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European Climate Policy: Burden Sharing after 2012

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ABSTRACT

Regardless of whether or not the Kyoto Protocol enters into force, the EU may decide to set itself a long-term greenhouse gas emission target and thus to continue its leadership role in international climate policy. As for the first commitment period of the Kyoto Protocol, the EU may decide on a burden-sharing agreement as an integral part of such a long-term climate policy. Against this background I analyse three different options to distribute an overall budget of emission entitlements until 2042 among the member states of an enlarged EU. It is shown who wins and who loses with regard to compliance costs. As the member states' attitudes towards the different approaches are likely to depend on the relative attractiveness of the allocation options, a relevance threshold is introduced which may help to predict and understand the complexity of future climate negotiations in Europe.

Key words: accession countries, allocation of GHG emission entitlements, burden sharing, European climate policy, EU-enlargement, future commitment periods

JEL-Classification: Q 25, Q 28

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Content

1 Introduction

The EU has been perceived / described as leader in the context of international climate policy. The implementation of an EU-wide emission trading scheme on installation level (EU 2003) may serve as the latest proof. Consequently, it may also set itself an (ambitious) emission target for the time after 2012, i.e. when the first commitment period of the Kyoto Protocol ends. This target setting may of course take place in the context of the negotiations in the framework of the United Nations Framework Conventions on Climate Change (UNFCCC) as well as in a European framework only in case the Kyoto Protocol does not enter into force.[1] An EU-wide target may then be symmetrically broken down to each member state (MS), i.e. a uniform reduction rate would apply for all MS. Alternatively, a differentiated agreement as it has been reached among member states for the first commitment period of the Kyoto Protocol could also be agreed upon. Both approaches offer advantages and disadvantages (for a discussion see for example Ringius 1997).

Against this background I analyse three different burden sharing rules, namely an allocation based on equal emissions per capita, on equal emissions per capita over time and based on the sovereignty principle.

During the analysis I assume that, regardless of the option chosen, emission trading is always possible. Thus, member states are not required to meet the emission targets through national measures only. They can rather buy emission rights[2] on the market in case they are cheaper than national actions. Provided this market is competitive and neglecting transaction costs, allocating a total EU budget differently among member states does not affect the overall efficiency of the trading scheme[3]. It is rather a distributional issue as the member states compliance costs' may be affected. As the absolute costs implications over such a long period are difficult to quantify, a qualitative analysis is provided instead. This analysis then forms the basis for an investigation of the consequences for the political bargaining process.

As the EU will see ten new members in Mai 2004 these should also be considered in any analysis of future European climate policy, especially when focussing on burden sharing rules. This aspect has been neglected so far. However, as Bulgaria and Romania may also be members of the EU in 2013, they are included in the following analysis, too.

[1] Agreements between like-minded countries may generally, i.e. not only in Europe, emerge instead of a global consensus (Sugiyama 2003).
[2] The terms emission allowance, entitlement and right are used equivalently throughout this paper.
[3] With regard to an allocation to entities *within* member states as for example describe in the EU directive on Emissions trading (EU 2003), different options do matter. See for example Burtraw et al. (2001) and Burtraw et al. (2002).

The paper is structured as follows. The next section briefly discusses some aspects of justice principles. Section three reviews the burden sharing for the period 2008 to 2012 with a focus on the EU. Section four shortly describes some aspects for post 2012 commitment on the global level before the focus is again on the European level in the section that follows. Section 6 concludes.

2 Climate policy, burden sharing and justice principles

When the signs of a changing climate due to human activity became clearer at the end of the eighties of the last century, a discussion on sharing the burden of limiting GHG emission started, too (d'Arge 1989, Rose 1990). Since then, different sets of justice principles, which imply certain allocations, have been presented (and applied). Some of them are quite similar, though they are called by different names. Rose (1992) for example discusses ten different principles which later have been distinguished with regard to whether a "criterion applies to the process by which a criterion is chosen, the initial allocation of allowances, or to be the final outcome of the implementation of the policy instrument..." (Rose et al. 1998). Blanchard et al. (2001) discuss six principles and Torvanger et al. (2002) present a set of three.

The principles have mostly been considered in the global discussion, i.e. in a burden sharing between industrialised and developing countries. However, when applying them for allocations of emission entitlements two major problems arise: Firstly, the different principles are in most cases equally justified. This is to say that one cannot decide which principle is to be preferred in case there are different opinions. The views on industrialised and developing countries are quite contrary.[4] To overcome this problem, Müller (2001) proposes the so-called *preference score method* to reach a "compromise-solution" between different principles or approaches, as discussed below. Secondly, apart from the principle, a reference base, e.g. population, as well as an operational rule for applying the principle, e.g. allocate in proportion to population, is required (Rose 1992). However, "there is no 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" (Torvanger et al. 1999 p. 15).

Regardless of these theoretical considerations agreements on burden sharing for the period up to 2012 have been reached. On the global level the distinction between Annex I and non-Annex I countries in the UNFCCC as well as the distinction between Annex B and non-Annex B countries in the Kyoto Protocol can be mentioned. The latter is described in more detail in the next section. Another example is the European burden-sharing agreement which was reached in 1998. It is also further analysed below.

[4] Interestingly, Rose et al. (1998) showed that different philosophical criteria may be mathematically equivalent and thus have the same welfare outcomes.

3 The first commitment period 2008 to 2012

3.1 The international level

After the United Framework Convention on Climate Change entered into force remarkably quick, it turned out at the first Conference of Parties that the non-binding targets in the Convention for the year 2000 were too vague and inadequate to address the global and long-term problem of climate change. As a consequence the ad-hoc Group on the Berlin Mandate was initiated, which had its first full session in 1995. Appropriate policies and emission targets were intensively discussed and different positions between the Parties become obvious (Grubb et al. 1999). During this process a number of proposals for determining a Party's contribution to limiting GHG emission have been presented. They differ mostly with regard to the justice principle they refer to and the corresponding indicators they use. Torvanger et al. (1999) provide an overview on differentiated proposals.

Tab. 1: Differentiated proposals for sharing the burden of limiting GHG emissions presented in the run-op 3rd Conference of Parties*)

Feature	Party
Convergence (of emissions per capita)	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
GDP per Capita	12. Poland et al.
	13. Estonia
	14. Poland and Russia
	15. Korea
Cost-effectiveness	16. New Zealand

*) Source: Torvanger et al. (1999)

Finally, at the third Conference of Parties the Kyoto Protocol was adopted which sets differentiated, binding emission targets for most of the OECD countries. On average, a reduction of 5.2 % compared to 1990 was agreed upon. It is interesting to note that there has been no "principled logic" (Babiker et al. 2002, p. 411) for the determination of the emission targets. They are rather the outcome of a political bargaining process with limited time (Torvanger et al. 1999 p. 13, Grubb et al. 1999 p. 86). The targets are listed in Table 8 in the Annex.

Already during the Kyoto negotiations the EU raised the question of how it could allocate its commitment among its member states. To give an example, in March 1997 an agreement was found which foresaw a reduction of minus 30% for Luxembourg as the strictest target while on the other side Portugal was allowed to increase emissions by 40 %. This in turn led to condemnations by other OECD countries as the EU was calling for equal reduction obligations for other Parties (Grubb et al. 1999, pp. 85-86, also Gupta et al. 2001). In the end the EU accepted a target of minus 8 % and the so-called "bubble" (Art. 4) found its way into the Kyoto Protocol.[5]

According to Haites (2001) forming a bubble and transferring emission rights under the other flexible mechanisms are economically similar, but differ operationally. With regard to these differences he argues correctly that forming a bubble should not confer any benefits to the members of a bubble. Economically, forming a bubble thus simply implies a reallocation of assigned amount units[6] without payment. So far the European Union (EU 15) formed the only bubble.

