JET-SET

Joint Emissions Trading as a Socio-Ecological Transformation

Cross-Section Project 3

Linking the EU Emissions Trading Scheme under Alternative Climate Policy Stringencies: An Economic Impact Assessment

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Joint Emissions Trading as a Socio-Ecological Transformation

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Abstract

This paper assesses the potential linkage of emerging emissions trading schemes (ETS) outside Europe with the recently established European Emissions Trading Scheme (EU ETS). Using a numerical multi-country equilibrium model of the world carbon market based on marginal abatement cost functions, economic and emission effects of alternative linked emissions trading schemes are assessed quantitatively. The simulations show that linking the European ETS to emerging non-EU schemes generally lowers Kyoto compliance costs, even for inefficient domestic emission allocations. However, the benefits from linking are rather small, as (non-trading) non-energy-intensive industries carry the essential part of the economic burden. Given an efficient allocation within domestic emissions trading systems, linking ETS causes a much stronger fall in compliance costs for all participants. Also the access to the Clean Development Mechanism (CDM) substantially lowers compliance costs for ETS regions by compensating non-energy-intensive industries by shifting abatement efforts to low-cost options of developing countries.

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Background

The signing of the Kyoto Protocol in 1997 marks an important milestone for the development and implementation of climate policy within the European Union (EU) and Germany: The implementation of so-called flexible instruments – here in particular the trading of emission certificates between industrialised countries – has since come to play a key role. The development of domestic emissions trading schemes (ETS) adds a new market-based instrument to environmental policy in the EU, which has traditionally been more oriented towards regulatory instruments. Implementing this instrument at the national level entails new societal opportunities as well as risks. Even though there is already a number of studies available from economics and political science, there is still a significant need for information on the ecological, economic, institutional and social impacts of emissions trading. Moreover, there is a strong need for further research on the further development of the EU ETS, both for the first commitment period of the Kyoto Protocol from 2008 to 2012 as well as beyond.

The aim of the **JET-SET** (**J**oint **E**mission **T**rading as a **S**ocio-**E**cological **T**ransformation) project, which is funded by the German Federal Ministry of Education and Research, is to conduct an integrated analysis and assessment of the impacts of emissions trading in the EU and in Germany. The project is coordinated by the Wuppertal Institute and designed as a multi-disciplinary research process.

Objectives of the Research Project

The project's basic **hypothesis** is that the introduction of the EU ETS will lead to far-reaching socio-ecological transformation and learning processes which will, among others,

- change the institutional setting of climate policy at the EU and national level,
- significantly influence the choices and market behaviour of companies,
- affect the public discourse about – and the public perception of – (inter)national climate policy, and
- affect the relationship between society and nature.

In this respect the introduction of an EU emissions trading scheme can be perceived as a transformation process which comprises both social and ecological dimensions and their interrelation.

The **aims** of the project are:

- monitoring the introduction of emissions trading in the EU and in Germany,
- integrated assessment of the economic, ecological and social implications of the EU ETS,
- the elaboration of policy recommendations with respect to the future design of the trading scheme, and
- the conceptual and theoretical embedding of the research results into the inter-disciplinary sustainability research.

Design of the Research Project

The **structure of the research project** reflects *analytical* and *practical-political* elements of socio-economic transformations induced by the introduction of the EU ETS:

In the ***first project phase***, the project partners focused on the currently emerging transformation processes triggered by the EU ETS from an analytical perspective. In line with the aims of the project, four so-called "**Base Projects**" (BPs) dealt with:

- the modifications of institutions within society and politics brought about by the progress of the EU ETS (BP1),
- the modification of business strategies (BP2),
- the changing discourses and public perception of climate policy (BP3), and
- land-use-changes, based on the example of energy crops (BP4).

Furthermore, gender aspects of international climate policy have been analysed. At the end of the first phase, an integrated research concept was developed that serves as the basis for the second project phase.

The ***second project phase*** addresses the potentials and risks related to linking the EU ETS with other emerging domestic trading schemes. Four so called "**Cross-Section Projects**" address the following aspects:

(1) Which countries are currently planning to introduce national greenhouse gas emissions trading schemes and when will these schemes be established?

(2) What are the economic effects (abatement costs, certificate price) of different alternative scenarios („storylines") of linking the EU ETS with other domestic schemes?

(3) What will be the contribution of linking to achieving more ambitious targets for reducing greenhouse gas emissions for the period after 2012?

(4) What are institutional and political preconditions for linking?

The project addresses these questions by an integrated assessment of different alternative policy scenarios of linking domestic emission trading systems (ETS) in four Cross-Section Projects (CSPs):

- Policy scenarios of linking (CSP1)
- Impacts of linking domestic ETS on the distribution of per capita emissions (CSP2)
- Economic and environmental effects (CSP3)
- Implications of design differences (CSP4)

Role of this Paper within the Research Project

This paper has been developed within CSP3. It assesses the potential linkage of emerging emissions trading schemes outside Europe with the EU ETS. Using a numerical multi-country equilibrium model of the world carbon market based on marginal abatement cost functions, economic and emission effects of alternative linked emissions trading schemes are assessed quantitatively. The simulations show that linking generally lowers Kyoto compliance costs, even for inefficient domestic emission allocations. However, the benefits from linking are rather small, as (non-trading) non-energy-intensive industries carry the essential part of the economic burden. Given an efficient allocation within domestic emissions trading systems, linking ETS causes a much stronger fall in compliance costs for all participants. Also the access to the Clean Development Mechanism (CDM) substantially lowers compliance costs for ETS regions by compensating non-energy-intensive industries by shifting abatement efforts to low-cost options of developing countries.

