

Klepper, Gernot; Peterson, Sonja

**Conference Paper**

## US participation, permit allocation, and hot air supply

**Provided in Cooperation with:**

Kiel Institute for the World Economy – Leibniz Center for Research on Global Economic Challenges

*Suggested Citation:* Klepper, Gernot; Peterson, Sonja (2002) : US participation, permit allocation, and hot air supply, 3rd Concerted Action for Tradable Permits (CATEP) Workshop on Global Trading, Institute for World Economics, Kiel, September 30 and October 1, 2002, Institute for World Economics (IfW), Kiel

This Version is available at:

<https://hdl.handle.net/10419/4237>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

# US Participation, Permit Allocation, and Hot Air Supply

Gernot Klepper & Sonja Peterson

Kiel Institute for World Economics (IfW)  
Department of Environmental and Resource Economics

September 2002

## **Abstract**

After Bonn and Marrakech it is likely that emission trading will be realized in the near future. Major influences on the permit market are the institutional details, the participation structure and the treatment of hot air. Different scenarios do not only differ in their implications for the demand and supply of permits and thus the permit price, but also in their allocative effects. Most repercussions can be expected to stem from the effects on the world markets for fossil fuel and especially the oil market. For example the withdrawal of the USA from the Kyoto Protocol and the allocation mechanism for the hot air in Russia, Ukraine and Eastern Europe influence the level of energy demand and gross and net energy prices which in turn change the production structure of energy intensive goods and influence welfare depending on whether a country is an energy net exporter or importer.

In this paper we discuss different institutional designs for hot air trading combined with the US withdrawal and quantify the effects by using a computable general equilibrium model. Besides detailed results for the analyzed scenarios, two major findings are relevant for future studies on emission trading: First, marginal abatement cost curves are not as stable as presumed up to now. Second, we find that indeed the allocative repercussions of a scenario are to a large degree determined by its effects on world energy demand and world energy prices. Both findings imply that partial equilibrium models of permit trading that are based on marginal abatement curves ignore the important interaction between the permit market and the world energy markets.

# Contents

<b>1</b>	<b>Introduction</b>	<b>3</b>
<b>2</b>	<b>Allocation Effects in the Market for Greenhouse Gas Emissions</b>	<b>4</b>
2.1	The Impact of the Participation of the USA . . . . .	4
2.2	Institutional Details of International Trading . . . . .	4
2.3	What is to be maximized with restricted supplies of Hot Air? . . . . .	7
2.4	The interaction of national permit regulation and hot air trading . . . . .	8
2.5	The Role of the US Participation in Hot Air Decisions . . . . .	9
<b>3</b>	<b>Issues in Modelling Hot Air Trading</b>	<b>10</b>
3.1	What is the available Amount of Hot Air? . . . . .	10
3.2	CDM, JI and Sinks . . . . .	11
3.3	Banking . . . . .	11
3.4	Regional Aggregation . . . . .	12
3.5	Strategic Behavior . . . . .	12
<b>4</b>	<b>Policy Simulations</b>	<b>14</b>
4.1	The DART Model . . . . .	14
4.2	Formulation of Policy Scenarios . . . . .	15
<b>5</b>	<b>Simulation results</b>	<b>17</b>
5.1	US withdrawal from Kyoto . . . . .	17
5.2	Trading hot air . . . . .	21
<b>6</b>	<b>Conclusions</b>	<b>27</b>
<b>A</b>	<b>The DART Model</b>	<b>31</b>

# 1 Introduction

The Kyoto-Protocol marks the first instance in which a multinational and potentially global emission trading system has become part of an international treaty. The introduction of emission trading has long been advocated by economists because of its efficiency aspects. Yet, the theoretically appealing concept has undergone several adjustments and refinements in the international political practice and it has been rejected by the United States government. As a consequence, it is not at all clear what the emission trading scheme will bring in terms of effectiveness, i.e. how much emission reduction will it eventually achieve, and in terms of its economic performance, i.e. what allocation effects are to be expected. Several studies have already attempted to narrow in on the range of prices of emission permits and on the resulting savings of marginal abatement costs for different regions (Weyant 1999; Boehringer 2001; Boehringer and Loeschl 2002; den Elzen and de Moor 2001a). So far, the narrowing has not been too successful as Klaassen and Percl (2002) find in their paper.

The divergence of results has many causes: modelling philosophies, complications of the definition of reduction commitments during the Bonn-Marrakech-Accords, the withdrawal of the United States from the Kyoto-Protocol, and finally the issue of hot air. In this paper we try to identify the impacts as well as the interactions of three of these aspects which we believe to constitute important determinants of the likely effects of international emission trading (IET) according to the Kyoto rules. The three major influences to be considered are

- the participation structure of the emission trading regime, i.e. the role of the USA,
- the institutional details of the permit allocation especially in countries with hot air, and
- the likely supply of hot air in the commitment period of the Kyoto-Protocol.

These three aspects are closely linked. The permit allocation within the two major suppliers of hot air, Russia and the Ukraine, has repercussions on the global permit market, and at the same time it influences the ability of these two countries to strategically control the global permit market. Similarly, the participation or non-participation of the USA in global trading influences the permit market, the climate protection costs of other regions and the benefits from strategic restrictions of hot air supplies.

The paper is organized as follows. The next section presents a qualitative discussion of these interactions and tries to give some intuition for the likely allocation effects of the trading regime agreed so far. Section 3 then presents some practical aspects of determining the size and the functioning of the market for greenhouse gas permits. The selection and exact

definition of the scenarios for emission trading is done in Section 4. Section 5 presents the results of the simulations with the CGE model DART both with respect to the participation of the USA and with respect to the likely supply of hot air. The paper ends with some conclusions and an appendix which gives a short description of the DART-Model.

## **2 Allocation Effects in the Market for Greenhouse Gas Emissions**

### **2.1 The Impact of the Participation of the USA**

In 2001 the new Bush administration announced that the USA are no longer willing to fulfill their Kyoto commitment, declaring the Kyoto-Protocol as "fatally flawed" (Bush-Administration 2001). Instead of fixed emission reductions the USA aim now to reduce their greenhouse gas intensity by 18% over the next ten years (Bush-Administration 2002). Though Bush claims that this would lead to 100 MtC less emissions in 2012, it is questionable if the plan implies any emission reductions at all. Without CO<sub>2</sub> abatement in the USA the amount of emission reductions of greenhouse gases associated with the Kyoto Protocol decreases from 5% to less than 1% relative to 1990 emissions. Furthermore, unrestricted economic growth in the USA will influence resource allocation world-wide, as world-market prices will respond in a globalizing world.

The most important impact of an American withdrawal from the Kyoto-Protocol is, of course, the rise in world energy prices because the additional energy demand from the USA will certainly have an impact on world markets. If this effect is large enough it will also lead to an adjustment of production, consumption and trade flows in all other economies. A second important effect concerns the marginal abatement costs of the other Annex-B countries. Since the reduction commitments of these economies are not changed, but the energy prices net of any climate policy induced mark-ups increase, the marginal abatement cost for reducing the emissions of greenhouse gases tend to fall. Again, the size of this effect is uncertain. It will essentially depend on the size of the energy price effect net of taxes or permit prices and the price flexibility of world supplies of fossil fuels.

### **2.2 Institutional Details of International Trading**

At first sight and according to standard economic theory, the way in which emission permits are allocated in each state - whether through auctioning, grandfathering, or updating (Baron and Bygrave 2002) - should not make a difference in terms of its allocation effect.

The only indirect effect would come through different income effects depending on where the ownership of emission rights and the subsequent rents are located. However, at least for the large participants of an international emissions trading regime with a considerable amount of hot air the institutional design of permit allocation makes an important difference. There are essentially two states which have been allocated most of the hot air in the Kyoto-Protocol and the Bonn-Marrakech-Agreements, Russia and the Ukraine (they are subsumed in the simulations later under FSU/EEC).

As the FSU/EEC is the largest seller of permits in the case of unrestricted emission trading, it is obvious that the FSU/EEC has the potential to influence the trading price of permits to maximize its profits from selling hot air or maximize welfare. As monopoly power implies a small number of sellers the studies that analyze market power implicitly assume that trading would take place in a centralized fashion and not through a large number of domestic entities that could act as independent agents (Baron 1999). The Kyoto Protocol and its related decisions do not explicitly state who is actually supposed to be trading. Probably we will see both government and firm trading. The modalities for emission trading adopted in Marrakech (UNFCCC 2001) state that to participate in IET Annex B countries have to establish national registries, that transfers and acquisitions between these registries shall be made under the responsibility of the Parties and that if a Party authorizes legal entities to transfer and/or acquire permits it has to supervise that it acts in accordance with the rules and remains responsible for the fulfillment of its obligations (Article 5). This suggests that it will be indeed national registries, that will trade with other national registries and act as a clearing board for national firms, so that market power might indeed be a relevant issue. On the other hand, as the Joint Implementation mechanism (JI) is seen as a chance for private investments in mitigation technologies, private firms are likely to be part of JI projects and this is nothing but some kind of emission trading on firm level.