3.2 The European level

3.2.1 The burden sharing for the first commitment period

Having an emission target for the EU as whole and subsequently differentiate the commitments between member states has been a guiding idea for the European climate police early in the 1990s. The rationale was to allow cohesion countries[7] to increase emissions while the richer ones in the North would reduce them. In 1991 the Commission proposed a burden sharing with the following three levels: - 5 % for Denmark, Germany and The Netherlands, + 15 % for the cohesion countries and stabilisation for the rest. However, it was rejected by several countries and thus not pursued any further. Only in the run-up to the Kyoto Protocol and the negotiations on binding targets did the discussion on the burden-sharing re-start. A new proposal by the Commission which foresaw a 10 % reduction for 2005, however, was not approved. Only when the Dutch presidency commissioned a study by some experts from The Netherlands did the BSA negotiations really got ahead (Michaelowa et al. 2001, p. 268).

The so-called Triptych approach (Phylipsen et al. 1998), developed by these experts, distinguishes between three sectors for each of which a target was defined. Theses targets

[5] Apart from the bubble three other flexible mechanisms were introduced that shall allow a cost-efficient meeting of the targets. This is international emissions trading (Art. 17) and the two project-based mechanisms joint implementation (JI, Art. 6) and the Clean Development Mechanism (CDM, Art. 12).

[6] assigned amount units = tradable emission rights allocated to Annex B countries of the Kyoto Protocol.

[7] Cohesion countries at that time were Greece, Ireland, Portugal and Spain which are low-income countries within the EU.

were, however, not meant to be sector targets, but rather the basis for the national targets. The underlying idea was to find a compromise between a simple symmetrical approach which was judged to be political unacceptable on the one hand and differentiated but complex and in-transparent agreements on the other hand.

The three sectors are: domestic (households, light industry and agriculture) energy intensive, export-orientated industry and electricity generation. For the domestic sector emissions per capita were to converge in all member states by 2030 at level 30 % below the EU 1990 level. Climatic aspects in the different countries have been considered. For the energy intensive, export-orientated industry sector an annual increase in energy efficiency by 1.2 and 1.5 % per year between was assumed. Production growth rate was assumed to be 1.1 and 2.1 %. For the energy sector an increase in demand of 1.9 % and 1 % was assumed for the cohesion countries and the other respectively. However, a tailor-made approach combining a country-to-country approach and general guidelines was followed to determine the electricity sector's final allowances (Ringius 1997).

The first proposal of early 1997 had been passed through several negotiations before a final agreement was reached in March of the same year. The latest negotiation result included methane and nitrous oxide, too (Phylipsen et al. 1998, p. 939). After the Kyoto Protocol had been adapted the agreement had to be renegotiated due to the inclusion of three more gases and a lower target for the EU (Michaelowa et al. 2001, p. 269). Table 2 provides an overview on the evolution of the first BSA.

Tab. 2: Burden sharing "agreements" for EU 15 in the run-up to the 3rd Conference of Parties

Country	Original triptique 1997 [1)]	Dutch proposal 1997 [2)]	1997 agreement [3)]	UK proposal 1998 [4)]	1998 agreement [5)]
Austria	-1 to -25	-25	-25	-20.5	**-13**
Belgium	-12 to -15	-15	-10	-9	**-7.5**
Denmark	-12 to -25	-25	-25	-22.5	**-21**
Finland	-4 to -7	-10	0	0	**0**
France	-4 to -12	-5	0	0	**0**
Germany	-17 to -30	-30	-25	-22.5	**-21**
Greece	-2 to 2	5	30	23	**25**
Ireland	-2 to -5	15	15	11	**13**
Italy	-5 to -9	-10	-7	-7	**-6.5**
Luxembourg	-17 to -20	-40	-30	-30	**-28**
Netherlands	-6 to -9	-10	-10	-8	**-6**
Portugal	16 to 21	25	40	24	**27**
Spain	6 to 11	14	17	15	**15**
Sweden	5 to 26	5	5	5	**4**
UK	-17 to -20	-20	-10	-12	**-12.5**
EU	**-9 to -17**	**-15**	**-9.2**	**-8.5**	**-8**

[1)] Range of four variants ; Blok et al. (1997); [2)] Ringius (1997) ; [3)] EU Council (1997) ; [4)] Michaelowa et al. (2001) ; [5)] EU Council (1998)

As mentioned the rational behind the Triptych approach was to offer an acceptable compromise. The evaluation of the burden sharing agreement, however, depends on criteria considered while judging. And the closer the agreement is coming to be effective, the higher is the opposition. Only recently did the Spanish employers' federation CEOE urge Madrid to renegotiate the burden-sharing deal as "Spain miscalculated emissions levels when it signed up" (PointCarbon 2003).

Table 3 gives some examples for selected criteria. As one can see, the burden already changes when the factual reduction obligation, i.e. the difference between baseline emissions and the emission target without any additional climate policy, is calculated (second column). The economic effects are shown in the next two columns. Again, effects differ strongly among member states and are not related to the 1998 agreement. For example, while the minus 12.5 % target of the UK seems rather strict compared to the minus 6 % target of The Netherlands, the model calculations suggest that the economic implications are rather modest for the UK compared to those for The Netherlands. Differences between welfare and GNP changes are inter alia due to favourable changes in terms-of-trade patterns.

Also when looking at the marginal abatement costs in case the member states were to meet their targets by domestic action only, large differences are found[8]. Blok et al. (2001, p.27) for example report a range between ¤$_{99}$ 1 and ¤$_{99}$ 100 per t $CO_{2\text{-eq}}$. Thus, even though some authors have (implicitly) argued that considering economical metrics would be one fair

[8] Note that absolute figures for abatement costs strongly depend on the baseline assumptions. Figures given above are to show the difference among member states only.

burden sharing rule[9], there are still problems when trying to determine "the one and only" fair rule.

Apart from that, in the contest of elaborating the national allocation plans for the European trading scheme on entity level Zhang (1999) and Viguier (2001) point out that no harmonisation is required. If national preferences differ among member states, different allocation plans (and thus costs) can still be efficient. The same is true for the discussion on the burden sharing among member states.

Given this discussion one may also consider non-economical-metric-based burden sharing rules. Column six shows the implicit allocation per capita of the 1998 agreement while column seven shows what a burden sharing based on equal emissions per capita would have had to look like. Column eight and nine provide two economic approaches. Note again that the results strongly depend on the assumption on future GHG emission development.

Tab. 3: Implications of the 1998 burden sharing agreement and alternatives

Country	Change in % compared to 1990[1)]	Change in % compared to baseline [2)]	Change of Welfare in % with BSA[3)]	Change of GNP in % with BSA[4)]	Implicit annual allocation per Capita of BSA 1998 (kg/capita) [5)]	Change in % compared to 1990 if BSA had been based on equal emissions per capita [6)]	Change in % compared to 1990 if BSA had been based on equal burden per Unit GDP [7)]	Change in % compared to 1990 if BSA had been based on equal marginal costs [8)]
Austria	-13	/	/	/	8.8	3.8	/	/
Belgium	-7.5	/	/	/	13.1	-25.9	1.1	-0.6
Denmark	-21	-43.4	-3.97	-5.72	10.6	-22.1	1.2	0.1
Finland	0	-31.5	-1.90	-2.73	15.5	-32.3	18.2	12.1
France	0	-16.0	-0.67	-1.11	9.9	6.1	-9.7	-8.0
Germany	-21	-17.8	-0.63	-1.17	12.1	-31.3	-26.6	-25.8
Greece	25	/	/	/	12.9	1.4	36.7	26.5
Ireland	13	/	/	/	17.2	-31.1	/	/
Italy	-6.5	-13.0	-1.01	-1.47	8.4	17.0	8.4	9.6
Luxembg	-28	/	/	/	20.5	-63.1	/	/
Netherlan	-6	-33.1	-4.92	-7.19	13.2	-25.3	5.5	3.4
Portugal	27	/	/	/	7.9	69.4	15.6	9.6
Spain	15	-27.2	-2.83	-4.76	8.4	43.5	3.0	7.3
Sweden	4	-31.0	-3.47	-5.11	8.8	24.0	5.8	9.1
UK	-12.5	-12,7	-0.96	-1.14	10.8	-15.3	-12.0	-10.8
EU	**-8**	**-19.7**	**/**	**/**	**10.5**	**-8**	**-8**	**-8**

[1)] 1998 agreement; [2)] Baseline without any climate policy, source: Viguier et al. 2003, p. 474; [3)] Change of welfare without international emission trading, i.e. targets must be met domestically, BSA = 1998 agreement, source Viguier et al. 2003, p 478, [4)] Change of GNP without international emission trading, i.e. targets must be met domestically, BSA = 1998 agreement, source Viguier et al. 2003, p. 478, [5)] population in 1990, emissions from EEA 2003, source: own calculations, [6)] population in 1990, own calculations, [7) 8)] source: Gielen et al. (1998)

[9] See for example Hauch (2003, pp. 517) who writes that "national emission targets that imply equal marginal costs internationally can be seen as one fair international sharing of reduction costs." One the other hand Dessai et al. (2001, p. 333) present a table which is labelled with " Emission change until 2010 under a fair burden sharing rule …" and which provides data on equal burden per unit of GDP and equal marginal cost.

