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# THE MULTI-SECTOR CONVERGENCE APPROACH OF BURDEN SHARING

## An analysis of its cost implications

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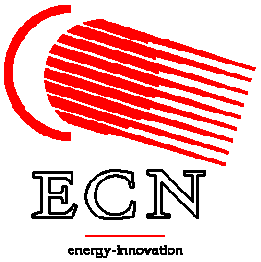


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This report is the sixth Working Paper of the Burden Sharing study project that aims *to identify the most promising rules applicable for differentiation of greenhouse gas emission reduction burden among countries*. The project is carried out jointly by CICERO (Oslo, Norway) and ECN (Petten, The Netherlands) under ECN project number 7.7170. The project started in October 1998 and was finalised in late 2000.

The Burden Sharing study project is financed by the Dutch National Research Programme on Global Air Pollution and Climate Change and by own contributions of the participating institutes. The project has resulted in the following publications:

- ECN-C--00-010 / CICERO WP 1999: 12 Project definition and introduction to some key concepts and issues - The joint CICERO-ECN project on sharing the burden of greenhouse gas reduction among countries. J.R. Ybema, J.C. Jansen, F.T. Ormel,
- ECN-C--00-011 / CICERO WP 1999: 13 Burden Differentiation: Fairness principles and proposals - The joint CICERO-ECN project on sharing the burden of greenhouse gas reduction among countries. L. Ringius, A. Torvanger, A. Underdal,
- ECN-C--00-012 / CICERO WP 1999: 14 Burden differentiation: GHG emissions, undercurrents and mitigation costs - The joint CICERO-ECN project on sharing the burden of greenhouse gas reduction among countries. J.R. Ybema, J.J. Battjes, J.C. Jansen, F.T. Ormel,
- ECN-C--00-013 / CICERO WP 2000: 1 Burden differentiation: Criteria for evaluation and development of burden sharing rules - The joint CICERO-ECN project on sharing the burden of greenhouse gas reduction among countries. A. Torvanger, L. Ringius,
- ECN-C--01-007 / CICERO WP 2001:4 The multi-sector convergence approach - A flexible framework for negotiating global rules for national greenhouse gas emissions mitigation targets. J.C. Jansen, J.J. Battjes, J.P.M. Sijm, C. Volkers, J.R. Ybema,
- ECN-C--01-008 / CICERO WP 2000:2 The multi-sector convergence approach - An analysis of its cost implications. J.P.M. Sijm, J.C. Jansen, J.J. Battjes, C. Volkers, J.R. Ybema,
- ECN-C--01-009 / CICERO WP 2001:5 Sharing the burden of greenhouse gas mitigation - Final report of the joint CICERO-ECN project on the global differentiation of emission mitigation targets among countries. ECN: J.C. Jansen, J.J. Battjes, F.T. Ormel, J.P.M. Sijm, C. Volkers, J.R. Ybema; CICERO: A. Torvanger, L. Ringius, A. Underdal.

## Abstract

This Working Paper analyses the cost implications of the multi-sector convergence approach of burden sharing for the period 2013-2017 as outlined in a previous Working Paper of the Burden Sharing study project (Jansen et al., 2000). It compares these costs with the burden differentiation of emission mitigation as agreed in the Kyoto Protocol for the first budget period (2008-2012). The analysis of cost implications of burden sharing resulting from the multi-sector convergence approach versus the Kyoto Protocol will both include and exclude the use of the Kyoto Mechanisms (Emissions Trading, Joint Implementation and the Clean Development Mechanism).

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# SUMMARY

This report provides an indication of the cost implications of the multi-sector convergence approach of burden sharing with regard to the so-called 'second budget period' (2013-2017). This approach offers a new sector-based framework for negotiating binding emission targets after the first budget period of the Kyoto Protocol (2008-2012), based on (i) the distinction of different sectors in the national economy, and (ii) the prescriptive norm that ultimately the amount of per capita emission assignments has to converge to the same level for all countries.

The cost indications of the multi-sector convergence approach for the years 2013-2017 are based on a model previously developed by ECN to study the impact of the Kyoto Mechanisms - i.e. Emissions Trading, Joint Implementation and the Clean Development Mechanism - in reducing GHG emissions. The outstanding characteristic of this model is that it covers all six GHGs, all three Kyoto Mechanisms and all major countries/regions in the world within an integrated, bottom-up approach.

If all reduction requirements of all Annex-I countries - resulting from the multi-sector convergence approach with regard to the second budget period - will be fully realised domestically, total annual direct abatement costs are estimated at 133 billion US$ (i.e. about 0.3 percent of their GDP in that period). However, in the case of unrestricted global emission trade, Annex I countries will meet some 50 percent of their reduction commitments abroad by means of the Kyoto Mechanisms. As a result, total annual direct abatement costs during the second budget period for all Annex I countries will fall to about 44 billion US$ (i.e. about 0.1 of their GDP), whereas non-Annex I countries are even able to realise net profits of almost 10 billion US$ by exporting CDM emission credits.

The major lesson or conclusion of the present report is that allocation-based burden sharing rules in terms of setting emission limitation targets related to a specific reference year have only a relative meaning compared to other, outcome-based burden sharing indicators. The main reason for this finding is that the burden of emission mitigation is not only determined by the setting of emission limitation targets related to a specific reference year but also by other factors such as:

- trends in GHG emissions between the reference and target years as determined by population/economic growth and other autonomous (technology) trends regarding GHG emissions,
- major differences in abatement potentials and costs among countries and regions,
- including or excluding the (unrestricted/limited) use of the Kyoto Mechanisms,
- including or excluding no-regret options in (inter)national abatement strategies.

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

The above-mentioned results should be interpreted carefully as the underlying analysis is characterised by data uncertainties, methodological shortcomings and other limitations such as the exclusion of implementation and macroeconomic costs resulting from mitigation policies. At the present stage of climate policy research, the major aim of the present study is just to give an indication of the direct abatement costs of the multi-sector convergence approach - notably in relative terms - and, above all, to analyse the factors and the underlying, structural causal relationships that affect the estimated outcome of the burden sharing indicators considered.

# 1. INTRODUCTION

In the fifth Working Paper of the Burden Sharing project (Jansen et al., 2000), the multi-sector convergence approach has been developed. This approach has resulted in a set of emission limitation targets for a large sample of countries with regard to the years following the first budget period of the Kyoto Protocol. These targets give an impression of burden sharing among countries in terms of reduction percentages or amounts of emissions to be mitigated. However, they do not provide an indication of burden sharing in terms of costs involved. The latter, i.e. indicating the cost implications of the multi-sector convergence approach is the main intention of the present report.

The cost analyses included in this report are based on a model previously developed by ECN to study the impact of the Kyoto Protocol in general and the role of the Kyoto Mechanisms - i.e. Emissions Trading, Joint Implementation and the Clean Development Mechanism - in reducing GHG emissions in particular. The outstanding characteristic of this model is that it covers all six GHGs, all three Kyoto Mechanisms and all major countries/regions in the world within an integrated, bottom-up approach (Sijm et al., 2000). One of the opportunities of this model is to estimate the costs of emission limitation commitments of the Annex I countries with regard to the so-called first budget period of the Kyoto Protocol (2008-2012). By adding some small adjustments to this model, it can also be used to estimate the cost effects of the multi-sector convergence approach of burden sharing among the countries/regions included in the model for the subsequent, second budget period (2013-2017).

The structure of the present report runs as follows. Firstly, Chapter 2 presents a brief outline of the methodology of the model and data sources used to estimate the cost implications of burden sharing arrangements such as the Kyoto Protocol or the multi-sector convergence approach. Subsequently, Chapter 3 discusses and compares the cost implications of the Kyoto Protocol in the first budget period (2008-2012) versus the multi-sector convergence approach during the second budget period (2013-2017). Finally, a summary and conclusion of this paper are provided in Chapter 4.

# 2. METHODOLOGY AND DATA SOURCES

## 2.1 A model simulation of trading emission credits

The methodology followed in this report is based upon a model developed by ECN to simulate a market for trading emission credits among countries in order to indicate the potential role and cost impact of the Kyoto Mechanisms in meeting GHG limitation commitments of Annex I countries as agreed in the Kyoto Protocol. The term 'emission credits' is used as the collective concept for credits generated and transferred by means of one or more of the Kyoto Mechanisms, i.e. Emissions Trading (ET), Joint Implementation (JI) or the Clean Development Mechanism (CDM). It is assumed that these emission credits are traded on an integrated market. In addition, the approach outlined below is based on the following assumptions:

- no restrictions on trading emission credits,
- no transaction costs for generating and trading emission credits,
- no risks and uncertainties, i.e. information is fully and freely available,
- no institutional changes affecting the market of emission credits,
- no strategic or dominant behaviour of market parties,
- market parties act rationally, i.e. they are maximising their objectives while minimising costs.