The question remains though, how the governments will distribute their assigned amount units (AAU). Will they sell them to local firms, or grandfather them for free? Will they distribute all their AAU to domestic firms or keep some to trade with international firms or registries themselves? The economic effects of these alternative permit allocation schemes are likely to be small in economies without hot air. Grandfathering, i.e. free allowances to local emitters, creates an income effect for those receiving the permits and it leaves the government without revenues from permit sales. The size of this income effect is confined to the question whether different demand structures and different propensities to consume exist between the groups that might receive the rents from allocating emission permits. In fact, in a world with perfect competition, a constant government budget surplus or deficit, and with representative consumers and producers - as it is usually assumed in CGE-models - there is no difference in the allocation. Of course, the rents to specific groups in the case

of grandfathering or additional government revenues in the case of an auctioning of permits change the internal distribution of incomes. Such distributional issues are not subject of this paper.

In economies with a considerable amount of hot air the allocation scheme does matter. Essentially three institutional settings with differing repercussions on international permit markets can be considered. First, governments of economies with hot air can insulate their domestic industries and consumers emitting greenhouse gases from the international permit market by relying on state trading on the international permit market and by issuing free permits to local emitters which are not tradable internationally. Hence, the governments can maintain a zero domestic price for emissions and they can choose the amount of hot air that is sold internationally at the then prevailing world market prices (Scenario ET1).

The second option is to include the domestic firms in emission trading and charge the same price to all emitters - domestic and foreign. In this case, state trading - i.e. only the government can in the first place sell permits - allows a government to strategically restrict the total supply of emission permits at its disposal (ET2). In this setting no price wedge is driven between national and foreign permit prices. Against the background of JI this scenario can also be interpreted the way that only the government is participating in IET while the domestic firms are required to hold emission permits and are allowed to take part in JI projects to sell or acquire permits. As noted above, under usual CGE model assumptions it does not matter whether the domestic firms have to buy their rights from the government or receive permits for their business as usual emissions for free.

The third option of grandfathering all permits to local emitters or citizens according to some rule would most likely preclude any strategic behavior because it would effectively produce perfect competition on the supply side of the permit market. The governments registry would only administer the bookkeeping of all permit sales with foreigners (ET3). In such a case all permits including all hot air would be used either domestically or sold on international markets. As in the second option, permit prices domestically and world market prices will equalize but at a much lower level.

State trading of excess amounts of permits not used inside the country will give local emitters a free endowment of permits which results in an improvement of comparative advantage of the energy intensive producers on world markets. It also gives the government the ability to strategically manipulate the supply of hot air, i.e. of additional emission permits, on world markets.

To the contrary, a grandfathering of all permits to local emitters will remove this strategic ability, but it will also endow firms with an additional source of income. However, some studies (Boehringer 2001; Loeschl and Zhang 2002; den Elzen and de Moor 2001b) claim

that this income can not be generated since the permit price might drop to zero. This depends essentially on the hypothesis that grandfathered permits will lead to a competitive supply behavior, hence revenue maximization with hot air on international markets by restricting supply is not possible.

If there is state trading and the economies with hot air are able to coordinate their supply behavior they can reap considerable rents from restricting supplies. But these gains depend not only on the ability to coordinate strategies between the largest hot air countries. The just mentioned internal institutional settings are important as well. Hence, a careful treatment of the institutional details of permit allocation and permit trading in the economies with hot air is necessary in order to correctly simulate the likely allocation effects.

### **2.3 What is to be maximized with restricted supplies of Hot Air?**

If the hot air economies want to act as a cartel, the question arises what kind of objective function they follow in determining the optimal supply of hot air. Many partial equilibrium studies (Boehringer and Loeschl 2001; Burniaux 1999) simply presume that revenue from selling hot air is to be maximized, while some sort of welfare maximization is assumed in general equilibrium analysis (Boehringer 2001; Bernstein, Montgomery, Rutherford, and Yang 1999). Though Babiker, Jacoby, Reilly, and Reiner (2002) state that both lead approximately to the same result, this need not be the case since restricting hot air has not only revenue but also allocation effects, the most important one coming through the impact of hot air trading on the world market prices for fossil energy net of taxes or permit prices.

An increase in the supply of hot air on international markets first of all lowers permit prices. Some studies claim that they can drop as low as to a zero price. Yet, at the same time the sale of hot air increases the demand for fossil energy and thus energy prices net of permit prices will rise. However, in economies restricted by the Kyoto-commitments gross energy prices will fall. This will in turn affect the comparative advantage of energy intensive industries in the different economies and change trade flows and as a consequence affect welfare. Since the region FSU/EEC is a strong net exporter of fossil energy and of energy intensive products rising net energy prices in their export markets would increase the comparative advantage of these sectors. In addition, the fall in gross energy prices will shift demand towards more energy intensive goods in the Annex B countries. This will need to be balanced against the rising energy prices in Non-Annex B countries whose demand for energy and energy intensive products will fall. The net effect of this price effect on demand and on competitiveness in the different economies can only be assessed quantitatively.



## 2.4 The interaction of national permit regulation and hot air trading

Studying the impact of the different internal allocation regimes of hot air on the global permit market is necessary if the regions involved are large enough to influence world market prices through their actions. This is most likely true for the countries with a significant amount of hot air, i.e. Russia and the Ukraine. The two options for these governments - participating in global trading without having local trading and global trading with local emitters facing the same permit prices - will have different allocative effects.

If the region FSU/EEC decides not to charge the local emitters of CO<sub>2</sub> the world market permit price or not to allow these emitters to sell grandfathered emission rights on the global permit market, it can sell a restricted amount of hot air on world markets in such a way as to maximize government revenue or welfare. At the same time local fossil energy users do not face an emission constraint nor do they have an incentive to reduce emissions. Selling hot air then has several effects:

- It raises government revenue in economies with hot air (revenue effect),
- by lowering the global emissions constraint it reduces gross energy prices in the other Annex B countries (marginal abatement cost effect)
- these lower gross energy prices raise world demand for fossil fuels - compared to a situation without hot air trading - thus leading to higher energy prices even in the countries not participating in emission trading (demand effect).

In hot air economies, an additional supply of hot air will - besides raising government revenues - increase exports (resp. reduce imports) of fossil fuels through the demand effect. At the same time local producers of energy intensive goods face higher energy prices whereas foreign producers may or may not experience an increase in energy costs. In particular, the other Annex B countries have lower gross energy prices thus increasing demand and Non-Annex B countries experience higher prices with a reduction in demand. Hence, a shift of energy intensive production away from hot air countries and Non-Annex B countries towards the abating countries will take place resulting in the a change in comparative advantage and possible welfare losses to the hot air suppliers. As a consequence, maximizing permit revenues and maximizing welfare will not yield identical optimal hot air amounts to be sold by the FSU/EEC. If the welfare effects from direct fuel exports dominate the indirect effect through the energy intensive goods then a fuel exporting country like FSU/EEC would sell more hot air in the welfare maximization case than in the revenue maximization case.

The other option for the FSU/EEC to sell a fixed share of the overall permits to local and international emitters alike has the same three effects, but now the marginal abatement

cost effect also applies for the domestic economy that benefits from lower permit prices, too. Hence, energy use increases in all Annex B countries. In addition, the relative price of energy intensive goods to the other goods falls thus leading to an expansion of these sectors. For the hot air region FSU/EEC this means that an additional amount of hot air promotes higher exports of energy and increased production of energy intensive goods. Compared to revenue maximization, welfare maximization would tend to lead to a higher supply of hot air in order to reap the benefits from the increased competitiveness of energy sectors *and* energy intensive industries.

When comparing the scenario ET1 in which local emitters in the region FSU/EEC are not constrained with the scenario ET2 in which the permits are auctioned to local emitters as well, the positive welfare effect of additional supplies of hot air is larger in ET2 than in ET1. This is so because in ET1 additional hot air reduces the comparative advantage of energy intensive industries in the FSU/EEC whereas it improves it in ET2. Therefore one can expect that a move from revenue maximization to welfare maximization in the determination of the optimal supply of hot air will result in a larger difference in the scenario ET2. The issue of maximizing welfare or revenue is therefore most important if the FSU/EEC also use the permit system inside their own economies.

## 2.5 The Role of the US Participation in Hot Air Decisions

Equally important for the strategic and institutional designs is the participation of the USA. As the largest buyer, the participation or non-participation influences the decisions by the hot air suppliers. The withdrawal of the USA from IET and from the Kyoto commitments essentially moves the largest economy into the Non-Annex B group. Although the qualitative effects of alternative hot air trading regimes remain the same, the size of the international allocation effects changes. First of all, the largest economy demanding emission permits would withdraw from the permit market thus drastically lowering permit prices. This would tend to reduce the optimal amount of hot air supplied.

A second effect comes in through different price reactions on world markets. Whereas an increase in hot air supplied in the case of a US participation will lower American energy prices it will raise them if the USA does not participate. A withdrawal of the USA would therefore drastically increase the demand for energy which to some extent would be supplied by the FSU/EEC thus benefiting FSU/EEC exporters of fossil fuels. At the same time the withdrawal improves the American comparative advantage in energy intensive products thus hurting the FSU/EEC competitive position. In scenario ET1 it also raises energy prices within FSU/EEC thus accelerating the American comparative advantage effect in energy intensive products. In contrast, the scenario ET2 has falling energy prices in

FSU/EEC, hence a diminished loss in comparative advantage. Which of these two effects finally dominates can only be assessed quantitatively. It is likely, however, that because of these opposite effects the participation or non-participation of the USA will make little difference between revenue and welfare maximization.