3.2.2 The EU bubble and the accession countries

As the EU member states have ratified the Protocol and submitted their corresponding documents to the UN, there is no possibility to include the accession countries joining in May 2004 in the EU bubble for the first commitment period. This would only be possible from 2013 onwards. As the accession countries have also ratified the Protocol there is no option for them to form a bubble of their own as suggested by Michaelowa et al. (2001, p. 277). They also propose that the EU and the accession countries could form an implicit strategic bubble to co-ordinate sale of emission rights and JI projects. The latter aspect is discussed in more detail by Armenteros et al. (2003).

4 Emission targets on the global level after 2012

As mentioned above the discussion on the contribution to limiting GHG emissions on the global scale started end of the eighties of the last century. The different views on equity between developing and industrialised countries which became obvious during the negotiation for the first commitment periods will continue to play a dominant rule for post 2012 negotiations that shall start in 2005 latest (Art. 3.9 Kyoto Protocol). A number of proposals which are differently specified exists as for example the Global Triptych (Groenenberg 2001), which transfers the European experience to the global scale, the Brazilian Proposal (UNFCCC 1997, IISD 2003) which bases on the historical responsibility for climate change, Contraction & Convergence (Meyer 2000) which bases on equity of rights and equal emissions per capita over time (Bode 2003) which combines the two former ideas.

With regard to the European climate policy it goes without saying that the international negotiations may influence the European discussion (for example Aidt et al. 2002). Indeed, most of the global approaches mentioned above imply a certain allocation for the single EU member states. However, this is not a must. The discussion of post 2012 emission targets within the EU does not necessarily require an agreement on the global level nor the ratification of the Kyoto Protocol. Setting a long-term emission target independently of the global discussion could rather put the EU in the position of the "directional leader[10]". Finally, apart from any agreement reached on international level, EU member states can always decide to re-allocate emission entitlements among each other according to whatever rule they like to.

5 European burden sharing after 2012

In the run-up of the negotiations in Kyoto the EU-Council concluded that "…given the serious risk of such an increase [of global average temperature] and particularly the very high rate of change, the Council believes that global average temperatures should not exceed 2

[10] As used by Gupta et al. (2001).

degrees above pre-industrial level and that therefore concentration levels lower than 550 ppm CO_2 should guide global limitation and reduction efforts" (EU Council 1996). The council's conclusion was recalled in 1997 adding that this "…calls for early action on emission reduction and indicates the need for significant reductions from industrialised countries in the 2000-2020 time-frame" (EU Council 1996).

Even though the two target figures of 550 ppm and a 2 degree Celsius increase seem quite clear, it is difficult to draw concrete emission targets from that. Apart from uncertainty in climate modelling the role of timing is of crucial importance. Nevertheless, some rough ideas are possible as for example shown in Table 4. However, it is not straightforward to determine the European share of the pie.

Tab. 4: Stabilisation level and related allowable emissions

WRE CO2 Stabilisation profile (ppm)	Accumulated CO_2 emissions 2001-2100 (Gt CO_2)	Year in which global emissions peak
450	1314-2646	2005-2015
550	2124-4068	2020-2030
650	2646-4932	2030-2045
750	2952-5400	2040-2060
1000	3258-5832	2065-2090

Source: IPCC (2001, p.108)

Interestingly, there has been no co-ordinated discussion on a post-2012 burden sharing agreement within (an enlarged) European community by now. Michaelowa et al. (2001, p. 278) state that the EU should negotiate a bubble when negotiations on CoP-level on post 2012 commitments start in 2005 with all members at this time. However, no concrete options for the burden-sharing agreement are mentioned. Armenteros et al. (2003, p. 271) state that there is no real strategy by the EU on climate policies in the accession countries. Nevertheless there will be an implicit climate policy due to the adoption of the acquis communautaire which includes lots of environmental regulation as for example the IPPC-directive.

On the other hand some statements by individual member states have been made. In the 2003 Energy White Paper on the UK government accepted "…the Royal Commission on Environmental Pollution's (RCEP's) recommendation that the UK should put itself on a path towards a reduction in carbon dioxide emissions of some 60 % from current levels by about 2050" (UK 2003, p. 4 and also RCEP 2003). In Germany the Socialist and the Green Party stated in their coalition treaty (SPD/Bündnis 90 Die Grünen 2000) that Germany would reduce emission by 40 % compared to the 1990 level by 2020 in case the remainder of the EU accepts a reduction target of 30 %.[11]

[11] However, one has to keep in mind that Germany already has a target of minus 21 percent. Thus, the additional commitment is about 19 percent points. As the remaining member states in the EU do have less stringent target

Against this background I discuss three burden-sharing options for the European Union for the time after 2012, namely equal emissions per capita, equal emissions per capita over time and the sovereignty principle. The approaches are discussed in detail in the next section. At this point it is only worthwhile to mention that an allocation of emission rights on the global scale based on equal emissions per capita has been supported by different European (and non-European) policy makers. Some examples which are all taken from Meyer (2000) are given below. The concept of Contraction & Convergence includes a reduction of global GHG emission (Contraction) and an allocation of tradable emission entitlements carried out on an equal basis to all of human kind – i.e. an equal per capita allocation (Convergence). One should remember that no allocation requires specific *domestic* emission reductions at any costs for any MS. There would always be the possibility to buy emission rights on the market.

- September 1998: The European Parliament adopts a resolution on climate change that calls for global constitutional principles for the long-term management of global climate change using Contraction & Convergence.
- October 1998: Tony Blair, UK Prime Minister, writes: "I agree that, in the fight against climate change (C&C) makes an important contribution to the debate on how we achieve long-term climate stability, taking into account the principles of equity and sustainability …"
- April 1999: Svend Auken, Danish Environment Minister: "The approach 'Contraction & Convergence' is precisely such an idea. It secures a regime that would allow all nations to join efforts to protect our global commons from being over-exploited, without the risk that any country would be deprived of its fair long-term share of the common environmental emission space."
- June 2000: Jan Pronk, Netherlands Environment Minister said that C&C is the most equitable, the cheapest and easiest and the most effective.

Given these statements one can quite reasonably imagine that an allocation within the European Community will take equal emissions per capita to a higher extend into account than in the Triptych approach. The sovereignty principle is included in the analysis as it offers a straightforward approach for sharing the burden.

For all analyses a "double fifty" approach is assumed, i.e. I assume that the EU sets itself a target of minus 50 % compared to the 1990 level. The target is to be met in 2042, i.e. 50 years after the Framework Convention was adopted in Rio de Janeiro.[12] Apart from environmental concerns industry, too, is likely to support long-term targets. This has become obvious in the recent discussion on the national allocation plans for the EU trading scheme.[13] For all cases I assume that the future commitment periods are of 5 years length which is by no means

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until 2012, the German proposal implies much stricter commitments by the other MS in the future. Furthermore, it was unclear whether EU 15 or an enlarged EU was considered.

[12] There is no economically motivated rational behind this target. It is rather the two times 50 approach that might be adopted by policy makers which sometimes like simple figures.