1 Introduction

The recent establishment of the European emissions trading system marked a milestone in international climate policy-making, as for the first time trading emission allowances at the company level became feasible in an international context (EU 2003). However, currently also countries such as Australia, Japan and parts of the USA are discussing domestic emissions trading schemes (ETS), envisaging a future linkage to the European ETS.

Since these schemes are expected to include mainly energy-intensive industries, as in the European ETS complementary national environmental policies such as environmental taxation or subsidies for renewable energy use are needed for the remaining industries in order to achieve an exogenous emission target – with consequences for the distribution of compliance costs between sectors. A potential linkage of emerging domestic ETS in non-EU-countries with the EU scheme can benefit all parties in terms of economic efficiency, but will alter the distribution of compliance costs between countries. At the same time, the directive linking the EU ETS with the project-based mechanisms of the Kyoto Protocol enables EU member states to make use of the Clean Development Mechanism (CDM) and Joint Implementation (JI), allowing emission allowances to be imported from developing countries such as Brazil, China or India (EU 2004). Imports from the CDM market may therefore serve as substitutes for allowances from the (various) ETS, and stronger substitution patterns in favor of the CDM will put supplementarity considerations on the agenda. In this context, the resulting distribution of emission reductions will be of interest from a political acceptance perspective. Both the potential linkage of national ETS and the use of project-based mechanisms depend heavily on the anticipated economic costs induced by emissions trading and CDM investments as well as on transaction costs. Besides this barrier to CDM usage, a crucial determinant of a firm’s decision on CDM investments is (host country) risk related to the underlying projects.

Using a numerical multi-country equilibrium model of the world carbon market based on marginal abatement cost functions, economic and emission effects of alternative linked emissions trading schemes and the usage of the CDM are assessed quantitatively in this paper. The model covers transaction costs and investment risk for CDM host countries. For an adequate reproduction of national ETS, the model explicitly divides the various national economies into energy-intensive sectors covered by the EU carbon trading directive (in the following referred to as *DIR* sectors) and remaining industries not covered by the directive (in the following referred to as *NDIR* sectors). As a result, distributional effects between ETS participants, CDM host and donor countries as well as between sectors of the economies are analyzed.[1]

[1] Institutional implications of linked emissions trading schemes are comprehensively laid out in Sterk et al. (2006).

The remainder of the paper is structured as follows. In section 2, regional reduction requirements as well as sectoral emission allocations are presented. In section 3, marginal abatement cost functions are specified. In section 4, scenarios of linked emissions trading schemes are presented before illustrating quantitative simulation results in section 5. Partial versus General Equilibrium analysis is discussed in section 6, section 7 concludes.

2 Reduction targets and allocation of emissions

2.1 Benchmark emissions and reduction requirements

Benchmark emissions serve as the starting point for our analysis. Data on carbon dioxide emissions was obtained from van Vuuren et al. (2006) who provide a nationally downscaled dataset based on the implementation of global IPCC-SRES scenarios (IPCC 2001) into the environmental assessment model IMAGE 2.2. A summary of benchmark emissions for relevant regions of the present analysis is shown in Table 1.[2]

In the Kyoto Protocol, industrial countries agreed on cutting greenhouse gas emissions by 5.2% on average during 2008-2012 compared to the reference year 1990 (UNFCCC 1997). The European Union redistributed its aggregate reduction commitment of 8% among Member States according to an internal Burden Sharing Agreement (EU 1999). Thereby, reduction requirements for each Member State are determined.

Table 1*: CO_2 emissions from energy, industry and deforestation (MtC per year)*

Region	1990 (total)	2010 (total)	2020 (total)	2010 (DIR)	2010 (NDIR)	2020 (DIR)	2020 (NDIR)
Austria	16.63	20.02	20.20	7.84	12.18	7.77	12.43
Belgium	32.36	38.92	39.25	19.70	19.23	20.91	18.34
Denmark	14.34	15.99	16.12	9.25	6.73	9.48	6.64
Spain	61.75	95.18	95.75	51.19	43.99	51.65	44.10
Finland	16.36	18.85	19.35	12.06	6.79	13.63	5.72
France	111.65	120.66	123.39	42.70	77.96	46.32	77.07
United Kingdom	166.10	182.06	186.02	86.68	95.38	91.60	94.42
Greece	23.39	29.88	30.38	20.85	9.03	22.01	8.36
Ireland	8.79	13.69	13.83	8.36	5.33	7.92	5.91
Italy	118.74	142.57	144.57	74.38	68.19	76.82	67.75
Netherlands	43.00	54.63	55.03	28.02	26.61	28.38	26.65
Portugal	13.88	21.35	21.80	13.73	7.62	13.99	7.80
Germany	291.99	281.62	290.05	143.57	138.05	152.49	137.56
Sweden	16.65	17.26	17.99	8.84	8.42	11.61	6.38
Central Europe	299.60	255.59	316.84	143.13	112.46	177.43	139.41
United States	1390.15	1826.21	1879.73	937.69	888.52	980.60	899.13
Canada	143.52	184.05	190.27	85.79	98.26	94.29	95.98
Japan	310.08	348.94	323.64	207.41	141.53	171.76	151.88
Pacific OECD (without Japan)	136.67	129.64	129.68	75.19	54.45	75.21	54.46
Former Soviet Union	1056.60	707.92	784.89	396.44	311.49	439.54	345.35
Brazil	330.82	244.02	341.44	127.71	116.31	189.08	152.36
China	690.31	1378.47	1774.81	1174.77	203.71	1409.21	365.60
South Korea	70.64	180.49	233.51	106.45	74.04	133.61	99.90
Mexico	143.55	202.82	260.28	91.64	111.18	117.85	142.43
India	200.56	509.91	824.88	435.19	74.73	692.16	132.72

Source: Netherlands Environment Assessment Agency (Van Vuuren et al., 2006)

[2] Note that the region Central Europe essentially represents new EU member states plus Bulgaria and Romania and that the region Pacific OECD (without Japan) is primarily represented by Australia and New Zealand. Both regions are based on the regional disaggregation of the POLES model (Criqui et al. 1999, see below).

