the other proposals, we increased the five-percent limit to 7.6 percent, so that overall reductions equalled the reduction for this group of countries in the Kyoto Protocol (6.0 percent). The outcome was defined for each country by the following formula:

$$R_i = \text{Min} \left\{ 7.6 \times \left(\frac{CDE_i / Pop_i}{CDE_a / Pop_a} \right); 7.6 \times \left(\frac{CDE_i / GDP_i}{CDE_a / GDP_a} \right); 7.6 \times \left(\frac{\partial Pop_i / \partial t_a}{\partial Pop_a / \partial t_i} \right); 7.6 \right\}$$

Where:

R_i = Reduction rate applied to country i

Min = a function that chooses the argument separated by ; inside the brackets with the smallest value

CDE = carbon dioxide equivalent emissions per year

Pop = Population

GDP = gross domestic product

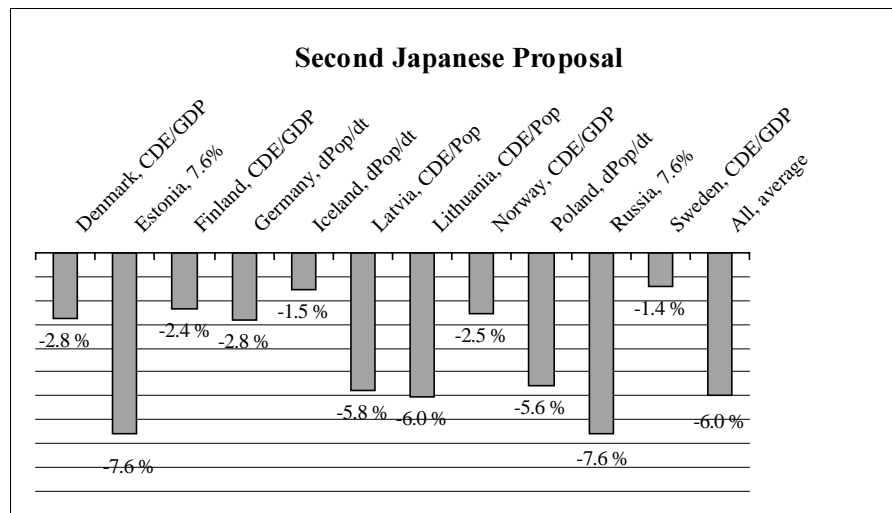
$\partial Pop / \partial t$ = population growth over the 5 year commitment period

i = indicate country i

a = indicate average of the group of countries

The results are presented in Figure 3. Information on the argument that would give the most beneficial outcome for the Party is also included.

Figure 3: Distribution of emissions according to the second Japanese proposal. Changes compared to 1990 levels, percent.



As Figure 3 illustrates, Russia and Estonia would not benefit from any of the criteria and is assigned the default 7.6 percent reduction rate. Latvia and Lithuania would prefer the emission per capita criteria, reducing emissions with 5.8 and 6.0 percent. Iceland, Germany and Poland would prefer the population growth criteria and reduce emissions by respectively 1.5, 2.8 and 5.6 percent, whereas Denmark (-2.8%), Finland (-2.4%), Norway (-2.5%) and Sweden (-1.4%) all would use the emissions per GDP criterion.

The French proposal

The French proposal aims at equalling emissions per capita of all countries in the year 2100 at a level in the range of 1 to 2.7 tonnes of carbon per year (which is equivalent to 3.67-9.90 t CO₂-eqv. per year). In order to achieve this, countries are to follow emission paths that converge to a specific common level. According to our calculations, a 2100 goal of 7 t CO₂-eqv per year would impose a 15 percent reduction in emissions for our group of countries. In order to reach the 6 percent reduction rate that is required in our analysis, the 2100 goal was set to 12.5 t CO₂-eqv. per year. As the formula presented in the French proposal used the year 2000 as base line, some adjustments were needed in order to match the schedule in our analysis. The adjusted formula is as follows.

$$E_{i,2010} = E_{i,1990}^{9/11} \times X^{2/11}$$

Where:

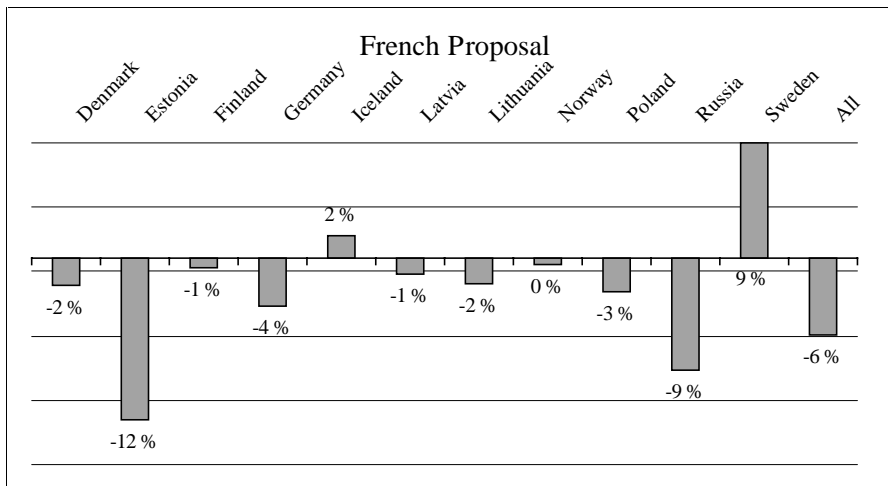
$E_{i,2010}$ = carbon dioxide equivalent emissions in year 2010 for country i

$E_{i,1990}$ = carbon dioxide equivalent emissions in year 1990 for country i

X =Emission goal per capita for all countries in 2100, =12,5

The resulting reduction rates are presented in Figure 4.

Figure 4: Distribution of emissions according to the French proposal. Changes compared to 1990 levels, percent.



According to the French proposal only Sweden and Iceland have emissions per capita that are below the required average in year 2100 and can hence increase emissions.

The Norwegian Proposal

The Norwegian proposal is a three-criterion formula. The weight of each criterion was in the original proposal subject to negotiation, but in later proposals they were equalised to one third. The formula is:

$$R_i = A \frac{1}{3} \left(\frac{CDE_i / Pop_i}{CDE_a / Pop_a} + \frac{CDE_i / GDP_i}{CDE_a / GDP_a} + \frac{GDP_i / Pop_i}{GDP_a / Pop_a} \right)$$

Where:

R_i = reduction rate applied to country i

CDE = carbon dioxide equivalent emissions per year

Pop = population

GDP = gross domestic product

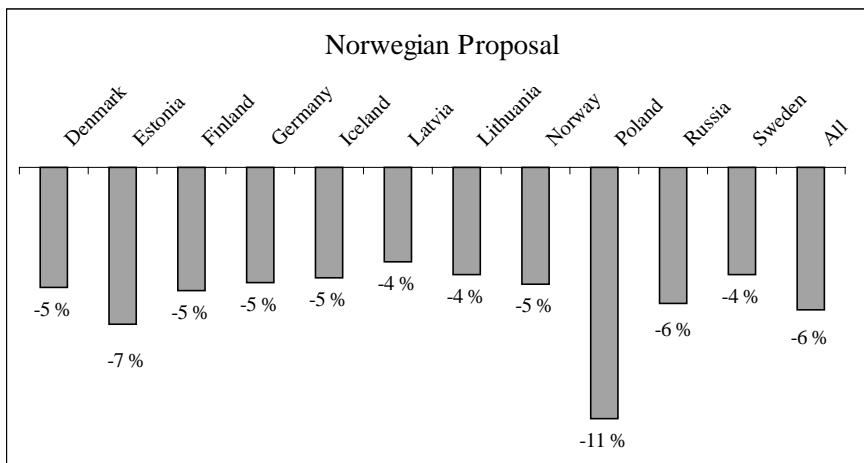
i = indicate country i

a = indicate average of the group of countries

A = scalar (equal to 4,51)

The scalar A is equal for all countries and the value assigned is set so that the overall reduction level is achieved. This burden-sharing rule produced the following set of reduction rates.

Figure 5: Distribution of emissions according to the Norwegian proposal. Changes compared to 1990 levels, percent.