[13] This is especially true for those industries with long-living investment as in the power sector. In Germany for example, this long-term aspect has been on the agenda in top-level discussions among Chancellor Schröder and CEO from major utilities (Anonymous 2003).

decided yet. If not stated otherwise EU means EU 27, i.e. EU 15 plus EU 10 (the accession countries joining in Mai 2004) plus Bulgaria and Romania[14]. Where required, emission data for the year 1991 to 2007 are based on real data until 2001 for EU 15 (EEA 2003) and for Cyprus and Malta (IEA 2003) and on data until 1999 for EU 10 (except Slovenia), Bulgaria and Romania (UNFCCC 2002). Data for Slovenia is taken from (Slovenia 2002). In subsequent years after the latest data on record emissions are assumed to linearly[15] reach the Kyoto-target in 2008[16].

5.1 Equal emission per capita

For the allocation based on equal emissions per capita (EEC) a linear decrease of emissions from the EU-budget in 2012[17] until the target is reached in 2042 is assumed. The available annual budget is distributed among the member states according to the member states share of total population in that year.[18] Population data is taken from USBC (2003). Of course, population changes differently among member states.[19] The highest increase can be observed in Luxembourg (+ 88 % in 2050 compared to 1990) whereas the biggest decrease is predicted in Bulgaria (- 47 % in 2050 compared to 1990). A corresponding graph is given in the annex. The results for each commitment period until 2042 are given in Table 9 in the annex. Cumulative emission rights for the period from 2013 to 2042 are shown in Table 5.

5.2 Equal emissions per capita over time (EECT)

An allocation based on equal emissions over time has been proposed by Bode (2003) and was applied on a global level. However, it is also applicable in the European context. The rationale behind this approach as follows: With an allocation based on equal emissions per capita as analysed in the previous section, the distribution may be perceived as fair from the point when EEC are reached. Until this point is reached, however, they may differ considerably (see Figure 1a). This is why it was proposed to allocate emissions entitlements in such a way that average emissions per capita in a period to be specified are also the same prior to the time when equal emission per capita are reached (hatched area in Figure 1b). Thus, when looking

[14] Accession targeted for Bulgaria and Romania in 2007.
[15] For Lithuania emissions are also assumed to change linearly between 1990 and 1998.
[16] Here: Kyoto target for 2008 = Assigned Amount for the five-year period 2008-12 divided by five. One may also argue that the emissions in 2008 can be higher when emissions in 2012 are lower to meet the emission budget. However, as below only five year periods are analysed the discussion of intra commitment period distribution is not important.
[17] EU-budget in 2012 is one fifth of the Assigned Amount in the first commitment period. For Cyprus and Malta, which are no Annex B countries yet, an 8 % reduction obligation has been assumed.
[18] Later allocations could also be based on population data of the previous year(s) instead of relying on prognoses for the year considered.
[19] In case one thinks that these changes imply to much uncertainty with regard to the allocation in a future year, one may consider to allocate on the basis of the member states' seats in the European Parliament which are based on population, too.

at per capita emissions in 2042 one cannot only say that the allocation is based on equity of rights in that year and later. One can also look back and see that average emissions per capita in different countries have already been the same for period considered. For the analysis below, the period is to start in 1992 the year the UNFCCC was adopted. Regarding the global discussion the approach allows for some interesting flexibility with regard to the start of entering an international agreement.

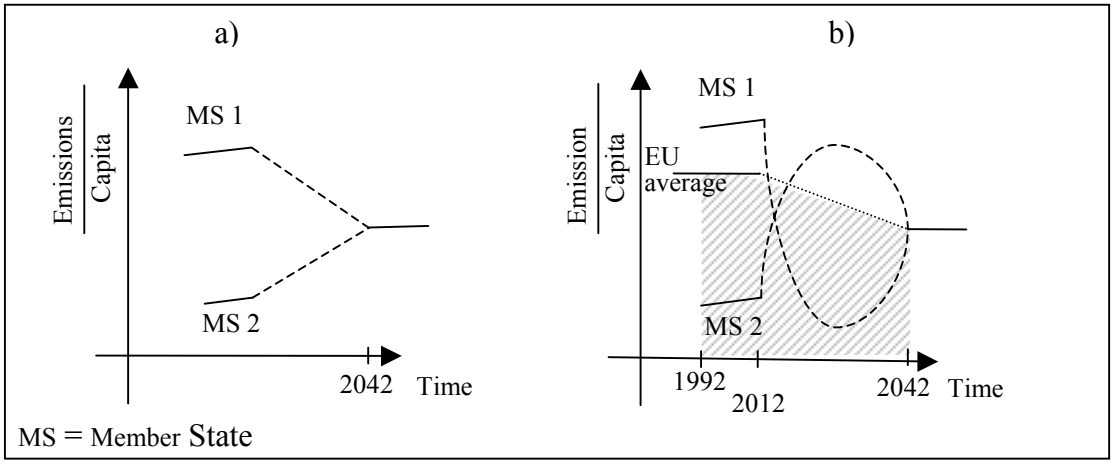

Figure 1: Schematic representation of a) converging emissions per capita and b) equal emissions over time

With the total emission budget in 2042 set and the population prognoses at hand one can calculate the allowed budget of average emissions per capita for the 50 year period from 1992 to 2042. Similar to the analysis is section 5.1, the allowed emissions per capita decrease linearly from the value in 2012 until the target value in 2042 which is of course identical to the first EEC approach. What is different is the allocation of emission entitlements.[20] Depending on a member state's cumulative emissions per capita until 2012, the allocation from 2013 onwards may take a form as shown in Figure 1b. For the exact determination of the allocation, I use the same quadratic function[21] as Bode (2003).

$$\int_{2013_i}^{2042} (a_i t^2 + b_i t + c_i)\,dt = A - D_i \qquad (1)$$

where a, b, c coefficients, t = time, A allowable budget, D_i describes the cumulative emissions per capita and year between 1992 and 2012 for member state i.

With the emissions per capita in 2012 and 2042 known for each member state, equation (1) can be solved.[22]

[20] As there is already a burden sharing agreement for the first commitment period the approach can only be applied from 2013 onwards.
[21] There is no economical rational behind the specific form of the quadratic function. It is rather used to be able to shift the vertex as required by the country specific emission balance (see also Figure 1b).
[22] For the analytic solution see Bode 2003.

As for the equal per capita approach the results for each commitment period until 2042 are given the Annex. Cumulative emission rights for the period from 2013 to 2042 are also shown in Table 5.

5.3 Sovereignty principle

The basic idea of the Sovereignty principle is that "all nations have an equal right to pollute and to be protected from pollution." An operational rule would be to "cut back emissions in a proportional manner across all nations" (Rose et al. 1998, p. 30). In the European context this means that all MS would have to reduce emissions by a uniform rate equal to the common target. The rationale behind this approach would be the idea of sovereign states with equal bargaining power negotiating over the allocation. The principle finally results in a protection of rights that have been established by usage or custom (Aidt et al. 2002, p. 13). Inequalities regarding the release of GHG emissions would thus be perpetuated (Blanchard et al. 2001). Regardless of any philosophical considerations, the sovereignty rule can be perceived as the simplest form of an allowances allocation (for example Schmidt et al. 1998) what makes it worth to analyse it. The results are given in Table 5 and Table 11 respectively.

5.4 Discussion

As turned out during the discussion of the 1998 burden sharing agreement there are different ways to analyse the "fairness" of allocation schemes. Table 5 summarises some important aspects. Column two to four show the member states' reduction obligation in 2042 compared to 1990 levels for the three approaches studied above. As can be seen, the individual allocation varies considerably depending on the approach while the total budget for the EU is always the same. However, this is only the specific outcome for the year 2042. From a member state's perspective the resulting cumulative emission entitlements are likely to be of the same importance. This is why the next three columns show the cumulative emission entitlements for the each MS for the period between 2013 and 2042, i.e. the period that can still be negotiated. To get an idea of the relative difference among the three approaches, column 8 shows the ratio between the minimum and the maximum allocation. A small figure indicates a high difference. As can be seen for most member states the number of allowances with an allocation based on equal emissions per capita lies between those of the two other approaches. Implications of the differences are discussed below.

Regarding EECT one should note that this approach would imply some bias as it would only be applied from 2013 on. Member states which are net allowance buying countries in the first commitment period will incur higher emissions compared to a no-trade or scenario. These

higher emissions (per capita) would be deducted from the countries budget after 2012, although they would be in line with the rule during the first period.