For individual countries (or regions), the methodology applied can be illustrated graphically by means of Figure 2.1. Quantities of emission credits - in tonnes of $CO_2$ equivalents - are indicated by the X-axis, whereas the price or cost of emission credits is reflected by the Y-axis. Emission reduction options and corresponding marginal cost levels are represented in Figure 2.1 by marginal cost curves for two different countries, A and B, indicated by $MC_a$ and $MC_b$, respectively. These curves express the supply of emission credits of the countries concerned.

The demand for emission credits depends on the amount of GHG emissions that a country is obliged to reduce. In Figure 2.1, this demand is represented by a vertical line for countries A and B, called $T_a$ and $T_b$, respectively. In case of 'no trade' (i.e. no use of Kyoto Mechanisms), the intersection of this line and the MC curve determines the equilibrium price ($P_a$ and $P_b$) on the domestic market of emission credits.

By allowing international trade in emission credits, price differences between countries will disappear, resulting in a global equilibrium price of emission credits ($P_m$). In such a situation, countries will reduce their domestic GHG emissions up to the point where their domestic marginal abatement costs are equal to $P_m$. In Figure 2.1, country A will reduce the amount of $Q_a$ emissions at home and buy the remaining amount ($T_a$ - $Q_a$) abroad in order to achieve its Kyoto target of $T_a$. In this case, total abatement costs of country A are equal to the area $OT_aVU$. Compared to the case of 'no trade', this implies a net saving of total abatement costs corresponding to area UVW. For country B, the amount of domestic emission reductions will be $Q_b$, whereas only $T_b$ is required, resulting in exports of emission credits ($Q_b$ - $T_b$), and net trading profits corresponding to area XYZ. Hence, the use of Kyoto Mechanisms is profitable for both importing and exporting countries of emission credits.[1]

[1] Non-Annex I countries are not obliged to reduce GHG emissions. In that case, $T_b$ is equal to O, whereas the net gains from trading emission credits correspond to area $OYP_m$ in the right part of Figure 1.

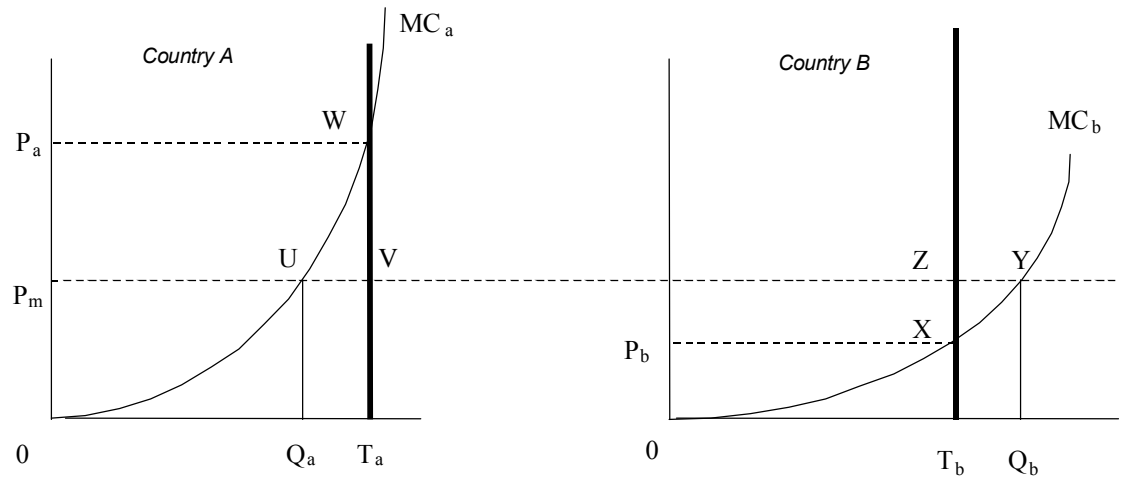


Figure 2.1 *Market of emission credits*

To summarise, the approach outlined above enables one to determine the equilibrium price of emission credits both 'before trade' and 'after trade', the marginal and total abatement costs before and after trade for each country or region included in the model, the amounts of emissions reduced at home and traded abroad, and the cost savings or 'net gains' of importing or exporting emission credits by means of the Kyoto Mechanisms ET, JI or CDM. Moreover, by adding data on GDP or population to the model, a variety of additional indicators - such as emissions per capita or abatement costs as a percentage of GDP - can be calculated. In addition, this approach enables one to analyse the impact of so-called 'ceilings' on using Kyoto Mechanisms as well of the effects of alternative burden sharing rules to reduce GHG emissions (compared to those agreed as part of the Kyoto Protocol).[2]

## 2.2 Data sources and qualifications

The present study relies heavily on the availability and reliability of a large variety of data for a large number of countries and regions. The most important data concern:

- National or regional GHG emissions in the reference year (i.e. 1990/95) and two future years (i.e. 2010 and 2015, as representative of the periods 2008-2012 and 2013-2017, respectively). By means of these data and certain reduction targets - derived from the Kyoto Protocol and the multi-sector convergence approach, respectively - national or regional reduction requirements have been calculated in terms of physical quantities of GHG emissions[3].
- The potential and costs to reduce GHG emissions in a certain country or region. These data have been used to determine individual cost curves for the reduction of GHG emissions in a particular country or region. Subsequently, these individual curves have been added up and combined into aggregated cost curves covering several or all GHGs, countries and/or regions. Finally, this process of adding up cost curves has resulted in the construction of a world-wide cost curve for the reduction of all GHG emissions.
- GDP and population size in 1990, 2010 and 2015.[4]

Table 2.1 provides an overview of the major sources of the data used for the present study. The main limitations and other qualifications of these data will be discussed below. More details can be found in the data sources and references mentioned in Table 2.1.

[2] See, for instance, Van Harmelen et al. (1997), Koutstaal et al. (1998), Gielen et al. (1999) and Ybema et al. (1999).

[3] For a discussion of the data with regard to GHG emissions in 1990 and 2010, see Sijm, et al. (2000) and references cited there, notably Olivier, et al. (1996), Alcamo, et al. (1998), and Fennhann (2000).

[4] GDP and population data are based on World Bank (1997 and 1999), and IEA (1998).

Table 2.1 *Overview of major data used in present study*

| | Western Annex I | CEE/FSU Annex I | Non-Annex I |
|---|---|---|---|
| *Emissions:* [5] | | | |
| $CO_2$ (1990, 2010/15) | 2, 4, 5 | 1 | 6, 7 |
| $N_2O/CH_4$ (1990, 2010/15) | 4, 5, 6, 7 | 6, 7 | 6, 7 |
| Other GHG (1990, 2010/15) | 4, 5, 8 | 8 | 8 |
| *Cost Curves:* | | | |
| $CO_2$ (2010/15) | 2, 4, 5 | 1 | 3 |
| Other/Total GHGs (2010/15) | 4 | 4 | 4 |
| *Other Data:* | | | |
| GDP/Population (1990, 2010/15) | 9, 10, 11, 12 | 9, 10, 11, 12 | 9, 10, 11, 12 |

1=Van Harmelen et al. (1997), 2=Koutstaal et al. (1998), 3=Van der Linden et al. (1999), 4=Gielen et al. (1998), 5=Ybema et al. (1999), 6=Olivier et al. (1996), 7=Alcamo et al. (1998, Scenario B), 8=Fennhann (2000), 9=World Bank (1997), 10=World Bank (1999), 11=CIA (1999), 12=IEA (1998).

In general, data on emission levels are less uncertain for $CO_2$ than for the other GHGs.[6] In addition, emission data seem to be more reliable, more readily available and more detailed for western Annex I countries than for countries in Central and Eastern Europe (CEE), the Former Soviet Union (FSU), and - particularly - the non-Annex I region. Moreover, estimates of emission levels for the reference year (1990/95) are less uncertain compared to baseline projections for the year 2010 as the latter are based on assumptions regarding trends in economic growth, economic structure and technological innovations. These assumptions vary per study. The consequences of these uncertainties are two-fold. Firstly, data on emission levels have to be interpreted with the necessary prudence. Secondly, estimates of emission levels may sometimes vary (significantly) by source or reference used, depending on the method of estimation, the major assumptions applied and adjustments made in the course of time. In general, the present study has tried to use the most reliable data, occasionally updated or adjusted to more recent information and insights.[7]

Marginal cost curves for reducing $CO_2$ emissions in western Annex I countries have been derived from ETSAP and COHERENCE studies, based on detailed energy and technology bottom-up models such as MARKAL and EFOM (Van Harmelen, et al., 1997, and Koutstaal et al., 1998). This type of model studies offers an optimisation strategy to achieve national emission reduction targets given certain economic and technological prior conditions such as international energy prices, characteristics of the energy sector, available emission reduction options, and expectations regarding future energy demand and economic structure. Hence, cost estimates of future emission reductions based on such models depend critically on assumptions made regarding these prior conditions. Other limitations of bottom-up studies refer to a lack of mutual comparability and the exclusion of cost effects and interactions at the macroeconomic level.