### **3 Issues in Modelling Hot Air Trading**

The qualitative aspects of the interactions of different participation structures, institutional details, and strategic supply behavior already give some important insights. However, the net effects can only be assessed in a quantitative study by using a simulation model. For running such models a number of empirical questions need to be resolved. These include the amount of available hot air, the regional aggregation, complications through other policies such as CDM, JI and Banking, sinks and the way market power is actually exercised.

#### **3.1 What is the available Amount of Hot Air?**

Hot air is defined as the difference between projected baseline emissions and the Kyoto target, in the case where the former turn out to be smaller than the latter. Thus every estimate of hot air depends on the projected baseline emissions which depend among others on the expected economic development of the FSU/EEC. Estimates for the overall amount of hot air available in 2010 range from 100 to 500 million metric tons of carbon (MtC). The newest EIA data (EIA 2002) project 2010 emission to be 745 MtC in the FSU and 233 in the EEC, while emission in 1990 were 1036 resp. 301 MtC. In addition the FSU is allowed to credit another 46 MtC for sinks and the EEC 7.5 MtC (den Elzen and de Moor 2001a). Thus, the amount of hot air would altogether be around 410 MtC. The largest suppliers are Russia and the Ukraine who account for about one third of total hot air each, followed by Romania who provides around 15% (Missfeldt and Villavicenco 2002).

Partial equilibrium models use these estimates directly (Boehringer and Loeschl 2001; den Elzen and de Moor 2001b), while most CGE models calibrate their business as usual or benchmark scenario where no abatement action is taken to such emission projections. Once a certain emission path is chosen, the amount of hot air is seen as fixed. This is misleading though, as the benchmark will not materialize since climate policies will be introduced in some regions thus changing the emission path even in regions with hot air. As soon as some Annex B countries face binding emission constraints, gross energy prices in these countries increase and the production of energy intensive goods is shifted to the rest of the world, including the hot air economies that do not face emission restrictions. This is also called "leakage" and leads to an increasing demand for energy in the rest of the world and the hot

air countries. Hence, the amount of *available* hot air is decreasing. Thus, the withdrawal of the USA from Kyoto has a double effect on the importance of hot air. First it decreases the demand for emission permits considerably. In addition, compared to the case where the USA fulfills its Kyoto commitment, less energy intensive production is shifted to the FSU/EEC, so that the amount of available hot air increases.

Due to the leakage effect, available hot air is also less in the case of emission trading compared to the case of unilateral action. With emission trading, the same reductions can be achieved at a lower abatement cost so that less production is shifted to non abating countries including the FSU/EEC. In our model for example, under unilateral emission reductions in all Annex B countries the amount of hot air is 6.3% less than in the benchmark. The difference reduces to around 4% without the US participation or under emission trading including the US.

Summarized, the *available* hot air, defined as the difference between the Kyoto target and the emissions actually demanded by the FSU/EEC depends on the economic development in the FSU/EEC as well as on the level and cost of abatement in the rest of the world.

### 3.2 CDM, JI and Sinks

Three further issues that influence the amount of hot air traded are the clean development mechanism (CDM), joint implementation (JI) and sink enhancement. CDM and JI work the same way. Countries can get so called Certified Emission Reductions (CER) for abatement in Non-Annex B countries in the case of CDM and Emission Reduction Units (ERU) for emission reducing projects by two or more Annex B countries in the case of JI. In addition the the Removal Unit (RMU) was created in Marrakech for sink credits. All mechanisms provide alternative sources of supply of emission reduction permits for economies with high marginal abatement costs. Hence, they lower the incentive of the Annex B countries to buy hot air from the FSU/EEC. In the following simulations JI is treated as part of IET while we ignore CDM and sink enhancement as substitutes for permit trading.

### 3.3 Banking

In Marrakech and Bonn it was agreed that general emission permits resulting from the Kyoto commitment, the assigned amount units (AAU), can be banked without a time constraint. CERs and ERUs can be banked up to a limit of 2.5 resp. 5% of a Party's initial assigned amount. RMUs can not be banked (IETA 2001). Independently of market power, banking provides an incentive for the hot air countries to defer a part of the hot air for later use and restrict their permit supply. Compared to a scenario of market power

and no banking, banking increases the benefits of restrictions, as the saved permits can be used e.g., when the FSU/EEC emissions reach the Kyoto limit in future. Thus, it can be expected that less hot air is sold compared to the no banking scenario. Manne and Richels (2001) use intertemporal optimization in the CGE model MERGE and find indeed that if one looks at the period until 2020 the FSU/EEC optimally banks over 80% of hot air if the USA participate in emission trading and even over 90% if not. This is more than most studies find to be optimal under market power only (see section 3.5). Using a partial equilibrium model based on marginal abatement curves, Steenberghe (2002) considers the period 2008-2017 and concludes that the total amount of banked permits in the first period is even larger than the amount of hot air. Intertemporal optimization is not uncontroversial though. The emissions, the permit demand and the permit endowment in the post Kyoto period are highly uncertain and it is questionable as to whether government decisions about the intertemporal allocation of permit revenues or of welfare benefits from using permits will be based on a time horizon of more than one decade. As until 2010 the FSU/EEC emissions will stay clearly below the Kyoto limit, it seems legitimate to focus on market power and ignore the additional benefits of banked permit for the future if one considers only the first commitment period.

### 3.4 Regional Aggregation

Another issue is, that there are several countries that can sell hot air. Due to the lack of data most studies work with the aggregated regions FSU and EEC or even one region FSU/EEC, which also includes Former Soviet Republics that are not Annex B countries. The studies then assume that the FSU/EEC behaves as a monopoly/cartel or that the FSU does so, while the EEC as a competitive fringe will follow the price leadership of the domination region FSU or that both do not cooperate at all (Boehringer and Loeschl 2001; Loeschl and Zhang 2002). Working with the regional aggregate FSU thus implies that Russia and the Ukraine coordinate their behavior and build a cartel.

### 3.5 Strategic Behavior

As discussed in section 2, it is likely that - under certain institutional setups - the hot air countries will act strategically. To analyze the outcome of the FSU/EEC maximizing its welfare or revenue a modeler has to make an assumption on how the market power is actually exercised. One possibility for the FSU/EEC is to participate in emission trading but to put a markup much like an export tariff on the FSU/EEC export price of permits. As a result, the FSU/EEC pays a lower permit price than the rest of the Annex B countries. This scenario, which is economically the same as an export quota, is modelled by Bernstein,

Table 1: Selected studies on hot air trading and market power

<b>Study/ paper</b>	<b>Model</b>	<b>Scenario US participation</b>	<b>Objec- tive</b>	<b>Optimal % hot air</b>
Babiker et al. (2002)	EPPA (CGE)	Export quota; +US	Revenue	??
Bernstein et al. (1999)	MS-MRT (CGE)	Markup on domestic price +US	Welfare	(180% markup in 2010 declines to 18% in 2030)
Boehringer (2001)	CGE	Export quotas -US	con- sumption	40%
Boehringer and Loeschl (2001), Loeschl and Zhang (2002)	PEM; (POLES*)	supply ceiling; -US 1) Cartel of FSU&EEC, 2) EEC fringe supplier, 3) Cournot Duopoly	Revenue	1) 35%; 2) FSU: 35%, EEC: 100%; 3) FSU: 32%, EEC: 100%
den Elzen and de Moor (2001a, 2001b, 2002)	PEM (World- SCAN*)	supply ceiling -US diff. emission scenarios	Revenue	30-60%
Burniaux (1999)	GREEN (CGE)	export quota equivalent to markup US participation?	Revenue -AC	(170% markup in 2005, 38% in 2010, 0 in 2050)
Manne and Richels (2001)	MERGE (CGE)	supply ceiling; -US	GDP	40-54%

\*: Provides the marginal abatement cost curves

PEM: Partial equilibrium model; CGE: Computable general equilibrium model

Montgomery, Rutherford, and Yang (1999) and also by Burniaux (1999) who assumes that the FSU/EEC is directly setting the international permit price, and presumably also in Boehringer and Loeschl (2001). In all the cases the FSU/EEC participates in the emission market and does even sell more than the hot air as long as the world market price is above its marginal abatement costs. Boehringer (2001) proceeds differently and assumes that the FSU/EEC exports a fixed amount of emission rights, while inside the FSU/EEC permits are given away for free<sup>1</sup>. Other CGE studies just state that the FSU/EEC act as price makers and are able to limit the amount of hot air available for sale (Manne and Richels 2001), that they do not supply all their permits on the market (Babiker et al. 2002) or talk about a ceiling on the supply side (Paltsev 2000) without explaining what is meant by this.

<sup>1</sup>Unfortunately it is not state clearly how the FSU/EEC permit system works, but marginal abatement cost are reported for all Annex B countries except the FSU/EEC this is what was most likely modelled.

In summary, the models differ with respect to the assumptions about the role of the FSU/EEC, the participation of the FSU/EEC firms in emission trading, the quantitative emission restrictions for domestic FSU/EEC emissions and exports and the price of FSU/EEC emissions compared to the world market price. As discussed in section 2, there are basically three realistic setups that we will analyze in this study to see whether the different settings make a difference in the allocative effect.

## 4 Policy Simulations

In order to assess the economic implications of different participation structures, institutional details and the treatment of hot air on international emission trading, we use the DART model for running different policy scenarios that will be defined below.