Tab. 5: Implications of different allocation methods for (future) member states of the EU[1)]

	Change in % in 2042 compared to 1990			Cumulative emission rights 2013-42 (1000 t)			
	Equal per Cap.	EECT	Sovereignty	Equal per Cap.	EECT	Sovereignty	ratio (min/max)
Austria	-39	-39	-50	1.979	2.175 [2)]	1.590	0,731
Belgium	-56	-56	-50	2.533	1.806	2.988	0,604
Bulgaria	-80	-80	-50	1.505	1.110	3.054	0,363
Cyprus	33	33	-50	206	283	82	0,290
Czech Rep.	-71	-71	-50	2.373	1.364	3.973	0,343
Denmark	-50	-50	-50	1.382	1.147	1.329	0,830
Estonia	-82	-82	-50	314	74	812	0,091
Finland	-61	-61	-50	1.268	769	1.718	0,448
France	-32	-32	-50	15.309	16.895	12.477	0,739
Germany	-62	-62	-50	19.502	16.707	23.268	0,718
Greece	-40	-40	-50	2.589	2.314	2.711	0,854
Hungary	-48	-48	-50	2.282	2.806	1.908	0,680
Ireland	-40	-40	-50	1.182	608	1.289	0,471
Italy	-37	-37	-50	13.615	15.738	10.838	0,689
Latvia	-63	-63	-50	504	643	554	0,784
Lithuania	-60	-60	-50	851	826	1.125	0,734
Luxembourg	-62	-62	-50	144	61	198	0,307
Malta	17	17	-50	108	137	49	0,355
Netherlands	-49	-49	-50	4.255	3.272	4.490	0,729
Poland	-62	-62	-50	9.166	8.859	10.641	0,833
Portugal	-6	-6	-50	2.422	3.053	1.608	0,527
Romania	-55	-55	-50	5.140	5.990	5.208	0,858
Slovak Rep.	-57	-57	-50	1.317	1.277	1.531	0,834
Slovenia	-45	-45	-50	458	502	398	0,792
Spain	-21	-21	-50	9.580	11.335	7.025	0,620
Sweden	-23	-23	-50	2.254	2.716	1.661	0,612
UK	-47	-47	-50	15.495	14.683	15.208	0,948
Total	**-50**	**-50**	**-50**	**117.732**	**117.151**	**117.732**	**0,995**

1) Overall emission target for EU in 2042: 50 % of 1990 levels (in lieu of 1990 for: Bulgaria (1988); Hungary (1985-87); Poland (1988); Romania (1989)); For Cyprus and Malta only CO_2 emission form energy combustion have been considered. [2)] Underlined figures show the maximum allocation

5.4.1 Cost implications of different allocation options

Different allocations of emission entitlements imply different compliance costs for the single member states. Compliance costs depend on the emission reduction obligation and the emission (reduction) costs. The reduction obligation to be considered before a certain commitment period has started is the difference of business as usual emissions less the

entitlements distributed.[23] Compliance costs are the costs incurred due to domestic abatement plus the costs for the purchase of entitlements on the market. An exact quantification of the different compliance costs is out of the scope of this paper. Yet, one may question whether it is reasonable to do so for a period of more than 20 years. First of all the development of future emissions and thus reduction obligations is highly unclear. A great number of scenarios exist (see for example IPCC 2000; Zhang 2002 gives an overview on estimates on EU baseline emissions in 2010 that already differ by factor 2). Secondly, development of the future abatement costs for the time horizon considered costs are also highly uncertain. On the other hand some qualitative relations may be of interest.

Given the differences in cumulative emissions in the period 1992 to 2042, consider a one period game. Assuming a competitive market und neglecting transaction costs one would always, for a given EU emission target, expect the same allowance price within the EU market regardless of the allocation to the individual member state.[24] Only the member states' compliance costs may change. This change will depend on whether the country is a net-seller or net-buyer of entitlements.

The net-buyer's and seller's situation in a one period game is depicted in Figure 2. Assuming a certain allocation option as a reference which results in a reduction obligation of q^1, the *buyer* will reduce the quantity q^* at home and buy the remaining entitlements q^1-q^* on the market at the equilibrium price p^*. Let us denote the *highest* reduction obligation a country can face under one of the three allocation approaches discussed above with q^b and the lowest obligation with q^s. With a different allocation method, the number of allowances received may either be smaller or bigger than the initial one. In case the number is smaller a buying country must reduce more what results in additional costs L amounting to

(1) $L = (q^b - q^1)p^*$

In case the number is higher the country has to reduce less and will realise a relative benefit B compared to the initial allocation amounting to:

(2) $B = (q^1 - q^s)p^*$ for $q^s \geq q^*$ and
(3) $B = (q^1 - q^*)p^* + [(q^* - q^s)p^* - (q^* - q^s)c(q)]$ for $q^s < q^*$

where $c(q)$ is the marginal abatement costs curve for domestic reduction measures at home (i.e. the term $(q^* - q^s)c(q)$ equals area A in Figure 2a)

[23] In case banking of entitlements is allowed they also have to be considered.
[24] In case the EU market is linked to other (regional) market the price may change depending on the stringency of emission targets in the other countries. For a discussion of resulting impacts see Haites et al. (2001), for options to deal with different stringency of targets see for example Rehdanz et al. (2002).

While in case (2) the country only buys less allowances on the market it also benefits from selling entitlements in the third case (see area B in Figure 2a).

For the selling country the situation is slightly different. Supposing it receives a bigger allocation it has to reduce less and can sell additional allowances resulting in an increased benefit *B* of

(4) $B = (q^1 - q^s)p^* - (q^1 - q^s)c(q)$

which equals area C in Figure 2b). If it is allocated a smaller number of allowances compared to the reference allocation it incurs a relative loss *L* compared to the reference allocation amounting to:

(5) $L = (q^b - q^1)p^* - (q^b - q^1)c(q)$ for $q^b \leq q^*$ and
(6) $L = [(q^* - q^1)p^* - (q^* - q^1)c(q)] + (q^b - q^*)p^*$ for $q^b > q^*$

In the last case the selling country would turn to a buying country.

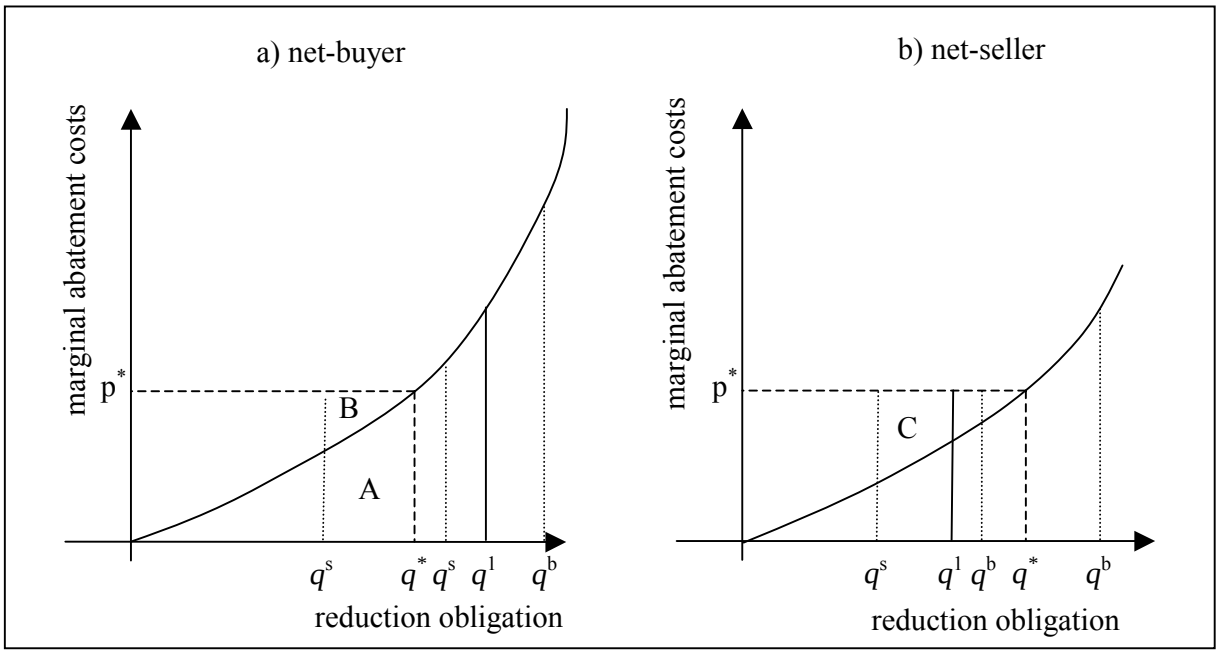

Fig. 2: Impact of different reduction obligations on abatement and compliance costs

Against this background one can quantify the maximum relative losses L^{max} due to a change of the burden sharing rule. [25] They occur when the reference allocation was the best possible one, i.e. $q^1 = q^s$ and amount to

(7) $L^{max} = (q^b - q^s)p^*$

[25] Assume that negotiators are most interested in minimising losses from changing the allocation scheme. One could also argue the other way around and argue that relative benefits are most important for determining a member states priority.

when comparing the three possible allocation rules.