[5] Excluding sinks, i.e. changes in GHG emissions due to land use changes and forestry activities. In general, emission projections for the year 2015 are simple extrapolations of projections for the year 2010 (see Sijm et al., 2000 and references cited there). The major exceptions concern Germany, the United Kingdom and the countries of CEE/FSU (both Annex I and non-Annex I). Whereas these countries are characterised by declining or stagnating emission projections for the years 1990-2010, an increase of GHG emissions has been assumed for the period 2010-2015 of 3 percent for Germany and the United Kingdom and, on average, of 10 percent for the CEE/FSU countries.

[6] See Sijm et al. (2000) for a discussion of data uncertainties regarding non-$CO_2$ GHG emissions in EU Member States.

[7] For additional remarks and other details on emission data of EU Member States, see Gielen et al. (1999) and Ybema et al. (1999).

For Annex I countries in the CEE/FSU region, $CO_2$ marginal reduction cost curves are scarcely available. As part of a previous study on Joint Implementation (Van Harmelen et al., 1997), ECN has estimated the potential and costs of reducing $CO_2$ emissions by means of two types of studies. Estimates of the demand-side potential and costs of $CO_2$ emission reductions have been based on energy-efficiency studies of the OECD (1996a and 1996b), whereas the supply-side potential and costs have been estimated by means of model simulations constructed by ECN for Slovakia and the Czech Republic (Van Harmelen et al., 1994a and 1994b; IEA, 1995; and De Kruijk et al., 1993). These estimates, however, have to be treated with caution as they suffer from uncertainties with regard to the availability of the so-called 'profitable reduction potential' (i.e. 'no-regret' options characterised by negative reduction costs). Therefore, ECN has developed two variants of the cost curve concerned, one including and one excluding this profitable potential.[8]

For the non-Annex I region as a whole, an emission abatement cost curve has been derived from information on the costs and potential of reducing GHG emissions in this region (Van der Linden et al., 1999). This information has been collected from a large variety of abatement costing studies covering some 300 GHG reduction options in non-Annex I countries. As these options concern mainly energy-related $CO_2$ emissions, the final result can be regarded as predominantly a $CO_2$ reduction cost curve. This result, however, has to be interpreted cautiously because of several critical limitations involved:[9]

- The total potential of reduction options is based on abatement costing studies in 24 non-Annex I countries - accounting for two-thirds of total GHG emissions in the non-Annex I region - and extended to the rest of this region, using a simple extrapolation method (i.e. scaling up potential by a factor 1.5).
- On the one hand, the total potential of reduction options may be heavily underestimated as numerous abatement costing studies excluded significant reduction options, notably outside the energy sector. On the other hand, it may be largely overestimated, as actual investor costs are likely to substantially exceed economic costs represented in the abatement studies.
- Transaction costs of potential CDM projects have often been excluded.

The potentials and costs of reducing emissions of non-$CO_2$ GHGs are based on a variety of studies as discussed by Gielen and Kram (1998). These studies focus on emission abatement options in EU Member States. Due to lack of empirical data, estimates of non-$CO_2$ reduction cost curves for non-EU countries and regions have also been based on these studies supplemented and adjusted by expert guesses of ECN staff.

For all countries and regions mentioned above, the same cost curves have been used for the first and second budget periods. It has been assumed that the most efficient - i.e. cheapest - emission reduction options will be used during the first budget period (2008-2012), followed by the subsequent, least-cost abatement opportunities in the second budget period (2013-2017).

Another limitation of the present analysis is that estimates of abatement potentials are based on reduction options that are assumed to be technically feasible. The present quantitative analysis, however, has not considered all kinds of political and institutional constraints to realise abatement projects, particularly in non-Annex I and CEE/FSU Annex I countries. Moreover, the Kyoto Mechanisms are still characterised by several unresolved issues with regard to their design and implementation (including the imposition of 'ceilings' on the use of the Kyoto Mechanisms). As a result, abatement potentials may be smaller or more expensive than supposed in this study, leading to less trade in emission credits and higher reduction costs. On the other hand, there might be a large potential of (cheap) reduction options - particularly in non-Annex I

[8] It should be noted that the present study has aggregated the Annex I countries of CEE/FSU into one region, whereas the JI study has also analysed $CO_2$ emission levels, reduction potentials and costs for individual countries. For details, see Van Harmelen et al. (1997).

[9] For details and some other limitations, see Van der Linden et al. (1999).

countries - which have not yet been identified and, hence, not included in the present analysis, implying that reduction costs may be estimated too high and trade options too low.

A final, but major qualification of the present study is that it is based on a static and partial, bottom-up analysis, i.e. it assesses only direct abatement costs but excludes other cost categories such as implementation costs and macroeconomic costs due do dynamic and feed-back effects of mitigation policies at both the project, sectoral and national level.

# 3. COSTS OF THE MULTI-SECTOR CONVERGENCE APPROACH

## 3.1 Introduction

This chapter analyses the cost implications of the multi-sector convergence approach of burden sharing with regard to the so-called 'second budget period' (2013-2017). These cost implications will be indicated for all major individual countries of the western Annex I region and for the Annex I countries of Central and Eastern Europe and the Former Soviet Union as a whole (CEE/FSU Annex I region).[10] Cost implications will not be indicated for non-Annex I countries as (i) most of these countries are not obliged to limit their GHG emissions during the second budget period, and (ii) necessary data are lacking at the individual country level. In fact, non-Annex I countries have been grouped in six sub-regions, i.e. Africa, Asia, the Former Soviet Union (FSU non-Annex I), Latin America, the Middle East and Oceania. It has been assumed that each sub-region as a whole is not subject to a GHG abatement commitment. However, non-Annex I countries participate in international climate policies by means of the Clean Development Mechanism, i.e. by generating emission credits through abatement projects and selling these credits to Annex I countries in order to meet the latter's commitment at reduced costs.[11]

The cost implications of any burden sharing regime depend on (i) the emission abatement potentials and marginal costs of all countries/regions involved, (ii) the emission reduction requirements of the countries/regions concerned, and (iii) the potential use of the Kyoto Mechanisms, i.e. the trade effects of domestic versus foreign abatement transactions. Hence, the structure of this chapter runs as follows. Firstly, mitigation potentials and costs of major countries/regions are briefly discussed in Section 3.2. Subsequently, Section 3.3 addresses the emission reduction requirements of Annex I countries/regions with regard to the second budget period. Finally, Section 3.4 analyses the trade and cost effects of the multi-sector convergence approach (both including and excluding the use of Kyoto Mechanisms). Throughout this chapter, these effects will be compared to those of the burden differentiation regime agreed in the Kyoto Protocol with regard to the first budget period.

## 3.2 Emission abatement potentials and marginal costs

Chapter 2 has illustrated that emission reduction costs and potentials can be expressed graphically by means of marginal cost curves. As part of previous ECN studies regarding the role and impact of the Kyoto Mechanisms, marginal cost curves have been constructed for a variety of countries and regions, including:

- each individual western Annex I country (western Annex I),
- the Annex I region of Central and East Europe/Former Soviet Union (CEE/FSU Annex I),
- each non-Annex I region, notably the FSU non-Annex I region, Africa, Asia, Oceania and the Middle East (non-Annex I).

Figure 3.1 shows the aggregated marginal cost curves for reducing GHG emissions in the western Annex I region, the non-Annex I region and the CEE/FSU Annex I region. It indicates that the potential of abatement options at relatively low costs are generally much larger in both non-Annex I and CEE/FSU Annex I countries than in western Annex I countries. In addition, Figure 3.1 illustrates that both the non-Annex I region and the CEE/FSU Annex I region have each a large potential of about 800 Mt of no-regret options, i.e. reduction options with negative mar-

[10] CEE/FSU Annex I countries have been grouped into one region because of model simplicity and data considerations.