The reduction rates derived from the Norwegian proposal are in a fairly close range running from 4 to 7 percent with the exception of Poland which is assigned a reduction rate of 11 percent.

Results for all countries and proposals/methods are shown in table 8.

Table 8: Distribution of emissions according to all proposals and all countries. Changes compared to 1990 levels, percent.

	Ability to pay	Egalitarian	Sovereignty	JAP II	French	Norwegian
Denmark	-14.3 %	17.5 %	-6.0 %	-2.8 %	-2.1 %	-5.1 %
Estonia	-4.3 %	-36.6 %	-6.0 %	-7.6 %	-12.5 %	-6.6 %
Finland	-15.4 %	26.9 %	-6.0 %	-2.4 %	-0.7 %	-5.1 %
Germany	-12.2 %	7.5 %	-6.0 %	-2.8 %	-3.6 %	-4.8 %
Iceland	-13.9 %	45.0 %	-6.0 %	-1.5 %	1.7 %	-4.7 %
Latvia	-4.0 %	23.0 %	-6.0 %	-5.8 %	-1.3 %	-3.9 %
Lithuania	-3.0 %	18.6 %	-6.0 %	-6.0 %	-1.9 %	-4.5 %
Norway	-14.1 %	29.0 %	-6.0 %	-2.5 %	-0.4 %	-4.9 %
Poland	-0.9 %	14.6 %	-6.0 %	-5.6 %	-2.5 %	-10.6 %
Russia	-3.7 %	-19.9 %	-6.0 %	-7.6 %	-8.7 %	-5.7 %
Sweden	-15.3 %	111.6 %	-6.0 %	-1.4 %	9.0 %	-4.5 %
All	-6.0 %	-6.0 %	-6.0 %	-6.0 %	-6.0 %	-6.0 %

6.2.2 Country-specific results

The results presented in the previous section were shown proposal by proposal for all countries. In order to illustrate the implications of the different methods on each country we will in this section present the same figures country by country. For illustrative reasons, we have also included the emission reduction targets that are stated in the Kyoto Protocol.¹⁴ The country-specific figures, which are displayed on page 44 to 47, can be grouped into three categories, where the countries in each category show showing similar responses to the various burden-sharing rules.

- **Group 1: The Nordic countries and Germany.**
This group of countries would all be allowed to increase emissions substantially if the burden-sharing rule was defined by the Egalitarian principle. They would also be most seriously affected if the rule were based on Ability to pay. Sweden and Iceland would be able to increase emissions if burdens were distributed according to the French proposal. Germany and Denmark are in the Kyoto Protocol subject to the most severe reductions in emissions, compared to any of the burden sharing rules examined in this chapter. All other rules would for all countries in this group imply reduction rates in the range of zero to 6 percent.
- **Group 2: Russia and Estonia.**
Russia and Estonia would under all circumstances need to reduce emissions. The most severe effects would occur if the burdens were distributed according to the Egalitarian rule. The other rules would imply reduction rates in the range of 4 to 12 percent. In the Russian case, the Kyoto Protocol allows higher emissions than all other burden sharing rules.
- **Group 3: Latvia, Lithuania and Poland.**
These countries show patterns that are between the first and the second group. They would all benefit from the Egalitarian burden-sharing rule, that rule being the only one where emissions are allowed to increase. The other principles would require emission reductions in the range of 1 to 11 percent. The Kyoto Protocol implies the most severe emission cuts for Latvia and Lithuania.

¹⁴ For the EU countries we have used the targets agreed upon internally within the EU, see Table .

It is important to be aware of the fact that the burden-sharing rules based on single fairness principles (Egalitarian, Sovereignty and Ability to pay), are extreme in the sense that they employ a single principle to meet targets already by the year 2010. These rules therefore generate larger variation in targets. According to the Egalitarian principle for example, all countries except Russia and Estonia can increase emissions substantially, where as the former two countries would need large reductions. It is perhaps more surprising that for all the other proposals in this analysis (Japan II, France and Norway), all countries would need to reduce emissions in the range of 0 to 12 percent, the exception being Sweden and Iceland in the French proposal. It is, however, important to bear in mind that emission burdens calculated under the Ability to pay rule was defined such that no country could increase its emissions. Even though burdens in general will become larger in the Russian and Estonian case, these countries have large reductions in their business as usual emission scenarios and expensive measures would therefore not necessarily be needed.