### 4.1 The DART Model

The DART (**D**ynamic **A**ppplied **R**egional **T**rade) Model is a multi-region, multi-sector recursive dynamic CGE model of the world economy developed by the Kiel Institute for World Economics to analyze climate policies. It covers 11 sectors and 12 regions that are

Table 2: Dimensions of the DART-Model

Countries and regions		Production sectors	
Annex B		Energy	
USA	USA	COL	Coal
WEU	West European Union	CRU	Crude Oil
ANC	Canada, Australia, New Zealand	GAS	Natural Gas
JPN	Japan	OIL	Refined Oil Products
FSU	Former Soviet Union & Eastern Europe	EGW	Electricity
Non-Annex B		Non energy	
LAM	Latin America	AGR	Agricultural production
IND	India	IMS	Iron Metal Steal
PAS	Pacific Asia	CPP	Chemicals, rubber, paper and plastic products
CPA	China and Hong Kong	Y	Other manufactures & services
MEA	Middle East and North Africa	TRN	Transport
AFR	Sub-Saharan Africa	CGD	Investment good
ROW	Rest of the World		

summarized in Table 2 and the two production factors labor and capital. The regional aggregation for this study include the FSU/EEC, the USA and other Annex B parties, that are essential for our analysis. The economic structure of the DART model is fully specified for each region and covers production, final consumption and investment. A more detailed model description can be found in the appendix.

## 4.2 Formulation of Policy Scenarios

In order to focus on the allocative effects of the different scenarios on prices, trade and production structure, and also for practical modelling reasons we have to make a number of simplifying assumptions. First, we do not include banking and CDM in our study. JI is only implicitly modelled through Annex B emission trading. The sink credits are included in the reduction targets (see Table 3), but we do not model sink enhancement. For the implementation of Kyoto we assume that the regions start emission reductions in 2005 and then reduce their emission by a fixed amount each year, until the target is reached in 2010.

Table 3: Emission targets after Marrakech (including sinks)

Country	Original target as percentage of 1990 emissions	Marrakech target
USA	94%	96.8 %
WEU	92%	94.8%
ANC	97%	109 %
JPN	94%	99.2%
FSU/EEC	98.5%	103%

Source: (Boehringer 2001; Boehringer and Loeschl 2001)

For the hot air modelling we focus on the cartel case and aggregate all hot air countries to the region FSU/EEC.

Besides the benchmark where we assume that no emission reductions are undertaken, the analyzed scenarios differ in two dimensions: the participation of the USA and whether the emission reductions are taken unilaterally or internationally by emission trading.

**+US:** Each Annex B country including the USA reduce its emissions accordingly to its Kyoto commitment.

**-US:** Only WEU, ANC and JPN reduce their emissions. The US emissions are not restricted.

**NOTR:** The abating countries achieve their emission reductions by individually either by



domestic emission trading or equivalently by applying a domestic carbon tax that is high enough to meet the commitment.

As discussed in section 2 three realistic scenarios for international emission trading among the Annex B countries, including the hot air, should be distinguished:

**ET1:** The government of the FSU/EEC is selling a fixed number of permits (hot air) on the international permit market. The FSU/EEC firms are isolated from the emission market and receive their permits from the FSU/EEC government for free<sup>2</sup>.

**ET2:** The FSU/EEC is selling a fixed number of permits to domestic and foreign emitters alike, charging the same price. Thus, FSU/EEC firms participate in IET and the international permit price also applies domestically.

**ET3:** The government grandfathers all permits (including the hot air) to its domestic firms. These participate in the competitive international emission market.

The first two scenarios imply that the FSU/EEC government is able to exercise market power, the third assume competitive behavior. These scenarios are combined with the two US participation scenarios. In addition for the scenarios ET1 and ET2 where the FSU/EEC is able to exercise market power, we differentiate between welfare maximization (ET1W/ET2W) and revenue maximization (ET1R/ET2R)<sup>3</sup>. All scenarios are summarized in Table 4:

Table 4: Policy Scenarios

	+US	-US	
NOTR	NOTR+US	NOTR-US	unilateral action
ET1	ET1W+US	ET1W-US	max welfare
	ET1R+US	ET1R-US	max revenue
ET2	ET2W+US	ET2W-US	max welfare
	ET2R+US	ET2R-US	max revenue
ET3	ET3+US	ET3-US	competitive market

<sup>2</sup>To be precise, our CGE model assumes that the permits not designated for the world market are sold on a domestic market. In all relevant scenarios though these domestic permits exceed the domestic demand, so that the price is zero.

<sup>3</sup>Some studies (Burniaux 1999) also compare the FSU/EEC to a monopolistic firm and maximize permit revenue minus total abatement cost. Market power is only relevant though in the case of government trading and as the government does not have to pay the abatement cost, it is only interested in revenue.

To determine the welfare and revenue maxima for scenarios ET1 and ET2 we varied the amount of hot air supplied by the FSU/EEC from 5% to 100%. Hot air is defined as the difference between the Kyoto target and the 2010 benchmark emissions and amounts to 465 MtC in our model. The revenue is in both scenarios the revenue for *exported* permits. Thus, in scenario ET2 the FSU/EEC government does not consider the revenue from its permit sells to local emitters, as it is only a redistribution in the own country.

## 5 Simulation results

All following results refer to the year 2010.

### 5.1 US withdrawal from Kyoto

Our first question is, how the US withdrawal influences the other regions and especially the remaining Annex B countries. As explained in section 2, the allocative effects stem from changes in the energy markets. The additional US demand for energy increases fossil fuel prices, and in turn effect marginal abatement costs. To separate the latter two from the decrease in international permit prices through lower US permit demand in the case of emission trading, we first compare the scenarios NOTR+US and NOTR-US. The results are summarized in Table 5.

As postulated in section 2 there is a significant impact of the withdrawal of the USA on the gross prices of fossil fuels and especially the oil price. What happens is, that without emission restrictions the USA demand more fossil fuels on the world market than if they follow the Kyoto Protocol. In turn, the world market price is driven up. This can be seen if one looks at the fossil fuel prices in the Non-Annex B countries in Table 5<sup>4</sup> which presumably are not subject to climate policy measures such as taxes or permits although they might somehow be distorted by other taxes and/or substitutes. The magnitude of the price increase depends on the import and export elasticities for the different fuels in the different regions. While coal prices increase by 2 - 6%, gas prices rise by only 1 - 2%. The rise in oil prices has the lowest variance and is 3 - 4% in all Non-Annex B countries. In the Annex B countries excluding the US, there is a second effect that works in a different direction: the higher world market prices reduce the demand for fossil fuels which automatically lead to lower emissions. Thus, the fixed emission target requires less additional abatement and is less costly. In other words, marginal abatement costs decline as we can also see in Table 5. Taken together the US withdrawal leads to higher net prices

---

<sup>4</sup>To avoid extensive data tables we restricted the reported data for the non Annex B regions to MEA as a representative energy exporting region and CPA as a representative energy importing region.

Table 5: US withdrawal from Kyoto

	Welfare (EV)			Emissions in GtC			Shadow price US\$/tC	
	bench- mark	NOTR +US	NOTR -US	bench- mark	NOTR +US	NOTR -US	NOTR +US	NOTR -US
USA	100	99.6	100.1	1.73	1.38	1.75	90.28	
WEU	100	98.6	98.4	1.05	0.94	0.94	51.68	45.19
ANC	100	97.2	98.1	0.26	0.23	0.23	58.34	52.51
JPN	100	98.0	97.9	0.40	0.32	0.32	130.12	122.64
FSU	100	98.3	98.9	0.91	0.94	0.93		
MEA	100	96.4	98.1	0.55	0.57	0.56		
CPA	100	100.3	100.2	1.33	1.37	1.35		
WORLD	100	99.4	99.6	8.20	7.81	8.10		

	Gross price COL*			Gross price GAS*			Gross price OIL*		
	bench- mark	NOTR +US	NOTR -US	bench- mark	NOTR +US	NOTR -US	bench- mark	NOTR +US	NOTR -US
USA	1.47	2.64	1.44	1.27	1.65	1.27	1.59	1.85	1.55
WEU	1.55	2.05	2.04	1.27	1.46	1.45	1.71	1.87	1.89
ANC	1.55	2.22	2.20	1.27	1.54	1.53	1.69	1.84	1.88
JPN	1.61	3.25	3.21	1.31	1.81	1.81	1.49	1.88	1.89
FSU	1.44	1.36	1.40	1.24	1.22	1.23	1.65	1.57	1.61
MEA	1.61	1.42	1.50	1.42	1.39	1.40	1.81	1.70	1.76
CPA	2.29	2.16	2.21	1.92	1.87	1.90	1.78	1.67	1.73

\* 1997 = 1

of energy whereas gross prices in the remaining Annex B countries vary. We can see that gross prices for coal and gas fall while the oil prices increase. The explanation is that for gas, the rise in net price was relatively low, so that the decrease in marginal abatement costs dominates. The carbon content of coal on the other hand is more than twice as high as the carbon content of gas. Thus, the drop in abatement costs dominates the price increase. Oil finally has a relatively low carbon content and in addition the price for oil increases more than the one for gas. In this case, the world market effect dominates the marginal abatement cost effect.

If we now look at the welfare effects of the US withdrawal, we find that their sign can be explained by the gross energy prices quite well. In the non abating countries, where gross prices are rising, welfare increases in the energy exporting regions FSU/EEC, MEA, LAM and AFR and decreases in the energy importing regions CPA, PAS and IND. As oil covers the largest part of energy in the remaining Annex B countries, the oil price effect dominates and gross energy prices also rise on average. Again we see, that energy exporters

gain (ANC) while energy importers (WEU, JPN) lose welfare.