For the net-buyer this is obvious from (1) due to the fact that a buying country cannot benefit from any sale of allowances when its reduction obligation is increased. For the seller it can be derived from (5) and (6) when assuming that abatement cost for the reductions considered are zero.[26] Whether these maximum losses will be realised is discussible. In case of a relative stringent emission target abatement costs of zero are unlikely to occur, so that the relative losses for the sellers are likely to be smaller than the maximum.

Though the carbon price is highly uncertain Table 6 provides an overview on financial implications of a price of 10 EUR. As absolute figures may distort the picture, annual costs are put in relation with the member states' GDP in 2000. As additional costs have to be born by someone, annual costs per capita are also presented. Such indicators may be relevant for policy implication as will be discussed in the next section.

As can be seen in Table 6 the annual costs as percentage of GDP in 2000 are highest for the accession countries incl. Bulgaria and Romania. Obviously, for those countries there is much more at stake. At the other end of the range the UK and Austria face rather low differences in costs with these three allocation options.

[26] In case abatement costs are even negative losses can be higher.

Tab. 6: Implications of different allocation options at a carbon price of 10 EUR/t $CO_{2\text{-eq}}$

	Allocation maximum (Mio. t) [1)]	Allocation minimum (Mio. t) [1)]	Delta (Mio. t)	Total costs 2013-42 (Mio. EUR)	Annual costs (Mio. EUR)	Annual Costs as % of GDP in 2000
Austria	2.175	1.590	585	5.852	195	0,09
Belgium	2.988	1.806	1.182	11.824	394	0,16
Bulgaria	3.054	1.110	1.944	19.441	648	4,73
Cyprus	283	82	201	2.011	67	0,70
Czech Rep.	3.973	1.364	2.608	26.082	869	1,44
Denmark	1.382	1.147	235	2.347	78	0,05
Estonia	812	74	737	7.375	246	4,39
Finland	1.718	769	949	9.491	316	0,24
France	16.895	12.477	4.418	44.180	1.473	0,10
Germany	23.268	16.707	6.561	65.613	2.187	0,11
Greece	2.711	2.314	397	3.966	132	0,11
Hungary	2.806	1.908	898	8.981	299	0,59
Ireland	1.289	608	682	6.815	227	0,22
Italy	15.738	10.838	4.901	49.009	1.634	0,14
Latvia	643	504	139	1.392	46	0,59
Lithuania	1.125	826	299	2.986	100	0,82
Luxembourg	198	61	137	1.371	46	0,21
Malta	137	49	88	883	29	0,72
Netherlands	4.490	3.272	1.218	12.180	406	0,10
Poland	10.641	8.859	1.781	17.814	594	0,33
Portugal	3.053	1.608	1.446	14.455	482	0,42
Romania	5.990	5.140	850	8.502	283	0,70
Slovak Rep.	1.531	1.277	255	2.548	85	0,39
Slovenia	502	398	104	1.043	35	0,17
Spain	11.335	7.025	4.311	43.106	1.437	0,24
Sweden	2.716	1.661	1.055	10.546	352	0,14
UK	15.495	14.683	812	8.120	271	0,02

[1)] see Table 5

5.4.2 Policy implications

Whether or not it is probable that in the case of the EU all *buying* countries receive a smaller allocation with a changing burden sharing rule can only be assumed. It might be possible for some countries which then would incur high losses. However, it is not possible to say, whether a certain member state will be in buying or selling country under the different schemes as future abatement costs are highly uncertain. However, the difference between maximum and minimum allocation is computable. Indeed it has already been presented in Table 5 which showed the ratio of the two figures. The lower the figure the higher the difference and thus the more likely a member state will be interested in getting a certain burden sharing rule.

For this a "relevance indicator" based on the minimum-maximum ratio is introduced. The indicator which is country-specific is determined as follows:

$$I_i = 1 - \frac{allocation_{\min}}{allocation_{\max}} \qquad 0 \le I_i \le 1$$

A value of one would mean that much is at stake while of value of 0 would mean that nothing is at stake as the different allocation rules result in the same allocation. As decision makers are unlikely to think in black and white only, a relevance threshold can be introduced. By so doing, one can determine the (number of) countries that are likely to be active during the negotiations with regard to a certain outcome (see Figure 3). To give example, assume that member states only care about the allocation if the indicator is greater or equal than 0.8. In this case 21 MS care about the allocation rule.[27] This indicator may be relevant if politicians are guided during the negotiations by idea that they want to prove their electorate that they fought for the biggest allocation possible regardless of the economic importance.

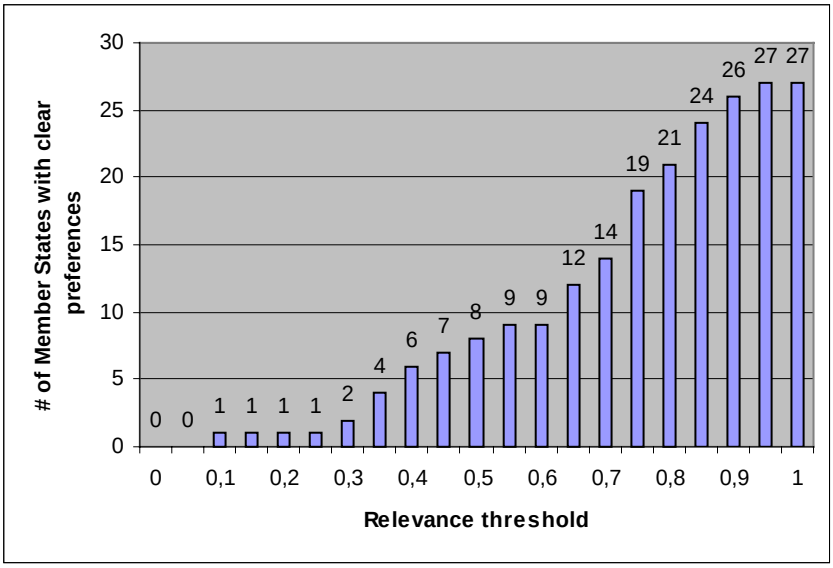

Fig. 3: Number of member states interested in a certain allocation rule as function of the relevance threshold

However, politicians may also keep the economic implications in mind. Referring to Table 7, one can determine the threshold that has to be passed in order to make a certain number of MS interested in the final allocation rule (see Table 7).

[27] The outcome depends on the period analysed. If emissions (entitlements) prior to 2013 are considered, too, the ratio is converging towards one. This can be explained by the fact that emissions (entitlements) in the first part (1992-2012) are independent of the allocation from 2013. Dividing two increasing numbers that differ by the same absolute value gives a result converging to one. The rational of extending the period considered could be to reflect historic emission or contribution to climate change. Whether and to what extend past emissions should be referred to is a value judgement to be taken by political decision makers. During the negotiations of the first BSA it did not play a role (Ringius 1997, p. 41). The discussion could, however, resume and thus influence the complexity of the negotiations.