[11] See the discussion on the participation of non-Annex I countries in Jansen et al. (2000).

ginal costs. It is still unclear whether these 'profitable potentials' will be allowed to be used as part of the Kyoto Protocol in general and the Kyoto Mechanisms in particular (Sijm et al., 2000). Hence, in considering the trade and cost effects of the multi-sector convergence approach (see Section 3.4), two cases will be distinguished. In case A, reduction options at negative marginal costs in non-Annex I and CEE/FSU Annex I countries are excluded from the analysis, whereas this 'profitable potential' is included in case B.

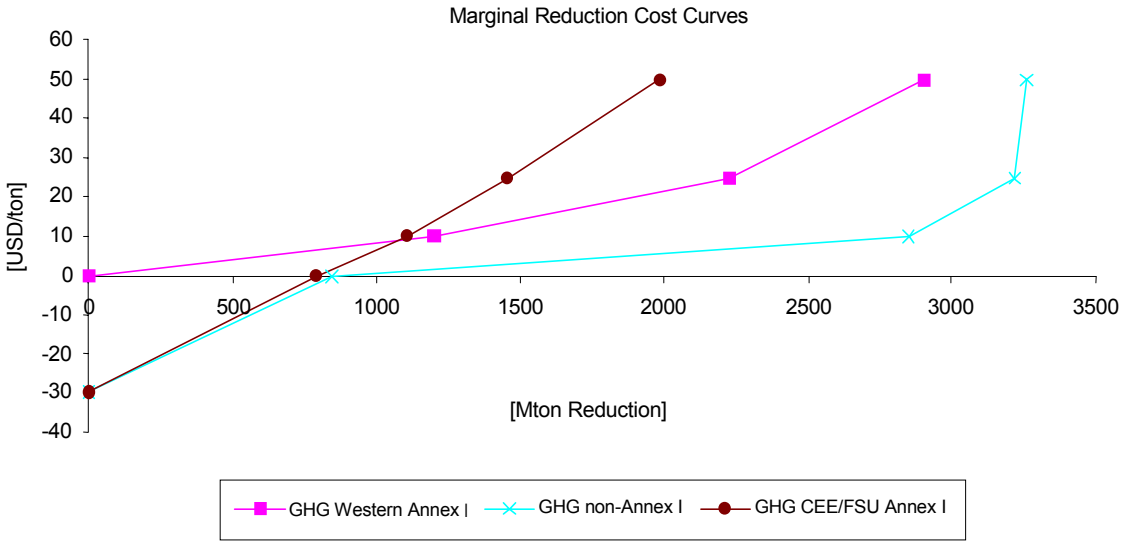


Figure 3.1 *Marginal reduction cost curves in major regions of the world*

## 3.3 Emission reduction requirements

Emission reduction requirements are defined as the difference between the expected (baseline) emissions in the year 2010/2015 and the so-called 'emission limitation target', i.e. the assigned amount of GHG emissions in 2010/2015 based on a certain percentage - for instance, 90 or 95 percent - of the emission level in the reference year. Table 3.1 summarises the estimated GHG emission levels in 1990, 2010 and 2015, the emission limitation targets and the resulting emission reduction requirements for each western Annex I country as well as for the Annex I countries of the CEE/FSU region as a whole.

Table 3.1 shows that the emission limitation targets of the Annex I countries are, on average, lower with regard to the first budget period (-5.2 percent) than regarding the second budget period (-7.7 percent). However, as the projected increase in baseline emissions is more significant in the years 1990-2010 (11.4 percent) than between 2010 and 2015 (6.2 percent), the emission reduction requirements in absolute amounts are higher for the first budget period (2.9 billion tonnes $CO_2$ eq.) than for the second budget period (2.5 billion tonnes $CO_2$ eq.). Moreover, these aggregated figures hide major differences at the disaggregated level of individual countries and regions. For instance, emission reduction requirements for the USA decrease from almost 2.0 billion tonnes in the first budget period to less than 0.8 billion tonnes in the second budget period, whereas they increase for the CEE/FSU Annex I region as a whole from, on average, 0 to more than 1.0 billion tonnes $CO_2$ eq. Note that the emission reduction targets of columns 4 and 5 in Table 3.1. have a relative meaning as an indicator of burden sharing among countries as real emission reduction requirements are not only (or mainly) determined by these targets and emissions levels of the base year, but also - sometimes even predominantly - by emission levels in the year 2010 or 2015 as determined by population and economic growth as well as other autonomous trends affecting baseline emission levels.

Table 3.1. *Emission levels, limitation targets and reduction requirements of Annex I countries (first and second budget period)*[a]

| Country/region | GHG baseline emissions[b] (in $MtC0_2eq.$) | | | Emission limitation targets (as reduction percentage, in %)[c] | | Emission limitation targets (as assigned amounts, in $MtC0_2eq.$) | | Emission reduction requirements (in $MtC0_2eq.$) | | Emission reduction requirements (as reduction percentage, in %)[d] | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1990 | 2010 | 2015 | 2010 | 2015 | 2010 | 2015 | 2010 | 2015 | 2010 | 2015 |
| Australia | 423 | 496 | 517 | -8 | 5.2 | 456 | 433 | 40 | 44 | 8 | 9 |
| Austria | 79 | 86 | 88 | 13 | 6.0 | 69 | 65 | 17 | 6 | 20 | 9 |
| Belgium | 130 | 144 | 148 | 7.5 | 7.8 | 120 | 111 | 24 | 13 | 16 | 11 |
| Canada | 340 | 402 | 419 | 6 | 5.3 | 320 | 303 | 82 | 34 | 20 | 10 |
| Denmark | 73 | 79 | 80 | 21 | 6.0 | 58 | 54 | 21 | 5 | 27 | 8 |
| Finland | 64 | 83 | 89 | 0 | 7.6 | 64 | 59 | 19 | 11 | 23 | 16 |
| France | 501 | 515 | 518 | 0 | 5.3 | 501 | 474 | 14 | 30 | 3 | 6 |
| Germany | 1203 | 976 | 1005 | 21 | 7.7 | 951 | 877 | 25 | 103 | 3 | 11 |
| Greece | 101 | 147 | 162 | -25 | 8.5 | 126 | 116 | 22 | 24 | 15 | 18 |
| Iceland | 3 | 4 | 5 | -10 | 4.3 | 3 | 3 | 1 | 1 | 29 | 22 |
| Ireland | 53 | 69 | 74 | -13 | 7.8 | 60 | 55 | 9 | 10 | 13 | 15 |
| Italy | 511 | 592 | 614 | 6.5 | 7.8 | 478 | 441 | 113 | 60 | 19 | 12 |
| Japan | 1333 | 1587 | 1658 | 6 | 7.2 | 1253 | 1162 | 334 | 162 | 21 | 12 |
| Luxembourg | 16 | 12 | 12 | 28 | 13.8 | 12 | 10 | 0 | 2 | 0 | 17 |
| Netherlands | 225 | 258 | 267 | 6 | 7.2 | 212 | 196 | 47 | 24 | 18 | 11 |
| New Zealand | 69 | 105 | 117 | 0 | 5.1 | 69 | 65 | 36 | 16 | 34 | 20 |
| Norway | 43 | 52 | 55 | -1 | 6.4 | 44 | 41 | 8 | 6 | 16 | 14 |
| Portugal | 68 | 86 | 91 | -23.9 | 6.4 | 84 | 79 | 2 | 10 | 3 | 11 |
| Spain | 294 | 358 | 375 | -15 | 6.3 | 338 | 317 | 19 | 39 | 5 | 11 |
| Sweden | 67 | 76 | 79 | -4 | 3.5 | 69 | 67 | 7 | 5 | 9 | 7 |
| Switzerland | 53 | 66 | 70 | 8 | 5.6 | 49 | 46 | 17 | 7 | 26 | 13 |
| United Kingdom | 752 | 699 | 720 | 12.5 | 6.4 | 658 | 616 | 42 | 62 | 6 | 9 |
| USA | 6187 | 7751 | 8200 | 7 | 5.6 | 5754 | 5434 | 1997 | 769 | 26 | 13 |
| *Western Annex I* | *12588* | *14645* | *15363* | *6.7* | *6.2* | *11748* | *11024* | *2898* | *1441* | *20* | *12* |
| CEE/FSU Annex I | 4885 | 4813 | 5295 | 1.5 | 11.5 | 4813 | 4258 | 0 | 1037 | 0 | 20 |
| *Total Annex I* | *17473* | *19458* | *20658* | *5.2* | *7.7* | *16561* | *15282* | *2898* | *2478* | *15* | *14* |

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

b) For an explanation of baseline emissions in 2010 and 2015, see Chapter 2 and references cited there.