Group 1

Figure 6: Impacts on Danish emission reductions using different burden-sharing rules.

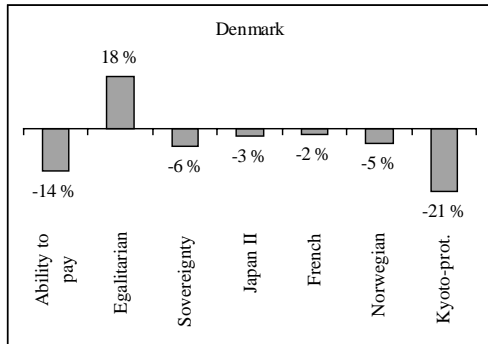


Figure 7: Impacts on Finish emission reductions using different burden-sharing rules.

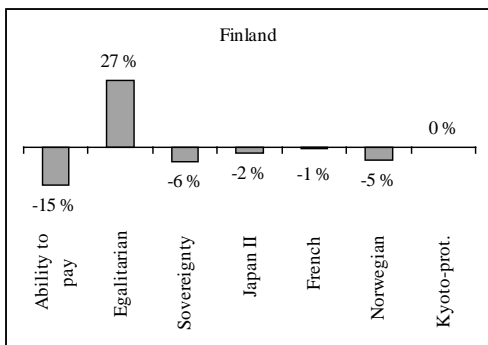


Figure 8: Impacts on German emission reductions using different burden-sharing rules.

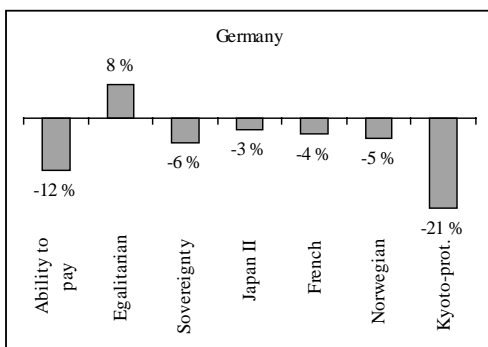


Figure 9: Impacts on Icelandic emission reductions using different burden-sharing rules.

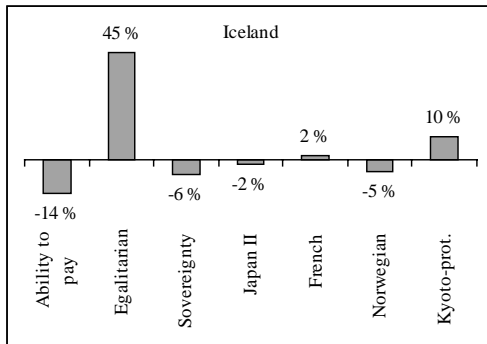


Figure 10: Impacts on Norwegian emission reductions using different burden-sharing rules.

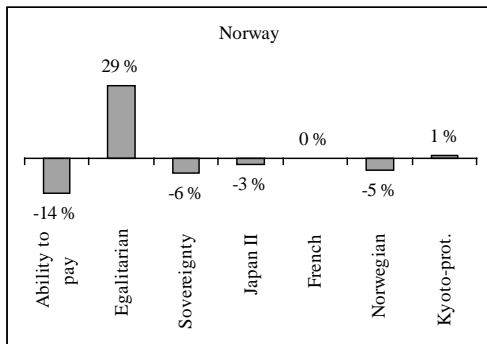
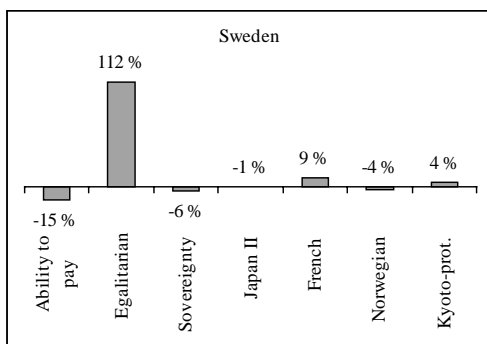


Figure 11: Impacts on Swedish emission reductions using different burden-sharing rules.