Tab. 7: Thresholds to be passed for member states being interested in the allocation rule with a carbon price of 10 EUR/ t $CO_{2\text{-eq}}$

		Number of member states interested					
		5	10	15	20	25	27
Costs as % in GDP in 2000	Threshold ≥	0.781	0.417	0.221	0.135	0.094	0.017

Depending on the negotiators' attitude assumed, one can get an idea on how negotiations will be. Assuming that they rather tent to fight in Brussels for a high allocation in order to get their voters' favour at home, negotiations will be difficult. Already for a threshold of 0.75, i.e. ¾ of the total scale, 19 member states will be active. In case the economic implications are also taken into account, the analysis is much more difficult as it depends on the carbon price assumed. However, to allow for a rough idea note that for example the indicative target for ODA is 0.7 % of *GNI* for industrialised countries. Though this figure does not seem very high, only very few states comply (OECD 2003). Thus, with carbon price of 10 EUR/ t CO_2 negotiations may become complex as member states may feel that much is at stake.

In addition to that the new member states may ask for money and assistance when new commitments enter into force as Dessai et al. (2001, p. 331) report for the cohesion countries in the past. With regard to the EU financial system in an enlarged Community Hefeker (2003) argues that redistribution should be done as lump-sum transfer and not through the agriculture and social fond any more. This may also be considered in the context of climate policy.

6 Conclusion

Sharing the burden of limiting GHG emission to the atmosphere has been done between different countries in the past on both global and European level. It is likely to play a vital role in the future, too. Against this background three different options for allocating an EU-budget to its member states until 2042 have been analysed in the paper. The options studied are an allocation based on equal emissions per capita, on equal emissions per capita over time and based on the sovereignty principle. The three approaches result in considerably different allocations at least for single member states.

As the different allocations will influence the countries compliance costs they are likely to have (strong) negotiating positions in case this difference is large. To study this aspect in more detail a relevance factor has been introduced that describes from what ratio between minimum and maximum allocation MS care about the specific allocation rule. Assuming a rather high threshold, negotiations on a future burden sharing rule are likely to be complicated

already with the limited number of allocation options discussed in this paper. Experienced and skilful negotiators may thus play a very important role in the future as they did in the past (Ringius 1997, p. 35). In order to avoid this complex bargaining process an auction of emission entitlements on EU level may serve this problem. However, some other questions as for example the issue of revenue use would emerge.

Future work may include other burden sharing rules. An extension of the Triptych approach is a very interesting option. A more detailed analysis of the cost implications that takes more information on the member states' abatement costs into account is also desirable.

7 Annex

Table 8: Quantified emission limitation or reduction commitment

Party	percentage of base year or period
Australia	108
Bulgaria	92
Canada	94
Croatia	95
Czech Republic	92
Estonia	92
European Community (EU 15)	92
Hungary	94
Iceland	110
Japan	94
Latvia	92
Liechtenstein	92
Lithuania	92
New Zealand	100
Norway	101
Poland	94
Romania	92
Russian Federation	100
Slovakia	92
Slovenia	92
Switzerland	92
Ukraine	100
United States of America	93

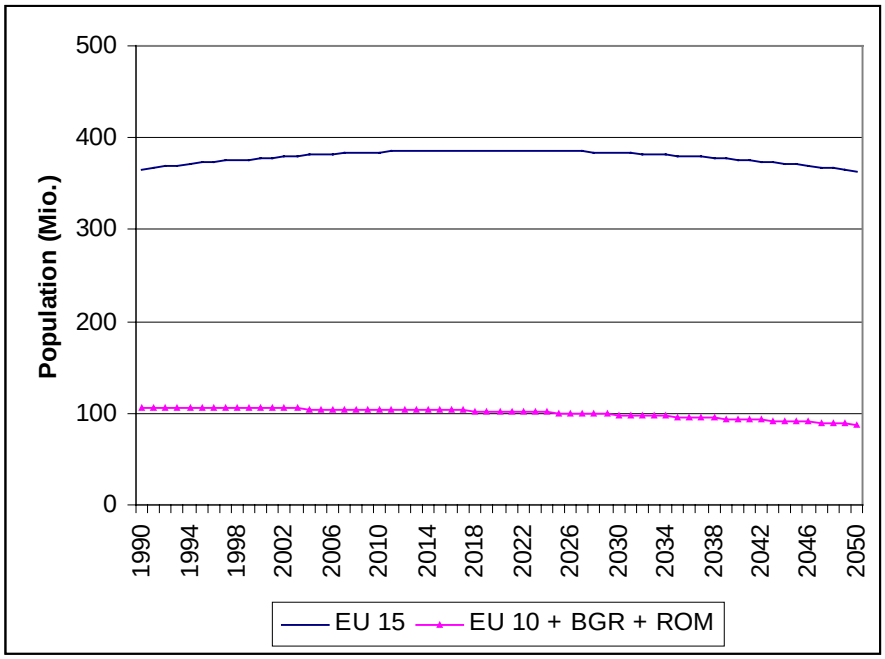

Fig. 4: Population development in Europe

Tab. 9: Assigned amount (AA) for EU member states with an allocation based on equal emission per capita (emissions and AA in Mio. t $CO_{2\text{-eq}}$)

	Emissions 1990 [2]	AA 2013-17	Change in % [1]	AA 2018-22	Change in %	AA 2023-27	Change in %	AA 2028-32	Change in %	AA 2033-37	Change in %	AA 2038-42	Change in %	AA 2043-47	Change in %
Austria	78	408	4	377	-3	346	-11	315	-19	283	-28	251	-36	237	-39
Belgium	141	518	-27	480	-32	442	-37	403	-43	365	-48	325	-54	310	-56
Bulgaria	157	341	-57	301	-62	265	-66	230	-71	199	-75	169	-78	154	-80
Cyprus [3]	4	41	109	38	97	36	85	33	70	30	55	27	40	26	34
Czech Rep.	190	502	-47	459	-52	416	-56	373	-61	331	-65	291	-69	272	-71
Denmark	69	277	-20	259	-25	241	-30	222	-36	202	-42	181	-48	174	-50
Estonia	41	67	-67	61	-70	55	-73	49	-76	44	-79	38	-81	36	-82
Finland	77	261	-32	242	-37	222	-43	202	-48	181	-53	160	-59	152	-61
France	561	3.091	10	2.881	3	2.666	-5	2.449	-13	2.226	-21	1.996	-29	1.910	-32
Germany	1.212	4.063	-33	3.734	-38	3.408	-44	3.084	-49	2.764	-54	2.448	-60	2.320	-62
Greece	105	534	2	493	-6	451	-14	410	-22	370	-29	330	-37	315	-40
Hungary	102	483	-5	440	-13	399	-21	359	-29	319	-37	281	-45	265	-48
Ireland	53	222	-17	214	-20	205	-23	193	-28	181	-32	167	-38	164	-38
Italy	509	2.860	12	2.616	3	2.377	-7	2.146	-16	1.920	-25	1.697	-33	1.600	-37
Latvia	31	109	-30	99	-36	88	-43	78	-50	69	-55	60	-61	56	-64
Lithuania	52	177	-31	163	-37	149	-42	134	-48	121	-53	107	-58	102	-61
Luxembourg	11	26	-52	25	-53	25	-54	24	-56	23	-58	21	-61	21	-61
Malta [3]	2	21	86	20	76	19	64	17	51	16	37	14	23	14	18
Netherlands	210	847	-19	795	-24	741	-29	685	-35	625	-40	562	-46	540	-49
Poland	564	1.917	-32	1.763	-38	1.606	-43	1.449	-49	1.292	-54	1.138	-60	1.072	-62
Portugal	61	504	64	463	51	423	38	383	25	344	12	304	-1	287	-6
Romania	265	1.089	-18	993	-25	899	-32	807	-39	719	-46	633	-52	595	-55
Slovak Rep.	73	272	-25	252	-31	231	-36	209	-42	187	-48	166	-54	157	-57
Slovenia	19	96	0	88	-9	80	-17	72	-25	64	-33	56	-42	53	-45
Spain	288	2.007	40	1.840	28	1.673	16	1.510	5	1.353	-6	1.198	-17	1.131	-21
Sweden	73	454	25	424	17	394	8	361	-1	328	-10	294	-19	282	-22
UK	744	3.083	-17	2.892	-22	2.697	-28	2.492	-33	2.277	-39	2.054	-45	1.982	-47
Total	**5.691**	**24.273**	-15	**22.413**	-21	**20.552**	-28	**18.692**	-34	**16.832**	-41	**14.971**	-47	**14.227**	**-50**
Emissions per Capita	12,06	9,9	-18	9,2	-24	8,5	-30	7,8	-36	7,1	-41	6,4	-47	6,2	-49