These findings, especially concerning the gross prices for fossil fuels were based on the observation that marginal abatement costs (MACs) are affected by the US withdrawal. Obviously the marginal abatement cost curves (MACCs), on which all partial equilibrium studies are based, are not as stable as Ellerman and Decaux (1998) claim them to be. To underline the finding that MACs decrease with higher US demand and rising fossil fuel prices, we generated the full MACCs for the NOTR+US and NOTR-US scenario along the lines of Ellerman and Decaux. We varied the effective emission reductions relative to the benchmark of one Annex B country while the others (including or excluding the US) were assumed to fulfill their Kyoto commitment.

As Table 6 shows we find that for low emission reductions MACs in the two scenarios can deviate by over 20%. The variation is especially high for Europe where the difference between the NOTR+US and NOTR-US scenario reaches 14.4% for the Kyoto target. For ANC it is still over 10% (11.1%). Only for JPN who has committed to relatively high effective emission reductions of 20.4% in 2010 (compared to 9.9% for WEU and 13.1% for ANC) the difference is only 6.1%.

The mechanisms behind these results can be explained by looking at the domestic market for fossil fuels in the Annex B countries. Let's take for example the oil market in the WEU as illustrated in Figure 1. Line  $d$  signifies the domestic WEU demand for oil. Since each barrel of oil contains a fixed amount of carbon, we can put the associated CO<sub>2</sub> emissions in MtC on the x-axis in Figure 1 instead. On the y-axis we mark of the price of oil in US\$.

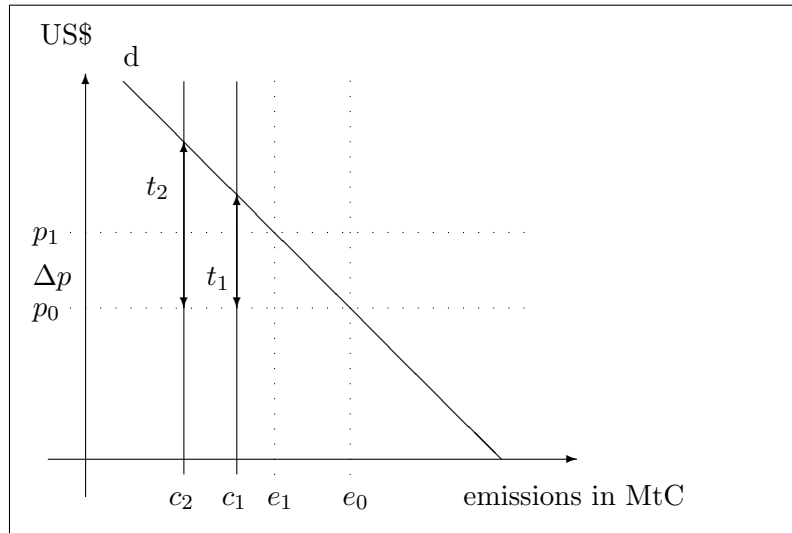


Figure 1: marginal abatement costs and fossil fuel prices

Table 6: Marginal abatement cost curves

WEU					JPN				
Reduction <sub>1</sub>		MAC <sub>2</sub> in NOTR		diff.	Reduction <sub>1</sub>		MAC <sub>2</sub> in NOTR		diff.
in %	in GtC	+US	-US		in %	in GtC	+US	-US	
5	0.05	30.36	23.77	-21.7	5	0.02	33.67	26.44	21.5
9.9*	0.10	51.68	45.19	-14.4	10	0.04	59.28	51.96	-12.4
10	0.11	52.35	45.86	-12.4	15	0.06	89.81	82.40	-8.3
15	0.16	77.60	71.21	-8.2	20	0.08	126.30	118.82	-5.9
20	0.21	106.79	100.50	-4.3	20.4*	0.08	130.12	122.64	-6.1
25	0.26	143.74	137.59	-4.3	25	0.10	174.60	167.13	-4.3
30	0.32	180.69	174.68	-3.3	30	0.12	222.91	215.44	-3.3
40	0.42	284.85	279.28	-2.0	40	0.16	366.38	359.17	-2.0

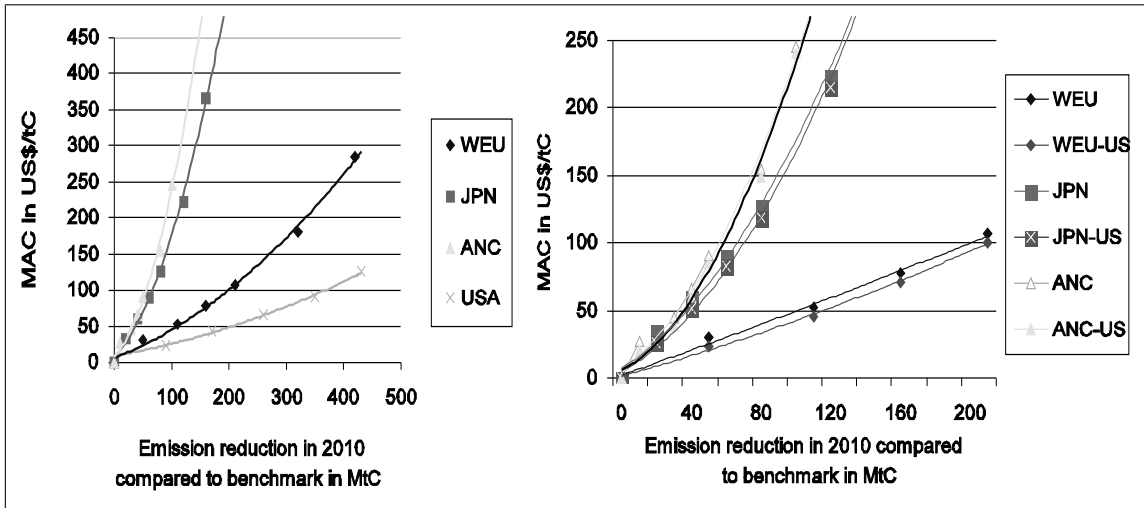
  

ANC					USA				
Reduction <sub>1</sub>		MAC <sub>2</sub> in NOTR		diff.	Reduction <sub>1</sub>		MAC <sub>2</sub> in NOTR		
in %	in GtC	+US	-US		in %	in GtC	+US		
5	0.01	26.80	20.78	-22.5	5	0.09	22.90		
10	0.03	44.99	39.09	-13.1	10	0.17	42.97		
13.1*	0.03	58.34	52.51	-11.1	15	0.26	65.27		
15	0.04	66.11	60.32	-8.8	19.8*	0.34	90.28		
20	0.05	90.79	85.12	-6.2	20	0.35	91.36		
25	0.07	122.54	117.01	-4.5	25	0.43	128.43		
30	0.08	154.29	148.90	-3.5	30	0.51	158.28		
40	0.10	245.47	240.55	-2.0	40	0.69	256.94		

1: Emission reduction in 2010 relative to benchmark

\*: Kyoto target

2: marginal abatement cost in US\$/tC



Assume that the oil price that is determined on the world market is initially  $p_0$ . Without any emission constraints WEU would emit  $e_0$  MtC. If the WEU now commits to emit only  $c_1$ , the marginal abatement cost is the difference between  $p_0$  and the price that would lead to  $c_1$  MtC. In Figure 1 this difference is denoted  $t_1$ .  $t_1$  is also equal to the emission tax that would have to be levied to achieve target  $c_1$  or the permit price that would build under domestic permit trading. One can also see that under a stricter commitment  $c_2$ , the MAC would rise to  $t_2$ .

If now the USA withdraw from Kyoto and its higher oil demand on the world market increases the world market price to  $p_1$ , the emissions associated with unrestricted oil demand decrease to  $e_1$ . In addition the difference between the world market price and the price that is needed to achieve a certain emission target (the MAC) decrease exactly by  $\Delta p = p_1 - p_0$  independent of the level of the target. As the absolute difference is the same for all abatement levels, the percentage difference is highest at low abatement levels with associated low MACs.

The level of  $\Delta p$  on the domestic market depends on how much the domestic price is correlated with the world market price. With oil though, this correlation should be very high. In Table 6 we can see indeed, that the difference in the MACs between the NOTR+US and NOTR-US scenario is relatively constant across countries and across abatement levels.

In summary, if the world market price of fossil fuels increases by  $\Delta p$  through the US withdrawal, the MACs in the remaining Annex B countries shift by approximately the same amount. As a result, percentage differences are higher with lower emission targets and lower MACs. We can conclude that it is not sufficient to analyze the permit market alone to determine the allocative implications of different participation and institutional details of scenarios for international emission trading. At least the interactions with the world energy markets, especially the oil market should also be considered. In practice this means that not only movements along the MACCs should be analyzed but also the shift of the MACCs.

## 5.2 Trading hot air

Our second question is how the different institutional set ups ET1-ET3 that differ in (1) the objective of the FSU/EEC (welfare vs. revenue maximization), (2) the permit allocation in the FSU/EEC, and (3) the participation of the USA influence the outcome of international emission trading. First, we compare welfare and revenue maximization in the two scenarios with market power (ET1 and ET2). Next, we assess how the non-participation (ET1) resp. participation (ET2) of the FSU/EEC firms in the permit market influences the outcome of the optimization process. In this context we also investigate the impacts of the USA

withdrawal. Finally we take a closer look at scenario ET2R as it shows the largest difference to the other scenarios and on competitive trading (ET3).