Whereas reduction commitments in 2010 (as the central year of the Kyoto commitment) for EU regions were deduced from the EU Burden Sharing Agreement, the requirements for other Annex B regions were generally derived directly from the Kyoto Protocol. For developing countries no commitments are assumed, resulting in targets equivalent to Business-as-Usual (BAU) emissions. While "Kyoto" targets are already agreed upon for the year 2010, there is no consensus on 2020 emission reduction requirements yet. For this reason, two alternative target scenarios for 2020 were set up: On the one hand, further developed (and similarly denoted) "Kyoto" commitments in 2020 were extrapolated from the 2010 values, considering national communications on future commitments of the respective states.[3] On the other hand, for 2020 reduction requirements compatible with stabilizing CO_2 concentrations at 450 ppm were derived. For these "450 ppm" targets, global CO_2 emissions in 2020 were distributed between Annex B and Non-Annex B regions aiming at a convergence of per capita emissions in the long term for equity reasons, using per capita income as a criterion to reflect the capability of Non-Annex B regions to start controlling their emissions. The capability criterion (1995 US$ (ppp)/cap) is set in a way that developing regions such as South America, Central America and China have to stabilize their per capita emissions from 2015 on.[4] In Table 2, the resulting CO_2 emission reduction requirements versus 1990 levels are listed for relevant regions.

Table 2: *"Kyoto" and "450 ppm" reduction requirements of CO_2 emissions vs. 1990*

Regions	"Kyoto" reduction requirements in 2010 (in % vs. 1990)	"Kyoto" reduction requirements in 2020 (in % vs. 1990)	"450ppm" reduction requirements in 2020 (in % vs. 1990)
Austria	13.0	19.7	30.6
Belgium	7.5	14.7	28.8
Denmark	21.0	27.1	39.2
Spain	-15.0	-6.1	11.4
Finland	0.0	7.7	23.0
France	0.0	7.7	23.0
United Kingdom	12.5	19.3	32.6
Greece	-25.0	-5.3	3.7
Ireland	-13.0	-4.3	13.0
Italy	6.5	13.7	28.0
Netherlands	6.0	13.3	27.6
Portugal	-27.0	-17.2	2.2
Germany	21.0	27.1	39.2
Sweden	-4.0	4.0	19.9
Central Europe	-4.8	3.3	18.4
United States	-27.3	-23.8	1.7
Canada	6.0	8.6	27.6
Japan	6.0	8.6	27.6
Pacific OECD (without Japan)	-7.0	-4.1	17.6
Former Soviet Union	0.0	2.7	23.0

[3] The procedure of setting up "Kyoto" reduction commitments is explained in greater detail in Appendix 9.2.

[4] The procedure of setting up "450 ppm" reduction commitments is explained in greater detail in cross-section project 2.

As shown in the table, the “450 ppm” reduction targets are much more ambitious than the “Kyoto” targets: The resulting reduction requirements for Annex B regions in 2020 range from 1.7 (USA) to 39.2 percent (Denmark and Germany) compared to 1990 emissions. In contrast, reduction requirements of “Kyoto” targets for 2020 range from an increase by 23.8 (USA) to a maximum reduction of 27.1 percent (Denmark and Germany).

Due to lower BAU emissions than the target level implied by its “Kyoto” reduction commitment, the Former Soviet Union features excess emission permits – so-called “Hot Air”. However, in all standard scenarios of the present paper we abstract from the “Hot Air” phenomenon, assuming that no excess permits will be allocated to the respective national installations (see section 4 below).

2.2 Allocation of emissions

In July 2003, the European Parliament approved the directive for a European carbon trading system proposed by the European Commission, which came into force by January 2005 (EU 2003). At the moment, the directive exclusively covers energy-intensive sectors of the economy. Emissions are allocated to firms by means of National Allocation Plans (NAPs) of the respective Member States, which specify an overall cap in emissions for sectors. The amount of free allowances depends on recent historic emissions. The NAPs can therefore be described by *fulfillment factors* that describe the fraction of baseline emissions that are freely allocated as allowances. For fulfillment factors of European regions in 2005 we refer to a recent study on EU NAPs (Gilbert et al. 2004), whereas for other world regions we made reasonable assumptions. We then extrapolated the 2005 values to 2010 and 2020, assuming a 10% decrease in fulfillment factor values in 2010 (2020) compared to 2005 (2010). As base year we chose the year of reduction requirement. Table 3 lists fulfillment factors for various regions and years.

Table 3*: Fulfillment factors for various regions and years*

Regions	Fulfillment factors 2005	Fulfillment factors 2010 (assumption)	Fulfillment factors 2020 (assumption)
Austria	0.940	0.846	0.752
Belgium	1.042	0.938	0.834
Denmark	0.850	0.765	0.680
Spain	0.940	0.846	0.752
Finland	0.980	0.882	0.784
France	0.995	0.896	0.796
United Kingdom	0.993	0.894	0.794
Greece	1.000	0.900	0.800
Ireland	0.970	0.873	0.776
Italy	1.074	0.967	0.859
Netherlands	1.030	0.927	0.824
Portugal	1.035	0.932	0.828
Germany	1.000	0.900	0.800
Sweden	1.000	0.900	0.800
Central Europe	1.000	0.900	0.800
United States	1.000	0.900	0.800
Canada	1.000	0.900	0.800
Japan	1.000	0.900	0.800
Pacific OECD (without Japan)	1.000	0.900	0.800
Former Soviet Union	1.000	0.900	0.800

Source: Gilbert et al. (2004), own calculations

It shows that the current allocation implies very low emission reduction efforts for energy-intensive sectors due to high fulfillment factors, i.e. a relatively generous allocation of emissions. Note that in the model simulations we adjusted fulfillment factors for regions whose target emissions lie above their BaU emissions (such as the Former Soviet Union or Central Europe). In that case, we assumed a fulfillment factor of one: regions that face no abatement obligation are not expected to restrict emissions of their energy-intensive sectors.