[1] compared to 1990 levels [2] In lieu of 1990 for: Bulgaria (1988); Hungary (1985-87); Poland (1988); Romania (1989) [3] CO_2 emissions from fuel combustion only (Source IEA 2003)

Tab. 10: Assigned amount (AA) for EU member states with an allocation based on equal emission per capita over time (emissions and AA in Mio. t $CO_{2\text{-eq}}$), footnotes as for Table 9

	Emissions 1990 [2]	AA 2013-17	Change in % [1]	AA 2018-22	Change in %	AA 2023-27	Change in %	AA 2028-32	Change in %	AA 2033-37	Change in %	AA 2038-42	Change in %	AA 2043-47	Change in %
Austria	78	370	-5	401	3	407	4	386	-1	340	-13	271	-31	237	-39
Belgium	141	527	-25	358	-49	248	-65	197	-72	205	-71	270	-62	310	-56
Bulgaria	157	465	-41	256	-67	126	-84	67	-91	70	-91	125	-84	154	-80
Cyprus [3]	4	32	62	49	151	58	199	59	202	51	162	35	77	26	34
Czech Rep.	190	623	-34	312	-67	119	-87	40	-96	70	-93	200	-79	272	-71
Denmark	69	248	-28	212	-39	186	-46	170	-51	164	-53	169	-51	174	-50
Estonia	41	108	-47	29	-86	-19	-109	-36	-117	-24	-112	15	-93	36	-82
Finland	77	290	-25	164	-58	83	-78	50	-87	63	-84	119	-69	152	-61
France	561	2970	6	3120	11	3111	11	2945	5	2618	-7	2133	-24	1910	-32
Germany	1.212	4148	-32	3274	-46	2649	-56	2271	-63	2135	-65	2231	-63	2320	-62
Greece	105	572	9	456	-13	370	-29	317	-40	295	-44	304	-42	315	-40
Hungary	102	452	-11	525	3	546	7	517	2	442	-13	323	-36	265	-48
Ireland	53	229	-14	124	-53	56	-79	29	-89	49	-81	120	-55	164	-38
Italy	509	2651	4	2936	15	2991	18	2827	11	2453	-4	1881	-26	1600	-37
Latvia	31	117	-24	126	-19	124	-20	113	-27	94	-39	69	-56	56	-64
Lithuania	52	217	-16	169	-34	133	-48	110	-57	98	-62	99	-62	102	-61
Luxembourg	11	29	-48	13	-76	3	-94	-1	-101	3	-95	14	-74	21	-61
Malta [3]	2	16	43	24	106	28	140	28	141	24	111	17	49	14	18
Netherlands	210	837	-20	628	-40	486	-54	415	-60	416	-60	490	-53	540	-49
Poland	564	1989	-29	1730	-39	1510	-46	1331	-53	1196	-58	1104	-61	1072	-62
Portugal	61	473	54	565	84	598	95	572	86	490	60	355	16	287	-6
Romania	265	1129	-15	1153	-13	1117	-16	1024	-23	880	-34	687	-48	595	-55
Slovak Rep.	73	301	-17	253	-30	214	-41	185	-49	166	-54	158	-56	157	-57
Slovenia	19	90	-6	95	-2	93	-3	87	-10	76	-21	60	-37	53	-45
Spain	288	1878	31	2115	47	2170	51	2053	43	1775	23	1344	-7	1131	-21
Sweden	73	434	19	497	37	520	43	499	37	435	20	331	-9	282	-22
UK	744	3059	-18	2752	-26	2491	-33	2275	-39	2109	-43	1996	-46	1982	-47
Total	**5.691**	**24255**	**-15**	**22336**	**-22**	**20418**	**-28**	**18530**	**-35**	**16694**	**-41**	**14919**	**-48**	**14227**	**-50**
Emissions per Capita	12.0	9.9		9.1		8.4		7.7		7.0		6.4		6,2	

Tab. 11: Assigned amount (AA) for EU member states with an allocation based on the sovereignty principle (emissions and AA in Mio. t $CO_{2\text{-eq}}$), footnotes as for Table 9

	Emissions 1990 [2]	AA 2013-17	Change in % [1]	AA 2018-22	Change in % 1)	AA 2023-27	Change in %	AA 2028-32	Change in %	AA 2033-37	Change in %	AA 2038-42	Change in %	AA 2043-47	Change in %
Austria	78	325	-17	301	-23	277	-29	253	-35	229	-41	205	-48	195	-50
Belgium	141	623	-12	573	-19	523	-26	473	-33	423	-40	373	-47	353	-50
Bulgaria	157	609	-22	569	-28	529	-33	489	-38	449	-43	409	-48	393	-50
Cyprus [3]	4	17	-12	16	-19	14	-26	13	-33	12	-40	10	-47	10	-50
Czech Rep.	190	824	-13	759	-20	694	-27	630	-34	565	-40	500	-47	475	-50
Denmark	69	263	-24	247	-29	230	-34	213	-38	196	-43	180	-48	173	-50
Estonia	41	164	-19	153	-25	141	-31	129	-36	118	-42	106	-48	102	-50
Finland	77	367	-5	335	-13	302	-22	270	-30	238	-38	206	-47	193	-50
France	561	2.664	-5	2.430	-13	2.196	-22	1.963	-30	1.729	-38	1.495	-47	1.402	-50
Germany	1.212	4.610	-24	4.317	-29	4.024	-34	3.732	-38	3.439	-43	3.146	-48	3.029	-50
Greece	105	615	18	550	5	484	-8	419	-20	354	-33	288	-45	262	-50
Hungary	102	373	-27	351	-31	329	-35	307	-40	285	-44	263	-48	254	-50
Ireland	53	285	7	257	-4	229	-14	201	-25	173	-35	145	-46	134	-50
Italy	509	2.267	-11	2.083	-18	1.898	-25	1.714	-33	1.530	-40	1.345	-47	1.272	-50
Latvia	31	105	-32	100	-36	95	-39	90	-42	85	-45	80	-49	78	-50
Lithuania	52	238	-8	218	-16	198	-23	177	-31	157	-39	137	-47	129	-50
Luxembourg	11	38	-30	36	-34	34	-38	32	-41	30	-45	28	-49	27	-50
Malta [3]	2	10	-12	9	-19	8	-26	8	-33	7	-40	6	-47	6	-50
Netherlands	210	941	-10	864	-18	787	-25	710	-32	633	-40	556	-47	525	-50
Poland	564	2.086	-26	1.961	-30	1.836	-35	1.711	-39	1.586	-44	1.461	-48	1.411	-50
Portugal	61	366	19	327	6	288	-6	248	-19	209	-32	169	-45	154	-50
Romania	265	1.045	-21	974	-26	903	-32	832	-37	762	-42	691	-48	662	-50
Slovak Rep.	73	319	-12	293	-19	268	-26	242	-33	217	-40	192	-47	181	-50
Slovenia	19	82	-15	76	-22	69	-28	63	-35	57	-41	51	-47	48	-50
Spain	288	1.560	9	1.404	-2	1.249	-13	1.093	-24	937	-35	781	-46	719	-50
Sweden	73	359	-1	326	-10	293	-19	260	-28	228	-37	195	-46	182	-50
UK	744	3.116	-16	2.884	-23	2.651	-29	2.418	-35	2.186	-41	1.953	-48	1.860	-50
Total	**5.691**	24.273	-15	**22.413**	-21	**20.552**	-28	**18.692**	-34	**16.832**	-41	**14.971**	-47	**14.227**	**-50**
Emission per Capita	12,06	9,9	-18	9,2	-24	8,5	-30	7,8	-36	7,1	-41	6,4	-47	6,2	-49

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