### Welfare versus revenue maximization

As discussed in section 2 welfare and revenue maximization do not lead to the same result and it can be expected that the optimal amount of hot air is larger under welfare maximization. Table 7 shows that this is indeed the case. Note that the provision of a certain percentage of hot air does not lead to the same overall FSU/EEC emissions in the two scenarios. While in scenario ET1 the domestic FSU/EEC emissions change relative to the benchmark due to the increase in international fossil fuel prices. Such a leakage can not occur in scenario ET2 where the FSU/EEC government restricts the total amounts of permits used by foreign *and* domestic firms.

Table 7: Welfare versus Revenue maximization

Scenario	Welfare maximization					Revenue maximization				
	hot air <sub>1</sub>	Permit price <sub>2</sub>	exp <sub>3</sub>	emis <sub>4</sub>	Wel- fare <sub>5</sub>	hot air <sub>1</sub>	Permit price <sub>2</sub>	exp <sub>3</sub>	emis <sub>4</sub>	Wel- fare <sub>5</sub>
ET1+US	65%	32.91	302	1230	103.1	60%	36.10	278	1208	103.1
ET1-US	30%	19.55	139	1058	100.7	25%	25.62	116	1037	100.7
ET2+US	70%	21.51	397	1237	101.8	30%	39.67	267	1052	101.0
ET2-US	35%	7.68	190	1074	100.1	0%	31.14	105	912	99.1
ET3+US		8.64	494	1376	101.1					
ET3-US		0.00	220	1132	100.0	equivalent to benchmark				

1: optimal % hot air (hot air = 2010 benchmark emissions minus Kyoto target = 465 MtC)

2: in US\$ je tC

3: FSU/EEC permit exports in MtC

4: domestic + exported emissions from FSU/EEC in MtC

5: benchmark 2010 = 100

Moving from revenue to welfare maximization in the scenario ET1 where the FSU/EEC firms receive their permits for free the hot air supply rises by only around 5% points. As the loss in welfare due to revenue maximization is close to zero (0.01%) though, both mechanisms lead in fact approximately to the same results as Babiker, Jacoby, Reilly, and Reiner (2002) claim. If the FSU/EEC firms are participating in emission trading, the difference is - as postulated in section 2 as well - much larger. Now, welfare maximization leads to the provision of 70% of the hot air with US participation and 35% without US participation while it would be optimal to sell only 30% respectively no hot air to maximize revenue. The reason for this large difference was already explained in section 2. In scenario

ET1 the provision of more hot air increases welfare through higher energy exports and decreases it by a loss in the comparative advantage in the production of energy intensive goods. In contrast, the comparative advantage is increased through a larger hot air supply in scenario ET2, as the domestic FSU/EEC firms gain from lower permit prices as well. Here, both effects work in the same direction and increase welfare from the additional supply of hot air. In ET2, revenue maximization results in a welfare loss of approximately 1%. The welfare and revenue curves of the different restrictions are plotted in Figure 2.

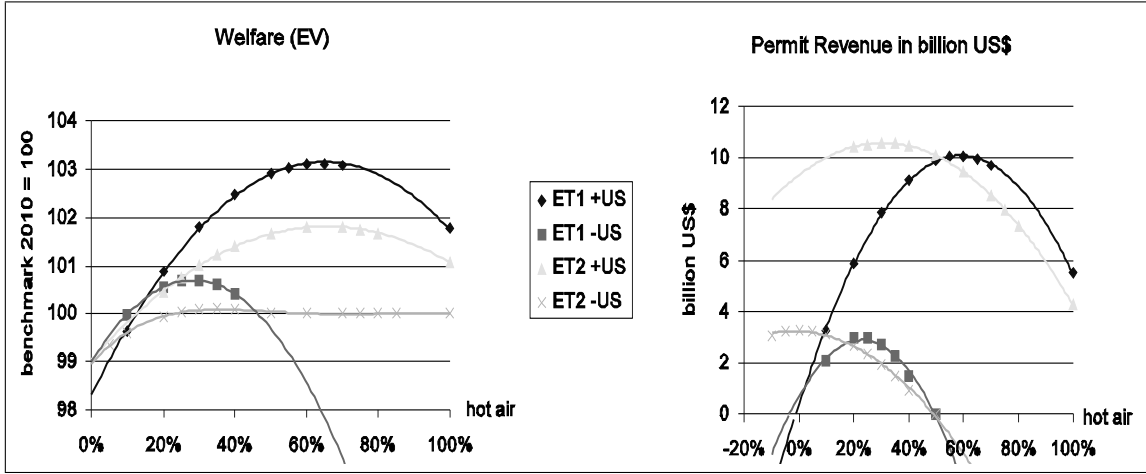


Figure 2: Welfare versus Revenue Maximization

Comparing revenue and welfare maximization from the point of view of the FSU/EEC, the final welfare result is practically identical in the scenarios ET1 with unconstrained emissions in the FSU/EEC. This is mainly due to the fact that the revenue effect dominates and energy price effects of increased energy exports through an increase in hot air are compensated by the loss in comparative advantage of energy-intensive industries thus leaving a very small net effect. This is quite different in ET2 where both competitive effects go into the same direction, such that increasing hot air supplies beyond the revenue maximizing level effectively raises welfare. The curvature of the welfare and revenue curves (Figure 2) also indicate that from a welfare point of view the exact amount of hot air supplied does not matter much since the curves turn out quite flat. Only if the governments look for revenue maximization in ET2 the determination of the share of hot air brought to international markets makes an important difference.

### Comparison of the two institutional setups under welfare maximization

Under welfare maximization, the deviation between the provided hot air in the two institutional setups ET1 and ET2 is relatively small and overall FSU/EEC emissions (domestic



plus exported) are almost identical. The difference between the two scenarios can only be seen in the variation in the world permit price and the resulting world prices for fossil fuels.

If the FSU/EEC firms are participating in trading (ET2W), the permit price is lower. As the abatement costs in the FSU are relatively small compared to the rest of the world, the FSU/EEC firms sell in scenario ET2W not only the hot air, but also additional permits stemming from domestic reductions. 20% (+US) resp. 15% (-US) of the FSU/EEC permits sold on the international permit market are not hot air but are associated with emission reductions in the FSU/EEC. The resulting increase in permit supply cuts down the permit price and raises energy demand in the countries participating in emission trading. Thus, with lower permit prices net energy prices go up world wide while gross prices decline in the countries that participate in emission trading. In the energy exporting countries, the FSU/EEC trading scenario ET2W with its higher energy demand and higher world market prices welfare increases. The energy importing countries are better off with the FSU/EEC grandfathering its permits (ET1W) and the resulting higher permit price and lower net energy price. This is also the case for the FSU/EEC itself. It faces lower gross energy prices in scenario ET1W resulting in 1.3% (+US) resp. 0.6% (-US) welfare increase compared to scenario ET2W. This is so because the FSU/EEC under welfare maximization can by selecting the optimal hot air supply introduce the equivalent of an optimal tariff on fossil energy.

The impact of the two institutional regimes on the welfare in the abating Annex B countries is predominantly determined by the permit price effect. In ET1 prices of 33 \$/tC with US participation and 22 \$/tC without the US prevail. They are by more than 10 \$/tC lower in ET2. This is due to the fact that in addition to the expected "official" hot air - i.e. benchmark emissions in 2010 minus Kyoto target - at the world market price domestic permits will be sold since the FSU/EEC has sufficiently low marginal abatement costs. As a consequence regions like WEU get cheaper permits in ET2 than in ET1 and thus experience higher welfare effects in ET2.

Finally we compare the scenarios of hot air trading with and without the USA. All things said so far also apply here. What is striking though, is the significant drop in permit prices without the USA. Even though the FSU/EEC react to the decreased permit demand by cutting the supply of hot air by half, the permit prices fall by 13 \$/tC which is 40% in ET1 and over 60% in ET2. The reason is that in both scenarios ET1+US and ET2+US the USA are responsible for around 60% of world permit demand. Under emission trading the US withdrawal thus not only induces a shift of the marginal abatement cost curves but also a downward move along the curves itself. Taken together the sharp drop in permit prices dominates the increase in fossil fuel prices in all abating Annex B countries, so that all gross prices for fossil energy - including the oil price which was rising in the NOTR-US scenario - decline. We can see in Table 8 that without the US welfare increases in all abating Annex B countries. From the point of view of the FSU/EEC the US withdrawal implies a loss in

Table 8: Comparison between the different institutional setups under optimal FSU/EEC behavior

	Welfare (Equivalent Variation)							
	bench	ET1W		ET2W		ET2R		ET3
	(ET3-US)	+US	-US	+US	-US	+US	-US	+US
US	100	99.7	100.0	99.8	100.0	99.7	100.0	99.9
WEU	100	98.9	99.2	99.4	99.7	98.8	98.9	99.7
ANC	100	98.5	99.2	98.9	99.7	98.1	98.7	99.5
JPN	100	99.6	99.7	99.8	99.9	99.6	99.5	99.0
FSU	100	103.1	100.7	101.8	100.1	101.0	99.1	101.1
MEA	100	98.5	99.4	98.9	99.7	98.0	98.9	99.6
CPA	100	100.1	100.1	100.1	100.0	100.2	100.1	100.0