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

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

## 3.4 Trade and costs effects

### 3.4.1 Main results

Table 3.2 presents the main trade and cost effects of the Kyoto Mechanisms during the first budget period (Kyoto Protocol) versus the second budget period (multi-sector convergence approach). As noted, two cases are distinguished. In case A, reduction options at negative marginal costs in non-Annex I and CEE/FSU Annex I countries are excluded from the analysis, whereas this 'profitable potential' is included in case B. For reasons of convenience, case A during the first budget period is indicated as A1 and during the second budget period as A2. The same indication applies to case B (i.e. B1 versus B2)

Table 3.2 *Main trade and cost effects of the Kyoto Mechanisms during the first and second budget period*

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

The first row of Table 3.2 provides the estimated reduction requirements of the Annex I countries as derived in Table 3.1. In case of free trade (i.e. unrestricted use of all Kyoto Mechanisms), these requirements will be met at an international equilibrium price of emission credits equal to 8 US$ per tonne $CO_2$ eq. in case A1 and 3 US$ in case B1 as far as the first budget period is concerned. In the second budget period, on the contrary, this price level will be much higher - i.e. 24 and 10 US$, respectively - as the cheapest reduction options have already been used during the first budget period.

Depending on the equilibrium price of emission credits, countries will determine the optimal level of both their domestic emission reductions and their foreign trade transactions in emission credits. For instance, in case A2 (i.e. an equilibrium price of 24 US$ per tonne), the Annex I countries will reduce 1410 Mt GHG emissions at home and import emission credits equal to an amount of 1068 Mt (Table 3.2). In case B2, however, the equilibrium price of emission credits will be lower (10 US$ per tonne). As a result, Annex I countries will reduce less GHG emissions at home (1070 Mt) and import more emission credits abroad (1408 Mt). In both cases, imported emission credits are predominantly achieved through CDM transactions with non-Annex I countries and hardly by ET transactions within the western Annex I region. JI transactions with countries in the CEE/FSU Annex I region are estimated to be 0 during the second budget period in contrast to the first budget period when they account for a substantial part of total trade in emission credits.[12]

In addition to the above-mentioned trade effects, Table 3.2 also presents the main cost effects of the decision to enable Annex I countries to meet their reduction requirements by means of Kyoto Mechanisms. It shows that, in case A1, global abatement costs are estimated to tumble from almost 76 billion US$ 'before trade' to 10 billion US$ after trade' (i.e. after relying on the Kyoto Mechanisms). Including no-regret options in the non-Annex I and CEE/FSU Annex I regions (case B1) results in a further decrease of total abatement costs to 1.6 billion US$. In the latter case, the average reduction costs per tonne will be only 0.5 US$ compared to 26 US$ 'before trade'. Similar, although slightly less spectacular cost savings will be realised during the second budget period (cases A2 and B2). Hence, it may be concluded that the decision to introduce JI, CDM and ET may result in tremendous global savings of total abatement costs, par-

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

ticularly if no-regret options in non-Annex I and CEE/FSU Annex I regions are included in global abatement strategies.

Table 3.3 *First budget period: domestic reductions and foreign trade effects of using Kyoto Mechanisms (Kyoto Protocol)*

| | Reduction requirements [Mt] | Domestic reductions [Mt] Case A1 | Case B1 | Trade in emission credits [Mt] Case A1 | Case B1 | Trade as % of requirements Case A1 | Case B1 |
|---|---|---|---|---|---|---|---|
| Australia | 40 | 23 | 13 | -17 | -27 | 43 | 69 |
| Austria | 17 | 5 | 3 | -13 | -14 | 73 | 80 |
| Belgium | 24 | 8 | 4 | -16 | -20 | 66 | 84 |
| Canada | 82 | 31 | 18 | -51 | -64 | 63 | 78 |
| Denmark | 21 | 4 | 2 | -17 | -19 | 83 | 91 |
| Finland | 19 | 7 | 3 | -13 | -17 | 65 | 86 |
| France | 14 | 36 | 17 | 22 | 3 | -158 | -22 |
| Germany | 25 | 59 | 29 | 34 | 4 | -135 | -14 |
| Greece | 22 | 11 | 6 | -10 | -16 | 48 | 74 |
| Iceland | 1 | 1 | 0 | -1 | -1 | 81 | 108 |
| Ireland | 9 | 6 | 3 | -3 | -6 | 29 | 64 |
| Italy | 113 | 25 | 11 | -88 | -102 | 78 | 90 |
| Japan | 334 | 57 | 48 | -278 | -286 | 83 | 86 |
| Luxembourg | 0 | 0 | 0 | 0 | 0 | N.A. | N.A. |
| Netherlands | 47 | 19 | 10 | -27 | -36 | 59 | 78 |
| New Zealand | 36 | 21 | 9 | -15 | -27 | 43 | 76 |
| Norway | 8 | 3 | 2 | -6 | -7 | 70 | 78 |
| Portugal | 2 | 7 | 4 | 4 | 1 | -183 | -49 |
| Spain | 19 | 28 | 14 | 9 | -5 | -48 | 26 |
| Sweden | 7 | 2 | 1 | -5 | -6 | 76 | 87 |
| Switzerland | 17 | 3 | 3 | -14 | -15 | 80 | 84 |
| United Kingdom | 42 | 20 | 10 | -22 | -32 | 52 | 77 |
| USA | 1997 | 734 | 341 | -1263 | -1656 | 63 | 83 |
| CEE+ FSU Annex I | 0 | 254 | 900 | 254 | 900 | N.A. | N.A. |
| Africa | 0 | 113 | 68 | 113 | 68 | N.A. | N.A. |
| Asia | 0 | 1116 | 1001 | 1116 | 1001 | N.A. | N.A. |
| FSU non-Annex I | 0 | 96 | 41 | 96 | 41 | N.A. | N.A. |
| Latin America | 0 | 151 | 177 | 151 | 177 | N.A. | N.A. |
| Middle East | 0 | 57 | 159 | 57 | 159 | N.A. | N.A. |
| Oceania | 0 | 1 | 0 | 1 | 0 | N.A. | N.A. |

N.A. Data not available since reduction requirements are equal to zero.

### 3.4.2 Disaggregated trade effects

Disaggregated results with regard to the trade effects of the Kyoto Mechanisms are presented in Tables 3.3 and 3.4 for the first and second budget periods, respectively. These trade effects concern the optimal levels of domestic emission reductions and foreign trade transactions in emission credits. Table 3.4 shows that, in case A2, several western Annex I countries will achieve 50 percent or more of their reduction requirements by importing emission credits - through one or all Kyoto Mechanisms - and the remaining share by domestic measures. Together, the western Annex I countries will import 1410 Mt of emission credits, i.e. about 43 percent of their total reduction requirements.

Note that in case A2, with an equilibrium price level of 24 US$ per emission credit, it would be most efficient for some western Annex I countries to export emission credits. These countries include particularly Canada and the USA. Their total export of emission credits, however, is equivalent to only 126 Mt (Table 3.2). In case A2, the main exporters of emission credits are CDM countries in Asia (665 Mt) and Latin America (61 Mt).

In case B2 (including no regret options), the equilibrium price of emission credits will be much lower (10 US$). In this case, western Annex I countries will even rely more on the use of Kyoto Mechanisms as, on average, some 57 percent of their reduction requirements will be covered by imports of emission credits (see Table 3.2). Compared to case A2 discussed above, the inclusion

of no-regret options will increase exports of emission credits by CDM countries from 942 Mt to 1406 Mt, whereas the amount of ET transactions between western Annex I countries will decrease from 126 to 3 Mt.