Group 2

Figure 12: Impacts on Estonian emission reductions using different burden-sharing rules.

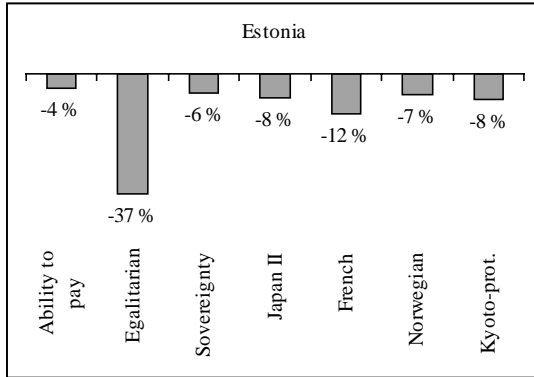
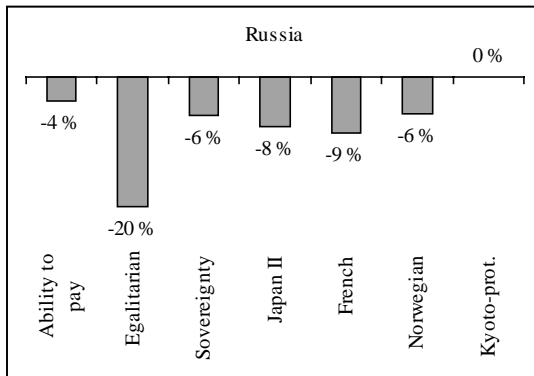


Figure 13: Impacts on Russian emission reductions using different burden-sharing rules.



Group 3

Figure 14: Impacts on Polish emission reductions using different burden-sharing rules.

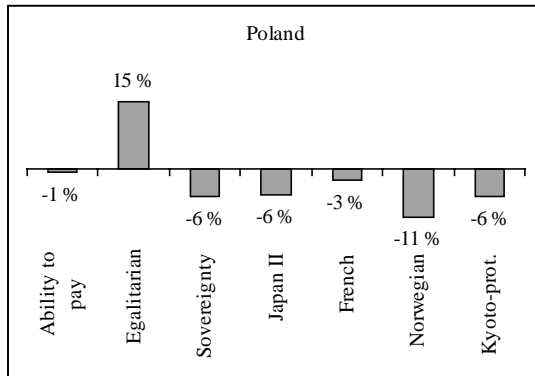


Figure 15: Impacts on Latvian emission reductions using different burden-sharing rules.

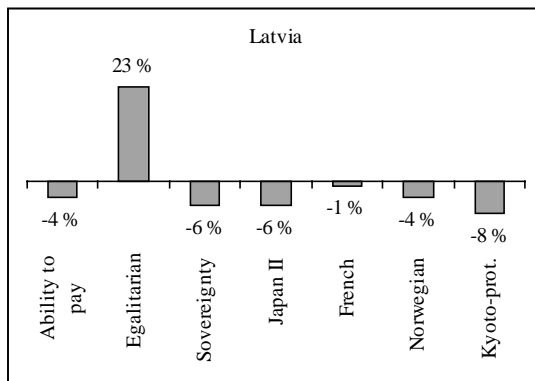
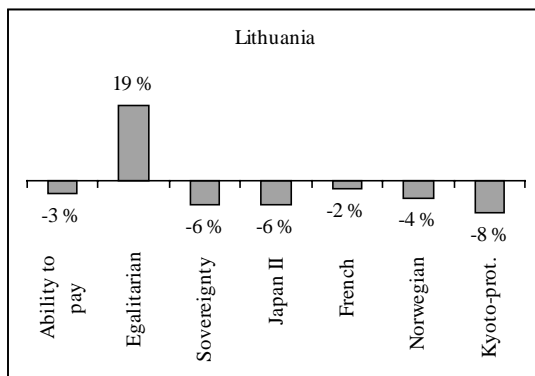


Figure 16: Impacts on Lithuanian emission reductions using different burden-sharing rules.