	Emissions in GtC							
	bench	ET1W		ET2W		ET2R		ET3
	(ET3-US)	+US	-US	+US	-US	+US	-US	+US
US	1.72	1.59	1.73	1.63	1.73	1.56	1.74	1.69
WEU	1.05	0.97	1.00	1.00	1.03	0.97	0.98	1.03
ANC	0.26	0.24	0.25	0.25	0.26	0.24	0.24	0.26
JPN	0.40	0.38	0.39	0.39	0.40	0.38	0.38	0.40
FSU	0.91	0.93	0.92	0.84	0.88	0.79	0.81	0.88
MEA	0.55	0.56	0.56	0.56	0.56	0.56	0.56	0.56
CPA	1.33	1.35	1.33	1.34	1.33	1.36	1.35	1.33
WORLD	8.20	8.02	8.16	8.02	8.16	7.88	8.06	8.13

	Gross Oil Price (1997 = 1)							
	bench	ET1W		ET2W		ET2R		ET3
	(ET3-US)	+US	-US	+US	-US	+US	-US	+US
US	1.59	1.68	1.58	1.64	1.58	1.69	1.57	1.61
WEU	1.71	1.83	1.79	1.78	1.74	1.85	1.84	1.74
ANC	1.69	1.79	1.76	1.75	1.72	1.80	1.80	1.72
JPN	1.49	1.57	1.54	1.54	1.51	1.58	1.58	1.51
FSU	1.65	1.62	1.64	1.72	1.68	1.78	1.76	1.68
MEA	1.81	1.77	1.79	1.78	1.80	1.75	1.78	1.80
CPA	1.78	1.74	1.76	1.75	1.77	1.72	1.75	1.77

welfare as the permit revenue declines by around 70% in both scenarios ET1 and ET2. The welfare loss is higher in ET1 (2.3%) than in ET2 (1.7%) as in ET2 the FSU/EEC firms benefit from the lower permit prices as well which compensates for part of the revenue loss.

## **Revenue maximization in scenario ET2**

The scenario ET2 in which the FSU/EEC auctions off permits to the domestic emitters is of particular interest. The difference between revenue and welfare maximization under the optimal hot air supply is largest, and under revenue maximization the lowest emissions world wide as well as the lowest emissions from the FSU/EEC (including the exported hot air) will be achieved.

The emission effect is, of course due to the positive price on emissions imposed on local emitters in the FSU/EEC. But the hot air available at the government - defined as the difference between the Kyoto commitment and benchmark emissions - will also not be supplied on world markets. The reason is the high price for permits. At high prices only few permits will be sold internally, hence the effective amount of permits that can be brought to the international market increases. One could also explain this effect in a different setting, where local emitters receive permits accordingly to benchmark emissions which then are tradable on the international market. At the world market prices and the low abatement costs more than 100 MtC would be supplied by the private sector of the FSU/EEC. Maximizing revenues of permit sales including the private supplies would result only in a small share of hot air supplied. In fact, without the USA participation it would be optimal to keep all hot air because the private supplies would already suffice to reach the revenue maximum for the FSU/EEC<sup>5</sup>.

These internal incentives to supply hot air also in part explain the drastic rise in hot air supplies in the case of welfare maximization. Increasing hot air supplies improve the competitive situation of the energy sectors in the FSU/EEC as discussed above. The additional hot air also lowers permit prices. With the USA in the Kyoto-process from 40 \$/tC to 22 \$/tC and without the USA from 31 \$/tC to less than 8 \$/tC. Such a drop in permit prices drastically reduces the permit supply of local emitters, hence the government can increase its supplies strongly, i.e. from 30% to 70% in ET2+US and from 0% to 35% in ET2-US. Finally it is interesting to note in the case without the US demand (ET2-US) almost any hot air supply is close to the welfare maximum, probably because the revenue effect from the international permit market and the competitiveness effect together with the abatement cost effect inside the FSU/EEC seem to substitute each other.

---

<sup>5</sup>The result of an optimal supply of 0% of hot air is accidental. In fact, the optimal supply is slightly below 0%, i.e. the FSU/EEC would bank even more than the predicted amount of hot air.

## Competitive Trading

Our third institutional set up in the FSU/EEC (ET3) assumed that the government grandfathers all its emission rights, including the hot air to the local firms that participate in international emission trading. This leads to a competitive market. As a result the supply of hot air is not restricted and the permit price falls in IET from 33 \$/tC in ET1+US and 22 \$/tC in ET2+US to 8 \$/tC in ET3+US. The withdrawal of the USA now leads to an excess supply of hot air, so that the prize drops to zero and scenario ET3-US reduces to the benchmark. The exported 220 MtC reported in Table 8 is the amount of hot air supply at which the price reaches zero. Thus, in the benchmark WEU, JPN and ANC emit together 220 MtC more then their common Kyoto target. In any case, ET3 is associated with the lowest permit prices and the highest world market prices for fossil fuels with the well known implications for energy exporting and importing countries and the abating Annex B regions. Finally, if we compare the FSU/EEC welfare under strategic behavior to the welfare under a competitive market, we can see that only under ET1 the FSU/EEC can significantly gain welfare (3%). Under scenario ET2 the increase in welfare compared to ET3 is almost negligible. The reason is that ET3 is the same scenario as ET2 with 100% hot air supply. As already explained, the welfare curve in Figure 2 is quite flat and the gains from further permit revenue through a restriction of hot air are compensated by the higher domestic permit prices.

## 6 Conclusions

In this paper we analyzed the impacts of the interaction between different participation structures, institutional set ups and strategic supply of hot air in international emission trading. It turns out that the allocation effects are to a large degree influenced by the impact of the permit trading and the participation structure on the prices for fossil fuels and especially those for crude oil. Therefore they should be explicitly considered in studies of alternative emission trading regimes. This has consequences for those analysis that only work with marginal abatement cost curves derived from CGE-studies since these curves are not independent from the level of energy prices. In other words, changes in energy prices will shift the marginal abatement cost curves more than marginally. This becomes not only apparent in the analysis of the withdrawal of the USA from the Kyoto-Protocol, it can also be observed when different supplies of hot air are analyzed.

Hot air supplies of mainly Russia and the Ukraine are important topics, of course. Many studies have found a wide range of optimal hot air supplies. We have shown that the permit allocation within the hot air countries is an important determinant of hot air supplies. Three

institutional scenarios appear to be most realistic:

- the FSU/EEC governments give emission permits to the domestic firms for free and isolates them from the international permit market while the governments themselves trade a certain percentage of the hot air on the world market,
- domestic firms participate in IET either directly or indirectly through JI but the FSU/EEC government controls the amount of permits that are available for both domestic firms and international entities,
- the FSU/EEC government grandfathers all emission permits to local firms that participate in IET

Within these three settings optimal hot air supplies vary between 0% and 35% in a trading system without the USA and between 30% and 7% with the USA participating. This variation is also influenced by the objective function used by the governments of the hot air countries provided they cooperate in order to strategically restrict the supply of hot air. Under welfare maximization always more hot air is sold than under revenue maximization, mainly because under welfare maximization hot air supplies can be used as trade policies for energy sectors and for energy-intensive industries.

The question as to whether the optimal degree of hot air really is an important one for the hot air economies depends mainly on the objective they are pursuing. In the case of a simple revenue maximization of revenues from the export of permits, it matters simply because - in the case of US participation and free permits to local producers - revenues can be increased from roughly 6 billion US\$ to 10 billion if hot air exports are restricted to 60%. Similarly strong effects occur in the other scenarios. It does not matter much if welfare maximization is the objective. A variation in the share of hot air supplied has almost no effect on welfare. This happens because restricting hot air raises revenues but it also hurts the domestic industry regardless whether local producers pay for emissions or not. Again the competitiveness effects of the energy price changes which accompany the variation in hot air are at work. There is one exception, though, in scenario ET1-US (no participation of the USA, free non-tradable permits in the FSU/EEC) the permit market is so thin such that the negative permit price effect always dominates the competitiveness effect.

## References

- Armington, P. (1969). A theory of demand for products distinguished by place of production. *IMF Staff Papers* (16), 159–178.

- Babiker, M. H., H. D. Jacoby, J. M. Reilly, and D. M. Reiner (2002). The Evolution of a Climate Regime: Kyoto to Marrakech. Report 82, MIT Joint Program on the Science and Policy of Gloabal Change.
- Baron, R. (1999, October). Market power and market access in international GHG emission trading. IEA Information Paper, International Energy Agency.
- Baron, R. and S. Bygrave (2002). Towards International Emission Trading: design implications for linkages. Paper prepared for the conference on Global Trading; Kiel 30. September - 1.October 2002.
- Bernstein, P. M., D. W. Montgomery, T. F. Rutherford, and G.-F. Yang (1999). Effects of restrictions on international permit trading: The MS-MRT model. *The Energy Journal Special Issue*, 221–255.
- Boehringer, C. (2001). Climate politics from Kyoto to Bonn: From little to nothing?!? Discussion Paper 01-49, ZEW, Mannheim.
- Boehringer, C. and A. Loeschl (2001). Market power in international emission trading: The impacts of U.S. withdrawal from the Kyoto Protocol. Discussion Paper 01-58, ZEW, Mannheim.
- Boehringer, C. and A. Loeschl (2002). Assessing the cost of compliance: the Kyoto Protocol. *European Environment* 12, 1–16.
- Burniaux, J.-M. (1999). How important is market power in achieving Kyoto? - An assesment based on the GREEN model. OECD paper, Economics Directorate, OECD, Paris.
- Bush-Administration (2001). Climate change review.
- Bush-Administration (2002). Global Change Policy Book - Executive summary of the Global Climate change Initiatives Bush announced on February 14, 2002.
- den Elzen, M. G. J. and A. P. G. de Moor (2001a). The Bonn and Marrakech Accords: An updated analysis. RIVM report 728001/017, Netherland National Institute of Public Health and the Environment (RIVM).
- den Elzen, M. G. J. and A. P. G. de Moor (2001b). Evaluating the Bonn Agreement and some key issues. RIVM report 728001/016, Netherland National Institute of Public Health and the Environment (RIVM).
- EIA (2002). International Energy Outlook 2002.
- Ellerman, D. A. and A. Decaux (1998). Analysis of Post-Kyoto CO<sub>2</sub> emission trading using marginal abatement curves. Report 40, Massachusetts Institute of Technology - Joint Program on the Science and Policy of Global Change.