3 Marginal abatement cost functions

We assess economic and emission effects of alternative linked emissions trading schemes and the usage of the CDM using a numerical multi-country simulation model of the world carbon market based on marginal abatement cost functions (*SIMAC*). The equilibrium model covers transaction costs and investment risk for CDM host countries. For an adequate reproduction of national ETS, the model explicitly divides the various national economies into energy-intensive sectors covered by the EU carbon trading directive (*DIR* sectors) and remaining industries not covered by the directive (*NDIR* sectors). The algebraic model formulation is given in the Appendix.[5]

In order to generate regional and sectoral marginal abatement cost functions we use data of marginal abatement costs and the associated emission reductions as simulated by the energy system model POLES (Criqui et al. 1999) that explicitly covers energy technology options for emission abatement for various world regions as well as energy-intensive and non-energy-intensive sectors up to the year 2020. In the model a sequence of carbon taxes (e.g. 0–600 US$ per ton of CO_2) is imposed in the respective year and regions, resulting in the associated emission abatement in DIR and NDIR sectors.

To estimate the coefficients for marginal abatement cost functions, we then employ an ordinary least squares (OLS) regression for the simulated data pairs of tax levels (marginal abatement costs) and respective abatement. Here, the dependent variable is the marginal abatement cost and the explanatory variables are abatement levels. In order to account for flexibility, we apply a polynomial of third degree as the functional form of marginal abatement cost functions.

For region *r* and sector *i* this results in the following equation:

$$-C'_{ir}(e_{ir}) = a_{1,ir}(e_{0ir} - e_{ir}) + a_{2,ir}(e_{0ir} - e_{ir})^2 + a_{3,ir}(e_{0ir} - e_{ir})^3 \qquad (1)$$

with C_{ir} as abatement cost in region r and sector $i \in \{DIR, NDIR\}$, $a_{1,ir}$, $a_{2,ir}$ and $a_{3,ir}$ as marginal abatement cost coefficients, e_{0ir} as baseline emission level and e_{ir} as emission level after abatement. Table 4 and Table 5 show the associated least-square estimates of marginal abatement cost coefficients for various regions in 2010 and 2020.

[5] The simulation model builds on Böhringer et al. (2005) who also provide the corresponding analytical framework for the European emissions trading scheme.

Table 4: *Marginal abatement cost coefficients in 2010*

Regions	Directive Sectors (DIR)			Non-Directive Sectors (NDIR)		
	$a_{1,DIR,r}$	$a_{2,DIR,r}$	$a_{3,DIR,r}$	$a_{1,NDIR,r}$	$a_{2,NDIR,r}$	$a_{3,NDIR,r}$
Austria	21.01	-5.93	15.28	169.52	-331.37	438.82
Belgium	5.82	1.82	-0.05	14.97	5.72	2.32
Denmark	69.29	-24.34	5.50	222.11	-140.94	175.06
Spain	2.78	0.03	0.01	26.23	1.81	0.13
Finland	12.55	-2.17	1.15	180.75	-106.60	65.65
France	4.68	0.09	0.01	6.46	0.64	0.01
United Kingdom	1.00	0.01	0.00	4.96	0.32	0.00
Greece	137.86	-14.50	0.57	117.44	-8.20	11.90
Ireland	9.93	-3.23	0.72	107.12	-40.03	45.65
Italy	2.99	0.09	0.01	9.09	1.51	0.20
Netherlands	7.57	-0.40	0.05	47.69	-0.97	0.23
Portugal	271.80	-51.23	3.68	226.96	-88.40	111.16
Germany	1.10	0.01	0.00	3.19	0.14	0.00
Sweden	122.11	565.41	-877.17	23.24	-5.32	2.43
Central Europe	0.56	0.00	0.00	3.44	-0.10	0.01
United States	0.07	0.00	0.00	0.48	0.00	0.00
Canada	1.90	-0.01	0.00	3.38	0.03	0.00
Japan	1.13	0.01	0.00	0.43	2.58	0.11
Pacifc OECD (without Japan)	1.50	-0.06	0.00	6.42	-0.65	0.06
Former Soviet Union	0.16	0.00	0.00	0.37	0.00	0.00
Brazil	1.50	-0.13	0.01	3.67	41.49	20.29
China	0.03	0.00	0.00	0.60	0.05	0.01
South Korea	2.56	0.04	0.00	16.39	5.95	-0.13
Mexico	2.82	0.00	0.00	2.55	0.09	0.01
India	0.18	0.00	0.00	9.32	-0.88	0.12