Table 3.4 *Second budget period: domestic reductions and foreign trade effects of using Kyoto Mechanisms (Multi-sector convergence approach)*

| | Reduction requirements [Mt] | Domestic reductions [Mt] | | Trade in emission credits [Mt] | | Trade as % of requirement | |
|---|---|---|---|---|---|---|---|
| | | Case A2 | Case B2 | Case A2 | Case B2 | Case A2 | Case B2 |
| Australia | 44 | 12 | 16 | -33 | -29 | 73 | 64 |
| Austria | 6 | 4 | 2 | -2 | -4 | 38 | 66 |
| Belgium | 13 | 14 | 7 | 0 | -6 | -2 | 48 |
| Canada | 34 | 38 | 19 | 4 | -15 | -13 | 43 |
| Denmark | 5 | 3 | 2 | -1 | -3 | 30 | 55 |
| Finland | 11 | 9 | 6 | -1 | -4 | 12 | 41 |
| France | 30 | 25 | 29 | -5 | -1 | 17 | 4 |
| Germany | 103 | 36 | 46 | -67 | -57 | 65 | 56 |
| Greece | 25 | 19 | 8 | -7 | -17 | 26 | 67 |
| Iceland | 1 | 1 | 1 | 0 | 0 | 24 | 14 |
| Ireland | 10 | 5 | 5 | -4 | -5 | 45 | 48 |
| Italy | 60 | 27 | 22 | -33 | -38 | 55 | 63 |
| Japan | 161 | 66 | 13 | -95 | -148 | 59 | 92 |
| Luxembourg | 2 | 1 | 0 | -1 | -2 | 68 | 77 |
| Netherlands | 24 | 25 | 13 | 1 | -11 | -5 | 44 |
| New Zealand | 15 | 17 | 18 | 1 | 3 | -9 | -17 |
| Norway | 6 | 2 | 1 | -3 | -4 | 60 | 75 |
| Portugal | 10 | 8 | 4 | -2 | -6 | 18 | 57 |
| Spain | 39 | 40 | 21 | 1 | -18 | -3 | 45 |
| Sweden | 5 | 3 | 1 | -2 | -4 | 42 | 77 |
| Switzerland | 7 | 5 | 1 | -2 | -6 | 30 | 82 |
| United Kingdom | 62 | 33 | 36 | -29 | -26 | 47 | 42 |
| USA | 769 | 886 | 597 | 118 | -171 | -15 | 22 |
| CEE+ FSU Annex I | 1037 | 405 | 223 | -632 | -814 | 61 | 78 |
| Africa | 0 | 36 | 103 | 36 | 103 | N.A. | N.A. |
| Asia | 0 | 665 | 1023 | 665 | 1023 | N.A. | N.A. |
| FSU non-Annex I | 0 | 31 | 88 | 31 | 88 | N.A. | N.A. |
| Latin America | 0 | 61 | 138 | 61 | 138 | N.A. | N.A. |
| Middle East | 0 | 21 | 51 | 21 | 51 | N.A. | N.A. |
| Oceania | 0 | 2 | 1 | 2 | 1 | N.A. | N.A. |

N.A. Data not available since reduction requirements are equal to zero.

The results of Table 3.4 - which concern the multi-sector convergence approach - can be compared with those of Table 3.3, which refer to the burden differentiation among Annex I countries as agreed in the Kyoto Protocol. The main difference between these two burden sharing approaches is that emission trade as a percentage of total reduction requirements is, on average, significantly higher in both cases of the first budget period (A1 and B1) than of the second budget period (A2 and B2, see also Table 3.2). This results from the fact that after relying on the most efficient trade options during the first budget period, the differences in cost structures between the countries and regions involved are less outspoken during the second budget period.

Another major difference between the first and second budget period is that the CEE/FSU Annex I region switches from a major exporter of JI credits during the first budget period to a significant importer of emission credits in the second budget period. This switch in trade position can be ascribed to the combination of two factors, i.e. (i) the reduction requirements of the CEE/FSU Annex I countries increase from, on average, 0 Mt in the first budget period to more than 1 billion Mt during the second budget period, and (ii) a major part of the cheapest domestic abatement options in the CEE/FSU Annex I region is used to export emission credits during the first budget period and is, hence, not available during the second budget period.

Table 3.5 *First budget period: costs effects of using Kyoto Mechanisms (Kyoto Protocol)*

| | Costs before trade [M US$95] | Costs after trade [M US$95] | | Costs as % of GDP 2010 | | | Net gains as % of GDP 2010 | |
|---|---|---|---|---|---|---|---|---|
| | | | | Before trade | After trade | | | |
| | | Case A1 | Case B1 | | Case A1 | Case B1 | Case A1 | Case B1 |
| Australia | 371 | 196 | 92 | 0.08 | 0.04 | 0.02 | 0.04 | 0.06 |
| Austria | 1167 | 104 | 43 | 0.37 | 0.03 | 0.01 | 0.34 | 0.36 |
| Belgium | 298 | 147 | 64 | 0.08 | 0.04 | 0.02 | 0.04 | 0.06 |
| Canada | 1090 | 474 | 205 | 0.14 | 0.06 | 0.03 | 0.08 | 0.11 |
| Denmark | 859 | 143 | 58 | 0.37 | 0.06 | 0.03 | 0.31 | 0.35 |
| Finland | 266 | 122 | 54 | 0.16 | 0.07 | 0.03 | 0.09 | 0.13 |
| France | 11 | -50 | 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Germany | 20 | -69 | 19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Greece | 162 | 115 | 53 | 0.13 | 0.09 | 0.04 | 0.04 | 0.09 |
| Iceland | 14 | 10 | 5 | 0.15 | 0.11 | 0.05 | 0.04 | 0.10 |
| Ireland | 46 | 40 | 20 | 0.06 | 0.05 | 0.02 | 0.01 | 0.03 |
| Italy | 7551 | 764 | 320 | 0.52 | 0.05 | 0.02 | 0.46 | 0.49 |
| Japan | 32222 | 2179 | 864 | 0.48 | 0.03 | 0.01 | 0.45 | 0.47 |
| Luxembourg | 0 | -1 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Netherlands | 506 | 266 | 117 | 0.09 | 0.05 | 0.02 | 0.04 | 0.07 |
| New Zealand | 282 | 192 | 93 | 0.42 | 0.29 | 0.14 | 0.13 | 0.28 |
| Norway | 242 | 49 | 20 | 0.12 | 0.03 | 0.01 | 0.10 | 0.11 |
| Portugal | 0 | -13 | 0 | 0.00 | -0.01 | 0.00 | 0.01 | 0.00 |
| Spain | 33 | 19 | 29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sweden | 128 | 46 | 19 | 0.04 | 0.01 | 0.01 | 0.03 | 0.04 |
| Switzerland | 1061 | 111 | 44 | 0.26 | 0.03 | 0.01 | 0.23 | 0.25 |
| United Kingdom | 595 | 231 | 106 | 0.04 | 0.02 | 0.01 | 0.02 | 0.03 |
| USA | 28830 | 12154 | 5341 | 0.30 | 0.13 | 0.06 | 0.18 | 0.25 |
| *Tot. western Annex I* | *75753* | 17230 | 7574 | 0.26 | 0.06 | 0.03 | *0.20* | *0.23* |
| CEE+ FSU Annex I | 0 | -1029 | -2557 | 0.00 | -0.09 | -0.23 | 0.09 | 0.23 |
| *Total Annex I* | *75753* | 16201 | 5017 | 0.25 | 0.05 | 0.02 | *0.20* | *0.23* |
| Africa | 0 | -432 | -138 | 0.00 | -0.06 | -0.02 | 0.06 | 0.02 |
| Asia | 0 | -4277 | -2347 | 0.00 | -0.08 | -0.05 | 0.08 | 0.05 |
| FSU non-Annex I | 0 | -370 | -68 | 0.00 | -0.17 | -0.03 | 0.17 | 0.03 |
| Latin America | 0 | -580 | -442 | 0.00 | -0.02 | -0.02 | 0.02 | 0.02 |
| Middle East | 0 | -217 | -444 | 0.00 | -0.02 | -0.03 | 0.02 | 0.03 |
| Oceania | 0 | -5 | -1 | 0.00 | -0.05 | -0.01 | 0.05 | 0.01 |
| *Total non-Annex I* | *0* | -5881 | -3439 | 0.00 | -0.06 | -0.03 | *0.06* | *0.03* |
| World | 75753 | 10321 | 1578 | 0.19 | 0.03 | 0.00 | 0.16 | 0.18 |

### 3.4.3 Disaggregated cost effects

Owing to the Kyoto Mechanisms, global abatement costs to meet reduction requirements of Annex I countries during the second budget period are estimated to tumble from 133 billion US$ 'before trade' to 35 billion US$ 'after trade' (case A2, excluding no-regret options), and even to 16 billion US$ if these options are included (case B2, Table 3.2). Table 3.6 provides a more detailed picture of these cost effects for the individual western Annex I countries, the western Annex I region as a whole, the CEE/FSU Annex I region and the other, non-Annex I regions of the world. It shows that, before trade, abatement costs in absolute terms are mainly born by major western Annex I countries such as Italy, Japan and the US due to either high reduction requirements or relatively high domestic reduction costs (or a combination of both factors). Total abatement costs of these three countries amount to 109 billion US$, i.e. some 82 percent of all cost to meet the reduction requirements of the western Annex I countries.