- Hall, R. E. and C. I. Jones (1999). Why do some countries produce so much more output than others? *Quarterly Journal of Economics* 114(1), 83–116.
- IETA (2001). IETA summary of Marrakech Accords. Memo, International Emissions Trading Association (IETA).
- IPCC (Ed.) (2001). *Special Report on Emission Scenarios*. Cambridge University Press.
- Klaassen, G. and O. Percl (2002). Carbon trading: models, markets and modest supply. Paper prepared for the conference on Global Trading; Kiel 30. September - 1.October 2002.
- Loeschl, A. and Z. X. Zhang (2002). The economic and environmental implications of the US repudiation of the Kyoto Protocol and the subsequent deals in Bonn and Marrakech. Nota di la Voro 23.2002, Fondazione Eni Enrico Mattei.
- Manne, A. S. and R. G. Richels (2001). US Rejection of the Kyoto Protocol: the impact on compliance costs and CO<sub>2</sub> emissions. Working Paper 01-12, AEI-Brookings Joint Center for Regulatory Studies.
- Missfeldt, F. and A. Villavicencio (2002). How can economies in transition pursue emission trading or joint implementation? Nota di la voro 59.2002, Fondazione Eni Enrico Mattei (FEEM).
- Paltsev, S. V. (2000). The Kyoto Protocol: "Hot air" for Russia? Working Paper 00-9, Department of Economics, University of Colorado.
- Rutherford, T. F. (1999). Applied general equilibrium modelling with MPSGE as a GAMS subsystem: an overview of the modelling framework. *Computational Economics* (14), 1–46.
- Rutherford, T. F. and S. V. Paltsev (2000). GTAPinGAMS and GTAP-EG: Global datasets for economic research and illustrative models. Working paper, University of Colorado.
- Springer, K. (2002). *Climate Policy in a Globalizing World: A CGE Model with Capital Mobility*. Kieler Studien. Berlin: Springer.
- Steenberghe, V. v. (2002). CO<sub>2</sub> abatement costs and permit's price: Exploring the impact of banking and the role of future commitment. Paper prepared for the conference on Global Trading; Kiel 30. September - 1.October 2002.
- UNFCCC (2001). Report of the Conference of the Parties on its 7th session held at Marrakech from 29 October to 10 November 2001. Part II: Action taken by the Conference of the Parties. Report FCCC/CP/2001/13/add.2, Bonn.
- Weyant, J. P. (Ed.) (1999). *The cost of the Kyoto Protocol - A multi-model evaluation*. The Energy Journal - Special Issue.

## A The DART Model

### Basic structure

The DART (**D**ynamic **A**ppplied **R**egional **T**rade)Model is a multi-region, multi-sector recursive dynamic CGE model of the world economy covering 12 regions and 11 sectors that are summarized in section 3.1 and the two production factors labor and capital. The sectoral aggregation covers among others the main energy sectors. The economic structure is fully specified for each region and covers production and final consumption. Each market is perfectly competitive. Output and factor prices are fully flexible. For each region the model incorporates two types of agents: producers, distinguished by production sector and the final consumer which comprises an representative household and the government.

**Producer** behavior is derived from cost minimization for a given output. Each industry is characterized by a multi-level nested separable constant elasticity of substitution (CES) function that describes the technological substitution possibilities between a value added composite of capital and labor, energy and non-energy intermediate inputs in domestic production. The distinction between energy and non-energy intermediate products is useful in the context of climate policies.

The **final consumer** receives all income generated by providing primary factors to the production process. A fixed share of income is saved in each time period. These saving are invested in the production sectors. The disposable income (net of savings and taxes) is then used for maximizing utility by purchasing goods. The expenditure function is modelled as a CES composite which combines consumption of an energy aggregate and a non-energy-bundle. Within the non-energy consumption composite, substitution possibilities are characterized by a Cobb-Douglas function of Armington goods.

To analyze climate policies **CO<sub>2</sub> emissions** are calculated for final and intermediate energy consumption.

All regions are linked by bilateral **trade** flows and all goods, except the investment good, are traded among regions. Following the proposition of Armington 1969 (1969), domestic and foreign goods are imperfect substitutes distinguished by country of origin. Import demand is a three stage, nested separable CES cost resp. expenditure function. On the first level domestic and imported goods are substitutes. Imports are itself a composite of the sum of exports and transportation costs from each other. On the export side, the Armington assumption applies to final output of the industry sectors destined for domestic and international markets.

**Factor markets** are perfectly competitive and full employment of all factors is assumed. Labor is assumed to be a homogenous good, mobile across industries within regions but



internationally immobile. In the basic version of the DART model capital is inter-sectorally but not internationally mobile. Capital stock is given at the beginning of each time period and results from the capital accumulation equation.

## Dynamics

The DART model is recursive-dynamic, meaning that it solves for a sequence of static one-period equilibria for future time periods connected through capital accumulation. The major driving exogenous factors of the model dynamics are population change, the rate of labor productivity growth, the change in human capital, the savings rate, the gross rate of return on capital, and thus the endogenous rate of capital accumulation. The savings behavior of regional households is characterized by a constant savings rate over time.

Labor supply considers human capital accumulation and is, therefore, measured in efficiency units,  $L_{r,t}$ . It evolves exogenously over time. Hence, labor supply for each region  $r$  at the beginning of time period  $t+1$  is given by:

$$\bar{L}_{r,t+1} = \bar{L}_{r,t} * (1 + gp_{r,t} + ga_{r,t} + gh_r)$$

where the bar denotes exogenous variables. An increase of effective labor implies either growth of the human capital accumulated per physical unit of labor,  $gh_r$ , population growth  $gp_r$  or total factor productivity  $ga_r$  or the sum of all.

The version of the DART model used for this paper assumes constant, but regionally different labor productivity improvement rates,  $ga_r$ , constant but regionally different growth rates of human capital,  $gh_r$ , which stem from Hall and Jones (1999), and declining population growth rates over time,  $gp_{r,t}$ , according to the World Bank population growth projections. Because of the lack of data for the evolution of the labor participation rate in the future the growth rate of population instead of the labor force is used implying that the labor participation rate is constant over time.

Current period's investment augments the capital stock in the next period. The aggregated regional capital stock,  $Kst$  at period  $t$  is updated by an accumulation function equating the next-period capital stock,  $Kst_{t+1}$ , to the sum of the depreciated capital stock of the current period and the current period's physical quantity of investment,  $Iq_{r,t}$ . The equation of motion for capital stock  $Kst_{r,t+1}$  in region  $r$  is given by:

$$Kst_{r,t+1} = (1 - \delta_t)Kst_{r,t} + Iq_{r,t}$$

where  $\delta_t$  denotes the exogenously given constant depreciation rate. The allocation of capital among sectors follows from the intra-period optimization of the firms.

For a detailed description of the DART-Model see (Springer 2002).

## Calibration

The static part of the DART-Model is currently calibrated to the GTAP version 5 database that represents global production and trade data for countries and regions, commodities and primary factors for the year 1997. Thus, DART is based on more actual data than most other models that still work with GTAP4 data for the year 1995 or even with older data. As the model is solved as a mixed complementary problem (MCP) using the Mathematical Programming Subsystem for General Equilibrium (MPSGE) described by Rutherford (1999), the GTAP data are transformed using the GTAPtoGAMS algorithm provided by Rutherford and Paltsev (2000). In addition the elasticities of substitution for the energy intermediate goods coal (0.6), gas (1.5) and crude oil (0.33) are chosen to reproduce the emission in 2030 that are projected from the IPCC<sup>6</sup>.

## Implementation of the Kyoto Protocol

To model the implementation of the Kyoto protocol, we assume that Annex B countries start abatement in 2005. In the following years emissions are reduced by the same absolute amount each year, until the target is reached in 2010.

To calculate the appropriate emission targets for our model, we run our model for the year 1997 with the base data. The resulting 1997 emissions are compared to the actual EIA data (EIA 2002). As DART overestimates emission for some countries and underestimates it for other, we use the differences to adjust the official 1990 emission data from EIA (2002). These adjusted 1990 data are finally multiplied with the reduction requirement implied by the Marrakech agreement. Table 3 in section 4.2 lists these new Marrakech targets as they are reported by Boehringer (2001). To calculate the rates for our regional aggregation these data are combined with the EIA emission estimates for 1990.

---

<sup>6</sup>For the calibration we choose the "middle" scenario B2 from (IPCC 2001) and calculate the average prognosis from all model used