Table 5: *Marginal abatement cost coefficients in 2020*

Regions	Directive Sectors (DIR)			Non-Directive Sectors (NDIR)		
	$a_{1,DIR,r}$	$a_{2,DIR,r}$	$a_{3,DIR,r}$	$a_{1,NDIR,r}$	$a_{2,NDIR,r}$	$a_{3,NDIR,r}$
Austria	77.95	-57.25	57.52	41.22	35.01	-1.63
Belgium	8.42	-0.60	0.06	19.65	4.63	-0.09
Denmark	36.58	-6.74	1.05	214.49	-184.19	322.64
Spain	3.14	0.01	0.00	28.89	1.67	0.07
Finland	9.49	-0.96	0.60	270.86	-479.02	595.73
France	2.75	0.01	0.00	6.58	0.43	0.05
United Kingdom	1.05	0.01	0.00	5.17	0.32	0.00
Greece	8.57	-0.29	0.03	109.49	-19.24	15.10
Ireland	6.17	0.26	0.23	87.60	-16.97	22.63
Italy	3.38	0.04	0.00	10.01	1.39	0.10
Netherlands	6.02	-0.26	0.04	58.16	-9.70	1.95
Portugal	139.90	-23.70	1.71	192.36	-81.11	63.55
Germany	0.75	0.01	0.00	3.51	0.11	0.00
Sweden	37.81	-19.43	7.52	47.64	17.62	18.88
Central Europe	0.49	0.00	0.00	3.01	-0.06	0.01
United States	0.06	0.00	0.00	0.61	0.00	0.00
Canada	1.02	0.01	0.00	3.82	-0.03	0.00
Japan	1.06	0.01	0.00	2.71	1.39	0.05
Pacifc OECD (without Japan)	0.54	0.02	0.00	3.84	0.14	0.00
Former Soviet Union	0.22	0.00	0.00	0.57	0.00	0.00
Brazil	2.01	-0.10	0.00	5.63	-27.52	30.82
China	0.03	0.00	0.00	2.17	-0.10	0.00
South Korea	0.96	0.00	0.00	14.50	0.58	-0.17
Mexico	1.91	0.05	0.00	2.63	0.06	0.00
India	0.14	0.00	0.00	7.32	0.90	0.76

4 Scenarios of linked emissions trading schemes

For our model simulations we specify various scenarios that differ with respect to four dimensions. The regional dimension distinguishes scenarios of linking regions establishing a domestic emissions trading scheme to the European ETS, the temporal dimension distinguishes scenarios in 2010 and 2020, and the institutional dimension distinguishes regulatory aspects of the trading schemes such as domestic emission allocation. Finally, an environmental dimension distinguishes the strictness of emission reduction commitments, i.e. "Kyoto" targets versus "450 ppm" targets.[6]

Table 6 lists the three regional scenarios *ETS EUROPE* (reflecting the current EU emissions trading system), *ETS KYOTO* (scenario linking the current EU ETS to emerging emissions trading systems in regions that ratified the Kyoto Protocol), and *ETS ANNEX B* (scenario linking the current EU ETS to emerging emissions trading systems in central regions listed in Annex B of the Kyoto Protocol), as well as the temporal dimension. Major developing countries may host CDM projects.

Table 6*: Regional and temporal scenarios*

Scenario \ Time	2010	2020
ETS EUROPE	EU-27	EU-27
ETS KYOTO	EU-27 Japan Canada	EU-27 Japan Canada Former Soviet Union
ETS ANNEX B	EU-27 Japan Canada Former Soviet Union	EU-27 Japan Canada Former Soviet Union Pacific OECD (without Japan) USA
CDM host countries	Brazil Mexico India China South Korea	

[6] A more elaborate development of the policy scenarios described in this section can be found in Schüle et al. (2006).

Our institutional scenarios involve four cases: *NOTRADE* (only cost-efficient domestic action by the respective regions, e.g. by domestic carbon taxation), *NAP* (reflection of *current* EU National Allocation Plans with exogenous fulfillment factors, assuming similar regulation in non-EU regions), *NAP_OPT* (*efficient* design of National Allocation Plans: endogenous fulfillment factors derived from unrestricted emission trading across *all* sectors and respective regions), *NAP_CDM* (*NAP*-scenario with option of conducting CDM projects in developing countries, thereby importing Certified Emission Reductions (CERs)) and *NAP_CDM8* (scenario *NAP_CDM* with supplementarity rule: imports of CERs are restricted to 8% of domestic allocated emissions). Table 7 lists the respective institutional scenarios.

Table 7*: Institutional scenarios*

Policy Scenario	**Regulatory Scheme**		**Emission Trading**	**Fulfillment Factor**	**CDM imports**
	DIR sectors	*NDIR* sectors	*DIR* sectors		*All sectors*
NOTRADE	CO_2 tax	CO_2 tax	No	None	No
NAP	Allowances	CO_2 tax	Yes	Exogenous	No
NAP_OPT	Allowances	CO_2 tax	Yes	Endogenous	No
NAP_CDM	Allowances	CO_2 tax	Yes	Exogenous	Unlimited
NAP_CDM8	Allowances	CO_2 tax	Yes	Exogenous	Restricted

In all our standard scenarios, we abstain from supply of potential excess permits from the Former Soviet Union – which has lower Business-as-Usual emission levels in 2010 and 2020 than in 1990 (so called “Hot Air”). In this context, “Hot Air” supply would imply that governments allocate their excess permits for free to national installations, which would be equivalent to a direct subsidy for the respective installations since the allocated permits could be exported to other ETS regions.[7] It is however not clear yet if such a climate regime will be agreed upon in the future (or even linked to the EU ETS). For this reason, here we abstract from the “Hot Air” phenomenon, assuming that no *excess* permits will be allocated to the respective national installations. In this case, the Former Soviet Union is assumed to have an emission reduction target vs. 1990 that resembles its BaU emissions.

[7] For assessments of the “Hot Air” effect at the country-level see Bernard et al. (2003) as well as Böhringer and Löschel (2003). For an analysis of strategic behaviour options of the Former Soviet Union in the context of European emissions trading see Böhringer et al. (2006).