6.3 Summary

Comparing the distribution of commitments across countries generated by the differentiation proposals we find that the span between the largest and smallest targets is much larger for the single fairness principles Egalitarian and Ability to pay than for the proposals from the climate negotiations. The Japan II proposals distribute targets between $-1,5\%$ to $-7,5\%$. The same figures for the French proposal are $+9\%$ to -12% , and for the Norwegian proposal -4% to -11% . In the same three proposals Estonia and the Russian Federation have to reduce their emissions by much more than the average. In the Norwegian proposal the heaviest burden falls on Poland. According to the French proposal Sweden and Iceland are allowed to increase (being the case of the Egalitarian rule). Denmark, Germany, Latvia and Lithuania their emissions due to a relatively low present emission level per capita.

Turning to the country specific results, the Kyoto Protocol is, compared to the burden sharing rules, favourable for Russia, and to some extent for Iceland, Norway and Finland (the exemption being the case of the Egalitarian rule). Denmark, Germany, Latvia and Lithuania have relatively strict Kyoto Protocol targets, and would receive more comfortable targets given any of the burden sharing rules considered here. The Nordic countries and Germany are allowed to increase their emissions substantially given the Egalitarian principle. However, given the Ability to pay principle these countries would get a much larger burden than the other countries. The results for the proposals from the climate negotiations all lie between these extremes. Latvia, Lithuania and Poland would also benefit relatively from the Egalitarian principle in terms of being allowed emissions increases. All the other principles and proposals require reduced emission, and in a range between -1 to -11% . Finally, Estonia and the Russian Federation will loose if the Egalitarian principle is chosen, since they then would have to carry out substantial emission reductions. For the other proposals these two countries have to reduce their emission by -4% to -12% .

7 An evaluation of the political feasibility of the proposals

With the aim to evaluate the political feasibility of the various differentiation methods we compare the results from chapter 6 across the countries in the Baltic Sea region, and divide them into OECD (which consists of the Nordic countries and Germany) and EIT (which consists of the three Baltic countries, Poland and Russia) countries.¹⁵ Furthermore, we interpret the outcome of the Kyoto Protocol (and the internal differentiation scheme within the European Community) as an example of a politically feasible differentiation scheme, which may then serve as a benchmark for comparison with the differentiation methods evaluated here.

The differentiation methods' deviations from the Kyoto Protocol outcome are calculated as the absolute percentage deviation of the target produced by a method and the Kyoto Protocol target, and summed over all countries for each differentiation method. As an example the deviation for Norway for the Japan II proposal is $(1\% + 3\%) = 4\%$, and the deviation for Germany in the case of the Egalitarian method is $(21\% + 8\%) = 29\%$. All these results are presented in Table, where also the sum for each method over all countries is given together with a ranking. A small sum consequently shows that the deviation from the Kyoto Protocol outcome is smaller than in the case of a larger sum.

Table 9: The differentiation proposals' percentage deviation from the Kyoto Protocol outcome.

Differentiation proposal	Sovereignty	Egalitarian	Ability to pay	Japan II	French	Norwegian
Denmark	15	39	7	18	19	16
Finland	15	27	6	2	1	5
Iceland	16	35	24	12	8	15
Norway	7	28	15	4	1	6
Sweden	10	108	19	5	5	8
Germany	15	29	9	18	17	16
Poland	0	21	5	0	3	5
Estonia	2	29	4	0	4	1
Latvia	2	31	4	2	7	4
Lithuania	2	27	5	2	6	4
Russia	6	20	4	8	9	6
SUM	90	394	102	71	80	86
RANKING	4	6	5	1	2	3

On the basis of these observations we can draw the following tentative conclusions:

1. The Sovereignty and Egalitarian methods seem less interesting. The first method yields no differentiation, and the latter is too extreme in the short run since it equalises per capita emissions of greenhouse gases in a group of countries where there are large differences in this respect.

¹⁵ EIT is an acronym for Economies in Transition to a market economy.

2. The Ability to pay method puts the largest burden on the OECD countries, whereas the Japan II proposal, the French proposal, and to some degree the Norwegian proposal, put the largest burden on EIT countries.
3. All the methods explored provide Russia with a stricter target than the Kyoto Protocol, while the opposite situation is the case for Denmark and Germany.
4. Japan II is the proposal that yields targets closest to the Kyoto Protocol, followed by the French and the Norwegian proposal. The three methods based on fairness principles cause larger deviations from the Kyoto Protocol outcome.