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

emission credits to Annex I countries. In case A2, such profits will be mainly realised by countries in Asia (7.5 billion US$) and in Latin America (0.8 billion US$).

Table 3.6 *Second budget period: costs effects of using Kyoto Mechanisms (Multi-sector convergence approach)*[a]

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

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

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

Table 3.7 *First budget period: Average costs to meet reduction requirements (Kyoto Protocol)*

| | Average costs per tonne before trade [US$/t] | Average costs per tonne after trade [US$/t] | | Average costs per capita before trade [US$95/CAP2010] | Average costs per capita after trade [US$95/CAP2010] | |
|---|---|---|---|---|---|---|
| | | Case A1 | Case B1 | | Case A1 | Case B1 |
| Australia | 9.3 | 4.9 | 2.3 | 21.8 | 9.8 | 4.6 |
| Austria | 67.4 | 6.0 | 2.5 | 145.9 | 13.0 | 5.3 |
| Belgium | 12.6 | 6.2 | 2.7 | 29.8 | 14.7 | 6.4 |
| Canada | 13.3 | 5.8 | 2.5 | 40.4 | 14.8 | 6.4 |
| Denmark | 41.0 | 6.8 | 2.8 | 171.8 | 28.7 | 11.7 |
| Finland | 13.7 | 6.3 | 2.8 | 53.3 | 24.4 | 10.8 |
| France | 0.7 | -1.4 | 0.6 | 0.2 | -0.8 | 0.2 |
| Germany | 0.8 | -1.2 | 0.6 | 0.2 | -0.8 | 0.2 |
| Greece | 7.5 | 5.3 | 2.5 | 16.2 | 10.4 | 4.8 |
| Iceland | 10.6 | 7.9 | 3.5 | 13.8 | 10.3 | 4.5 |
| Ireland | 5.1 | 4.4 | 2.3 | 11.5 | 9.9 | 5.0 |
| Italy | 66.6 | 6.7 | 2.8 | 130.2 | 13.6 | 5.7 |
| Japan | 96.4 | 6.5 | 2.6 | 251.7 | 17.0 | 6.8 |
| Luxembourg | 0.0 | -4.0 | -1.6 | 0.0 | -1.0 | -0.2 |
| Netherlands | 10.8 | 5.7 | 2.5 | 33.7 | 16.7 | 7.3 |
| New Zealand | 7.9 | 5.3 | 2.6 | 94.1 | 48.1 | 23.2 |
| Norway | 28.7 | 5.8 | 2.4 | 60.5 | 9.9 | 4.0 |
| Portugal | 0.0 | -2.0 | -0.1 | 0.0 | -1.3 | 0.0 |
| Spain | 1.7 | 0.7 | 1.5 | 0.8 | 0.5 | 0.7 |
| Sweden | 18.2 | 6.5 | 2.7 | 16.0 | 5.1 | 2.1 |
| Switzerland | 61.0 | 6.4 | 2.6 | 151.6 | 15.8 | 6.3 |
| United Kingdom | 14.3 | 5.6 | 2.5 | 10.4 | 3.9 | 1.8 |
| USA | 14.4 | 6.1 | 2.7 | 106.8 | 40.9 | 18.0 |
| CEE/FSU Annex I | 0.0 | -4.0 | -2.8 | 0.0 | -3.4 | -8.5 |
| World | 26.1 | 3.6 | 0.5 | 14.5 | 1.5 | 0.2 |

The last two columns of Table 3.6 express net gains of using Kyoto Mechanisms as a share of the estimated GDP in 2015. In these terms, the countries that benefit most include Italy, Japan, Iceland and Luxembourg, mainly due to their relatively high domestic reduction costs.

The most important exception to the cost savings patterns discussed above concerns the CEE/FSU Annex I region. For the second budget period, abatement costs before trade are estimated at 0.8 billion US$. After trade, however, these costs increase to 9.7 billion US$ in case B2 and even to 22 billion US$ in case A2. At first sight, this outcome seems to contradict both economic theory and common sense that states that international trade benefits all parties involved. The outcome, however, can be explained by the methodology used to estimate abatement costs during the second budget period. The case 'before trade' presented in Table 3.6 (and other tables referring to the second budget period) concerns the situation where emission reduction requirements are met fully by only domestic actions in both the first and second budget periods. On the other hand, case A2 (B2) refers to the situation where no-regret options are excluded (included) in both the first and second budget periods. Hence, from both a theoretical and a common-sensible point of view, it would be more adequate to compare the costs of either case A2 or case B2 with the costs of the 'no trade' option during the second budget period *after* either case A1 or B1 has been applied during the first budget period. In that case, costs before trade will be higher than after trade and, hence, it makes sense to rely on the Kyoto Mechanisms (as economic theory would suggest).

Regarding the contents of the issue mentioned above, an additional explanation is at stake. For the first budget period, reduction requirements of the CEE/FSU Annex I region as a whole is, on average, 0 MT.[13] As a result, this region exports large amounts of JI emission credits in both cases A1 and B1 at relatively low international price levels (see Tables 3.2 and 3.3). For the second budget period, however, the reduction requirements of the CEE/FSU Annex I region are

[13] Although the CEE/FSU Annex I region has accepted a reduction target of, on average, 1.5 percent of its 1990 emission level, reduction requirements turn out to be 0 Mt as baseline emissions in 2010 are estimated to decline autonomously to the assigned amounts of GHG emissions for this year.

estimated at more than 1 billion Mt (Table 3.4). Whereas this region exports a major part of its cheapest reduction options at relatively low prices during the first budget period (in either case A1 or B1), it imports a major part of its reduction requirements at relatively high prices during the second budget period.[14]

Table 3.8 *Second budget period: Average costs to meet reduction requirements (Multi-sector Convergence Approach)*[a]

| | Average costs per tonne before trade [US$/t] | Average costs per tonne after trade [US$/t] | | Average costs per capita before trade [US$95/CAP2010] | Average costs per capita after trade [US$95/CAP2010] | |
|---|---|---|---|---|---|---|
| | | Case A2 | Case B2 | | Case A2 | Case B2 |
| Australia | 67.9 | 21.5 | 8.9 | 143.4 | 45.5 | 18.9 |
| Austria | 225.2 | 19.0 | 9.0 | 168.9 | 14.3 | 6.8 |
| Belgium | 57.1 | 15.7 | 8.4 | 74.2 | 20.4 | 10.9 |
| Canada | 68.1 | 14.7 | 8.1 | 69.4 | 14.9 | 8.3 |
| Denmark | 121.0 | 17.6 | 8.4 | 121.0 | 17.6 | 8.4 |
| Finland | 63.8 | 15.6 | 7.6 | 140.4 | 34.4 | 16.8 |
| France | 6.0 | 15.8 | 6.7 | 2.9 | 7.8 | 3.3 |
| Germany | 17.5 | 20.5 | 8.5 | 21.8 | 25.5 | 10.6 |
| Greece | 31.0 | 18.4 | 9.1 | 68.7 | 40.8 | 20.2 |
| Iceland | 331.0 | 0.0 | 5.0 | 331.0 | 0.0 | 5.0 |
| Ireland | 66.4 | 17.9 | 7.8 | 166.0 | 44.8 | 19.5 |
| Italy | 248.3 | 19.8 | 8.7 | 268.4 | 21.4 | 9.4 |
| Japan | 304.9 | 21.2 | 9.9 | 383.5 | 26.6 | 12.5 |
| Luxembourg | 83.0 | 18.0 | 8.0 | 166.0 | 36.0 | 16.0 |
| Netherlands | 74.1 | 15.3 | 8.2 | 109.4 | 22.6 | 12.1 |
| New Zealand | 57.2 | 13.4 | 5.9 | 199.6 | 46.8 | 20.7 |
| Norway | 111.7 | 18.7 | 8.3 | 126.7 | 21.2 | 9.5 |
| Portugal | 10.3 | 18.2 | 9.1 | 10.3 | 18.2 | 9.1 |
| Spain | 11.8 | 15.5 | 8.2 | 11.8 | 15.5 | 8.2 |
| Sweden | 51.4 | 19.8 | 9.4 | 27.7 | 10.7 | 5.1 |
| Switzerland | 182.7 | 17.7 | 9.0 | 182.7 | 17.7 | 9.0 |
| United Kingdom | 80.1 | 14.2 | 5.9 | 81.7 | 14.5 | 6.1 |
| USA | 59.1 | 13.9 | 7.4 | 149.4 | 35.2 | 18.6 |
| CEE/FSU Annex I | 0.8 | 20.9 | 9.4 | 2.8 | 72.2 | 32.4 |
| World | 53.8 | 14.2 | 6.4 | 18.4 | 4.8 | 2.2 |

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

A comparison of Table 3.5 (Kyoto Protocol) and Table 3.6 (multi-sector convergence approach) reveals that abatement costs - both before and after trade - are generally substantially higher in the second budget period than in the first budget period. As a percentage of GDP, however, global abatement costs rise only from 0.2 percent in the first budget period to 0.3 percent in the second budget period.