5 Simulation results

Referring to the regional, temporal, institutional and environmental dimension above, in this section we assess the economic and emission effects of alternative linked emissions trading schemes using a numerical multi-country equilibrium model of the world carbon market based on the derived marginal abatement cost curves. Combining the three dimensions yields the scenarios to be simulated with our numerical model.

As for the detailed quantitative economic and emission effects of resulting scenarios, in Table 10 to Table 21 of the Appendix simulation results are presented in terms of total compliance costs (i.e. total abatement costs including costs and revenues from the permit market) and emission reductions vs. Business-as-Usual for the years 2010 and 2020. In Table 10, e.g. scenario *NAP_OPT EUROPE* represents the regional scenario *ETS EUROPE* in combination with the institutional scenario *NAP_OPT* for the year 2010.

For a more transparent demonstration of results, in the following the central findings of our model simulations are presented graphically.

5.1 Linking the EU ETS in the context of “Kyoto” targets

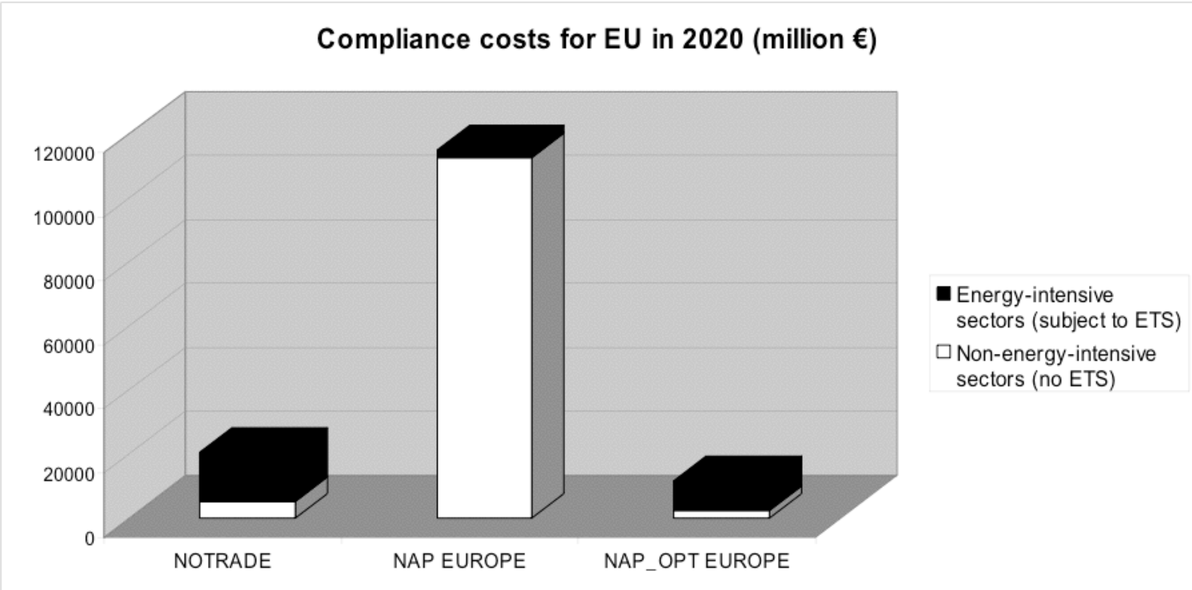
In the following, we analyze the linkage of emission trading schemes in the context of reduction commitments related to the Kyoto-Protocol (so-called “Kyoto targets”) as presented in Table 2.

5.1.1 Linking ETS in the absence of the CDM: the EU perspective

Our first case represents a setting that ignores the CDM as potential substitute for emissions trading. Thereby we are able to analyze the economic and emission effects from linking ETS in an isolated manner. As we start by regionally focusing on the EU, as a political background we begin our analysis by highlighting efficiency aspects of the EU Emissions Trading Scheme in 2020 without linking to other ETS. Simulation results are illustrated in Figure 1 (for detailed quantitative results compare Table 12 of the Appendix).[8]

[8] Note that in the simulation results the region EU-27 is approximated by EU-15 regions without Luxemburg and the *POLES* model region Central Europe.