Based on this analysis, and in particular table 9, one might claim that a ranking of the differentiation methods according to political feasibility would be:

1. Japan II
2. French
3. Norwegian
4. Ability to pay
5. Sovereignty
6. Egalitarian

However, putting more emphasis on the second conclusion above, one might argue that the Ability to pay method should have a higher ranking, and maybe be ranked in first place. The argument for this would be that it is unfair, and consequently also less politically feasible, to demand that the relatively poorer EIT countries should reduce their emissions by a larger percentage than the OECD countries. A contra argument could be that there are more opportunities for cheap emission reductions in the EIT countries due to low energy efficiency in their economies, so that the ranking above is still the most realistic in terms of political feasibility.

Among the countries in the Baltic Sea region Poland might be taken as proxy of a developing country due to its relatively low per capita GDP and its average per capita emissions of greenhouse gases. In such a case the most promising methods for involving developing countries are based on the Ability to pay principle and the French proposal, since these methods are likely to yield relatively softer targets for developing countries. In this context we leave out the Egalitarian and Sovereignty proposals for reasons explained earlier in this chapter.

Finally, we should not forget the Triptique and Brazil-RIVM methods that could give interesting results of a high political feasibility, which we unfortunately have not been able to analyse further in this study.

8 Literature

- Australian Bureau of Agricultural and Resource Economics (ABARE) and Department of Foreign Affairs and Trade (DFAT) (1995). *Global climate change - Economic dimensions of a cooperative international policy response beyond 2000*. Commonwealth of Australia, Canberra.
- Barrett, S. (1992). 'Acceptable' Allocations of Tradable Carbon Emission Entitlements in a Global Warming Treaty. In *Combating Global Warming*. UNCTAD, Geneva.
- Berk, M. and M. den Elzen (1998). *The Brazilian Proposal and other Options for International Burden Sharing*, paper presented at a special event at UNFCCC/COP-4 in Buenos Aires, 5 November 1998, Netherlands National Institute for Public Health and the Environment, Bilthoven, Netherlands.
- Blok, K., Phylipsen, G.J.M. and Bode, J. W. (1997). The Triptique Approach: Burden Differentiation of CO₂ Emission Reduction Among European Union Member States, Department of Science, Technology and Society, Utrecht University, Utrecht, the Netherlands.
- Bureau of Industry Economics (1995). Greenhouse Gas Abatement and Burden Sharing – An Analysis of Efficiency and Equity Issues for Australia. *Research Report No. 66*, Australian Government Publishing Service, Canberra.
- Burtraw, D. and Toman, M. A. (1992). Equity and International Agreements for CO₂ Containment. *Journal of Energy Engineering* 118 (2) 122-135.
- Claussen, Eileen and Lisa McNeilly (1998). *Equity and Global Climate Change – The Complex Elements of Global Fairness*, Pew Center on Global Climate Change, Washington, D.C.
- Kawashima, Y. (1996). Differentiation of Quantified Emission Limitation and Reduction Objectives (QELROs) according to National Circumstances: Introduction to Equality Criteria and Reduction of Excess Emission. Paper presented at Informal workshop on quantified limitation and reduction emission objectives, Geneva, 28 February.
- Ridgley, M. A. (1996). Fair Sharing of Greenhouse Burdens. *Energy Policy* 24 (6) 517-529.
- Ringius, L., A. Torvanger and B. Holtmark (1998). Can multi-criteria rules fairly distribute climate burdens? – OECD results from three burden sharing rules, *Energy Policy*, Vol. 26, No. 10, pp. 777-793, and *CICERO Working Paper* 1998:6, CICERO, Oslo.
- Ringius, L., Torvanger, A., and Meze, E. (1996). *Climate Policy, Burden Sharing and the Nordic Countries*. TemaNord No. 572, Nordic Council of Ministers, Copenhagen, and *CICERO Report* No. 2, Oslo.
- Rose, A. (1992). Equity Considerations of Tradable Carbon Emission Entitlements. In *Combating Global Warming*. UNCTAD, Geneva.