Finally, Tables 3.7 and 3.8 present the average costs per tonne and per capita of meeting reduction requirements, both before and after trade. Table 3.8 (second budget period) shows that average abatement costs at the global level decrease from 54 US$/tonne before trade to 14 and 6.4 US$ after trade in cases A2 and B2, respectively. In per capita terms, these costs decline from 18 US$ to 4.8 and 2.2 US$, respectively. These average figures, however, hide major differences between countries and regions. In case B2, for instance, average abatement costs per tonne or per capita hardly decrease due to the trade option in countries such as Spain or Portugal, whereas they tumble significantly in countries such as Japan or Iceland.

[14] For case A2, a similar explanation also applies to countries such as France, Germany, Portugal and Spain. These countries export ET credits at relatively low prices during the first budget period (A1), but import emission credits at relatively high prices during the second budget period (A2). As a result, abatement costs after trade (A2) seem to be higher than 'before trade', although – as explained in the main text – this is mainly a result of the methodology and presentation applied in Table 3.6.

# 4. INDICATORS OF BURDEN SHARING: SUMMARY AND CONCLUSION

The analysis in the previous chapter can be summarised by comparing some indicators of burden sharing among Annex I countries. In Table 3.9 - referring to the first budget period of the Kyoto Protocol - five indicators are recorded:

1. Emission limitation targets for the year 2010, expressed as a reduction percentage of emission levels in the base year 1990. These targets originate from the Kyoto Protocol and the subsequent burden differentiation among the Member States of the EU.
2. Emission reduction requirements in 2010, expressed as an abatement percentage of emissions levels in the year 2010 (which stands for the first budget period 2008-2012).
3. Reduction costs as a percentage of GDP in 2010, excluding both no-regret options and the use of Kyoto Mechanisms.
4. Reduction costs as a percentage of GDP in 2010, excluding no-regret options but including the use of Kyoto Mechanisms.
5. Reduction costs as a percentage of GDP in 2010, including both no-regret options and the use of Kyoto Mechanisms.

Table 3.9 *First budget period: Indicators of burden sharing (Kyoto Protocol)*

| Emission limitation targets for 2010 | | Emission reduction requirements in 2010 | | Costs as % of GDP 2010 | | | | |
|---|---|---|---|---|---|---|---|---|
| (as reduction % of 1990 emissions)[a] | | (as reduction % of 2010 emissions) | | Before trade | | After trade | | |
| | | | | | | Case A1 | | Case B1 |
| Luxembourg | 28 | New Zealand | 34 | Italy | 0.52 | New Zealand | 0.29 | New Zealand | 0.14 |
| Denmark | 21 | Iceland | 29 | Japan | 0.48 | USA | 0.13 | USA | 0.06 |
| Germany | 21 | Denmark | 27 | New Zealand | 0.42 | Iceland | 0.11 | Iceland | 0.05 |
| Austria | 13 | Switzerland | 26 | Austria | 0.37 | Greece | 0.09 | Greece | 0.04 |
| UK | 12.5 | USA | 26 | Denmark | 0.37 | Finland | 0.07 | Canada | 0.03 |
| Switzerland | 8 | Finland | 23 | USA | 0.30 | Canada | 0.06 | Denmark | 0.03 |
| Belgium | 7.5 | Japan | 21 | Switzerland | 0.26 | Denmark | 0.06 | Finland | 0.03 |
| USA | 7 | Austria | 20 | Finland | 0.16 | Ireland | 0.05 | Australia | 0.02 |
| Italy | 6.5 | Canada | 20 | Iceland | 0.15 | Italy | 0.05 | Belgium | 0.02 |
| Canada | 6 | Italy | 19 | Canada | 0.14 | Netherlands | 0.05 | Ireland | 0.02 |
| Japan | 6 | Netherlands | 18 | Greece | 0.13 | Australia | 0.04 | Italy | 0.02 |
| Netherlands | 6 | Belgium | 16 | Norway | 0.12 | Belgium | 0.04 | Netherlands | 0.02 |
| CEE/FSU | 1.5 | Norway | 16 | Netherlands | 0.09 | Austria | 0.03 | Austria | 0.01 |
| Finland | 0 | Greece | 15 | Australia | 0.08 | Japan | 0.03 | Japan | 0.01 |
| France | 0 | Ireland | 13 | Belgium | 0.08 | Norway | 0.03 | Norway | 0.01 |
| New Zealand | 0 | Sweden | 9 | Ireland | 0.06 | Switzerland | 0.03 | Sweden | 0.01 |
| Norway | -1 | Australia | 8 | Sweden | 0.04 | UK | 0.02 | Switzerland | 0.01 |
| Sweden | -4 | UK | 6 | UK | 0.04 | Sweden | 0.01 | UK | 0.01 |
| Australia | -8 | Spain | 5 | France | 0.00 | France | 0.00 | France | 0.00 |
| Iceland | -10 | France | 3 | Germany | 0.00 | Germany | 0.00 | Germany | 0.00 |
| Ireland | -13 | Germany | 3 | Luxembourg | 0.00 | Luxembourg | 0.00 | Luxembourg | 0.00 |
| Spain | -15 | Portugal | 3 | Portugal | 0.00 | Spain | 0.00 | Portugal | 0.00 |
| Portugal | -23.9 | Luxembourg | 0 | Spain | 0.00 | Portugal | -0.01 | Spain | 0.00 |
| Greece | -25 | CEE/FSU | 0 | CEE/FSU | 0.00 | CEE/FSU | -0.09 | CEE/FSU | -0.23 |

a) A positive figure means that emissions in the first budget period should decrease by the percentage indicated compared to the level of GHG emissions in 1990, whereas a negative sign implies that they are allowed to increase by the percentage recorded.

For each indicator, countries have been ranked to descending order of burden sharing. The table reveals that the ranking of countries may differ significantly depending on the indicator used. For instance, Greece is ranked lowest (position 24) in terms of indicator 1, i.e. according to the Kyoto Protocol Greece is allowed to increase its emission level in 2010 by 25 percent compared to 1990 (columns 1-2). However, as growth in GHG emissions over the period 1990-2010 is relatively high compared to other Annex I countries, Greece is ranked on position 14 in terms of indicator 2 (columns 3-4). The ranking of Greece increases further to position 11 in terms of reduction costs expressed as a percentage of GDP in 2010 (columns 5-6, excluding both no-regret options and the use of Kyoto Mechanisms). Finally, Greece reaches the fourth position in terms of reduction costs expressed as a percentage of GDP in 2010 if all Annex I countries are allowed to use the Kyoto Mechanisms unrestrictedly, irrespective whether no-regret options are

included or excluded (columns 7-10). Similar and other irregular patterns of ranking according to different indicators of burden sharing can be discerned for other countries such as Australia, Iceland, New Zealand, Italy or Japan (Table 3.9).

Table 3.10 provides similar indicators of burden sharing for the second budget period as derived from the multi-sector convergence approach. Significant shifts in ranking per indicator can be noticed for a variety of countries such as Iceland, New Zealand, Australia, Germany, Italy or the CEE/FSU Annex I region.

Table 3.10 *Second budget period: Indicators of burden sharing (Multi-sector Convergence Approach)*

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

a) A positive figure means that emissions in the first budget year should decrease by the percentage indicated compared to the level of GHG emissions in 2010, whereas a negative sign implies that they are allowed to increase by the percentage recorded.

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

The major lesson or conclusion from the above analysis is that allocation based burden sharing rules in terms of indicator 1 have only a relative meaning compared to other burden sharing indicators included in Tables 3.9 and 3.10. The main reason for this finding is that the burden of emission mitigation is not only determined by the setting of emission limitation targets for the year 2010/2015 (expressed as a reduction percentage relative to emission levels in 1990/2010) but also by other factors such as:

- trends in GHG emissions between 1990 and 2010/2015 as determined by population/economic growth and other autonomous (technology) trends regarding GHG emissions,
- major differences in abatement potentials and costs among countries and regions,
- including or excluding the (unrestricted/limited) use of the Kyoto Mechanisms,
- including or excluding no-regret options in (inter)national abatement strategies.

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

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