Figure 1: ***Total compliance costs for the EU in 2020 (without linking)***



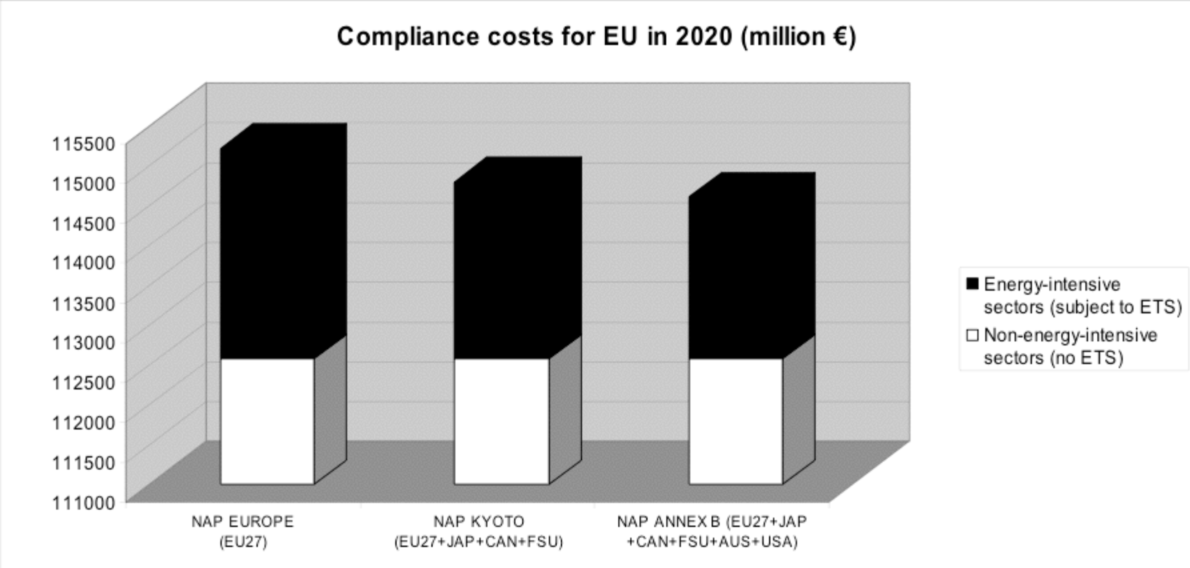
The figure shows that the total costs for compliance with the "Kyoto" targets in policy scenario *NAP* are higher for the EU than under *NOTRADE*: if designed like the current NAPs, emissions trading schemes induce substantially higher compliance costs than purely domestic action. This inefficient situation is due to the high marginal abatement costs of (non-energy-intensive) NDIR sectors which have to account for almost the whole reduction requirement, whereas the (energy-intensive) DIR sectors face only minor reduction efforts because of a rather generous allocation of permits (compare Table 3). However, compliance costs in institutional scenario *NAP_OPT* are lower than in *NAP* and even lower than under *NOTRADE*: an efficient design of NAPs (implying a stricter allocation of emissions to DIR sectors) would drastically lower compliance costs compared to the current NAP design, and would be preferable to purely domestic action. Now those sectors with lower marginal abatement costs, the DIR sectors, carry the major part of the compliance burden. *NAP_OPT* is comparable to a situation of unrestricted emissions trading of polluters and represents a cost-efficient design of national allocation plans.[9]

Also our analysis of linking ETS starts from the perspective of the European Union. Here, we focus on the three different regional constellations of linked emissions trading schemes in 2020, assuming the current (inefficient) allocation of emissions between sectors. Simulation results are illustrated in Figure 2 (for detailed quantitative results compare Table 12 of the Appendix).[10]

[9] Note that these results are in line with the findings of Böhringer et al. (2005).

[10] Note that in subsequent figures the following abbreviations are used: JAP (Japan), CAN (Canada), FSU (Former Soviet Union), AUS (Pacific OECD without Japan), USA (United States).

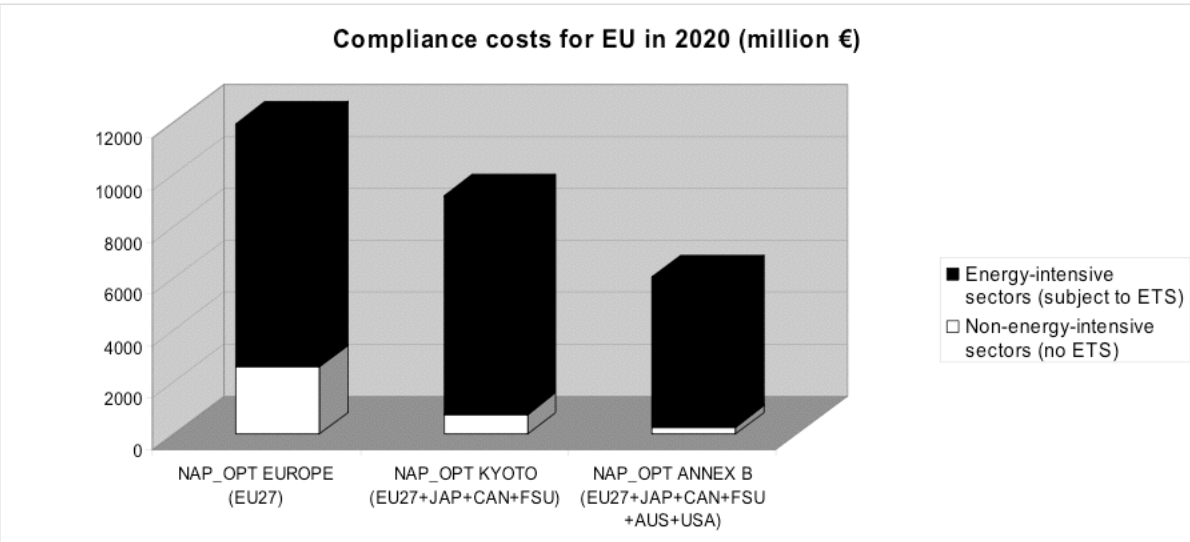
Figure 2: ***Total compliance costs for the EU from linking in 2020 (current allocation)***



We find that linking the EU ETS to emerging domestic ETS lowers Kyoto compliance costs for the EU, even assuming the current allocation. However, the benefits from linking are rather small: the major part of the economic burden is carried by *non-trading* NDIR sectors, so that the efficiency benefits from international emissions trading only apply to a minor fraction of polluters (note that the cost scale in Figure 2 does not start at zero).

Our next simulations concern the same regional setting of linked ETS from the perspective of the EU, however now we account for an optimal allocation of permits between sectors of the respective economies. Simulation results are illustrated in Figure 3 (for detailed quantitative results compare Table 12 of the Appendix).