- Rose, A., Stevens, B., Edmonds, J. and Wise, M. (1998). International Equity and Differentiation in Global Warming Policy. *Environmental and Resource Economics* **12** (1) 25-51.
- Rose, A. and Stevens, B. (1998). A Dynamic Analysis of Fairness in Global Warming Policy: Kyoto, Buenos Aires and beyond. *Journal of Applied Economics* **1** (2) 329-362.
- Rowlands, I. H. (1997). International Fairness and Justice in Addressing Global Climate Change. *Environmental Politics* **6** (3) 1-30.
- Torvanger, A., Berntsen, T., Fuglestvedt, J., Holtmark, B., Ringius, L. and Aaheim, A. (1996). Exploring Distribution of Commitments - A Follow-up to the Berlin Mandate. *CICERO Report No. 3*, Oslo.
- United Nations, Framework Convention on Climate Change (1995). *Implementation of the Berlin Mandate, Comments from Parties, Note by the interim secretariat, Addendum*. FCCC/AGBM/1995/Misc.1/Add.1, 29 September 1995.
- United Nations, Framework Convention on Climate Change (1996). Strengthening the Commitments in Article 4.2(a) and (b); Quantified Emission Limitation and Reduction Objectives within Specified Time-Frames; Review of Possible Indicators to Define Criteria for Differentiation among Annex I Parties; Note by the Secretariat. FCCC/AGBM/1996/7, 8 July 1996.
- United Nations, Framework Convention on Climate Change (1996). *Implementation of the Berlin Mandate, Proposals from Parties, Note by the secretariat, Addendum*. FCCC/AGBM/1996/Misc.2/Add.2, 15 November 1996.
- United Nations, Framework Convention on Climate Change (1996). *Implementation of the Berlin Mandate, Proposals from Parties, Note by the secretariat, Addendum*. FCCC/AGBM/1996/Misc.2/Add.4, 10 December 1996.
- United Nations (1997). *United Nation Statistical Yearbook, Forty-first issue*. Department for Economic and Social Information and Political Analysis, United Nations, New York.
- United Nations, Framework Convention on Climate Change (1997). *Framework Compilation Of Proposals From Parties For The Elements Of A Protocol Or Another Legal Instrument, Note by the Chairman*. FCCC/AGBM/1997/2, 31 January 1997.
- United Nations, Framework Convention on Climate Change (1997). *Implementation Of The Berlin Mandate, Proposals from Parties, Note by the secretariat*. FCCC/AGBM/1997/Misc.1, 19 February 1997
- United Nations, Framework Convention on Climate Change (1997). *Implementation Of The Berlin Mandate, Proposals from Parties, Note by the secretariat*. FCCC/AGBM/1997/Misc.1/Add.1, 26 February 1997.

United Nations, Framework Convention on Climate Change (1997). *Implementation Of The Berlin Mandate, Additional proposals from Parties, Addendum, Note by the secretariat*. FCCC/AGBM/1997/Misc.1/Add.3, 30 May 1997.

United Nations, Framework Convention on Climate Change (1997). *Implementation of the Berlin Mandate, Proposals from Parties, Note by the secretariat*. FCCC/AGBM/1997/Misc.1/Add.6, 23 October 1997.

United Nations, Framework Convention on Climate Change (1997). *Review of the implementation of commitments and of other provisions of the Convention. Review of information communicated under Article 12. National communications from Parties included in Annex I to the Convention. Second compilation and synthesis of second national communications. Addendum*. FCCC/CP/1998/11/Add.2, 5 October 1998.

This is CICERO

CICERO was established by the Norwegian government in April 1990 as a non-profit organization associated with the University of Oslo.

The research concentrates on:

- International negotiations on climate agreements. The themes of the negotiations are distribution of costs and benefits, information and institutions.
- Global climate and regional environment effects in developing and industrialized countries. Integrated assessments include sustainable energy use and production, and optimal environmental and resource management.
- Indirect effects of emissions and feedback mechanisms in the climate system as a result of chemical processes in the atmosphere.

Contact details:

CICERO
P.O. Box. 1129 Blindern
N-0317 OSLO
NORWAY

Telephone: +47 22 85 87 50
Fax: +47 22 85 87 51
Web: www.cicero.uio.no
E-mail: admin@cicero.uio.no