Figure 3: ***Total compliance costs for the EU from linking in 2020 (optimal allocation)***

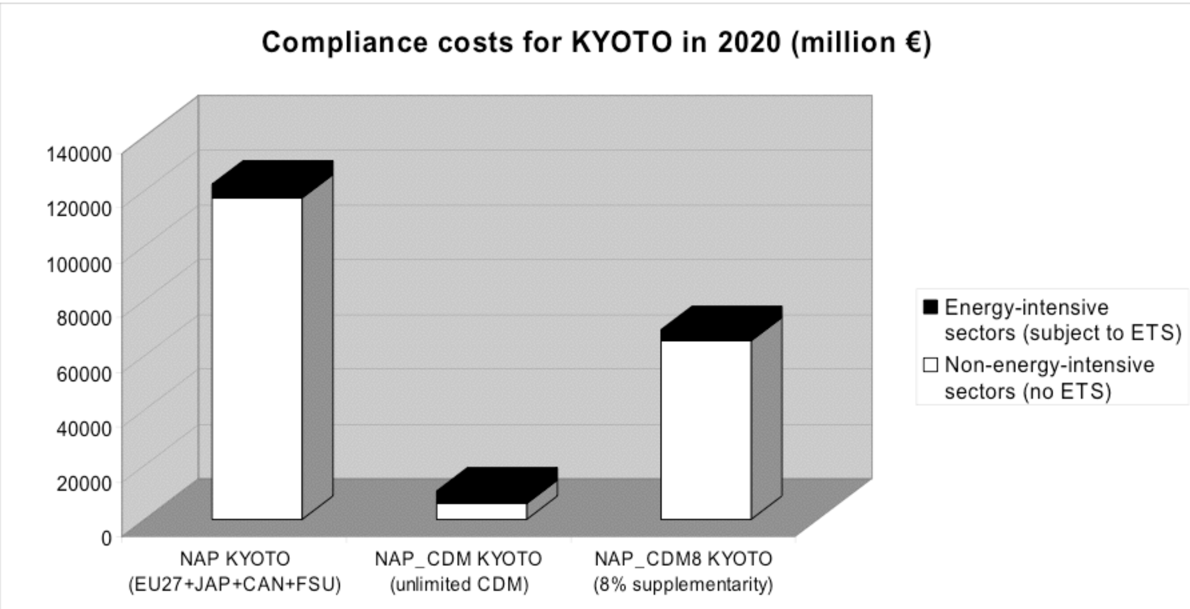


Given an optimal emission allocation within domestic emissions trading systems, linking ETS causes a much stronger fall in compliance costs for the EU. In such an efficient setting, the benefits from linking are greater since the major part of the economic compliance burden is carried by *trading* DIR sectors with low marginal abatement costs. The efficiency effect is the stronger, the more regions participate in the joint trading scheme. Note again that these results are independent of the supply of potential excess permits from the Former Soviet Union: Beneficial effects result merely from the relatively cheap abatement options of this region.

5.1.2 Linking ETS in the presence of the CDM

As soon as high economic burdens are imposed on parts of the economy, substitution reactions of regulated industries become relevant. The following model runs analyze a climate policy regime where certified emission reductions (CERs) generated by the CDM represent an alternative to emission permits from the linked economies. As an example we focus on the linked region *KYOTO* in 2020, assuming the current (inefficient) emission allocation. Simulation results are illustrated in Figure 4 (for detailed quantitative results compare Table 12 of the Appendix).

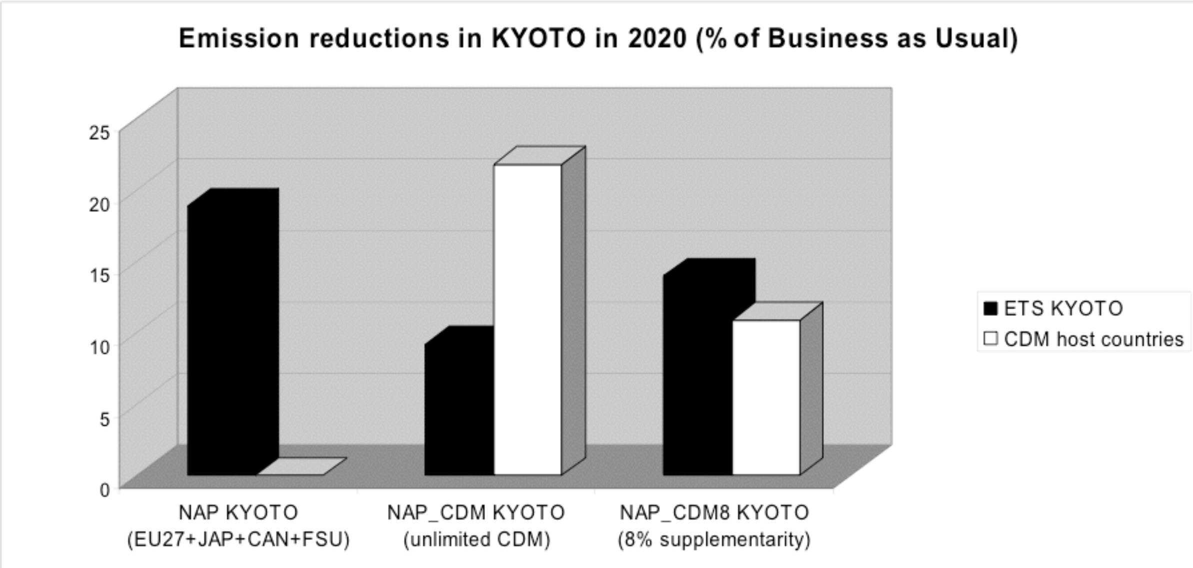
Figure 4: ***Total compliance costs for region KYOTO from linking in 2020 (current allocation)***



We first see that compliance costs in policy scenario *NAP_CDM* are substantially lower than under *NAP*: the allowance of unlimited CER imports causes substantial efficiency gains. The reason are low marginal abatement costs of developing countries which then are able to sell emission permits to industrial countries at a low price, thereby generating revenues on the emission market. This effect is especially relevant for NDIR sectors who previously were highly burdened. Regional governments are able to substitute expensive abatement efforts in these sectors by the imports of CERs. Second, compliance costs in policy scenario *NAP_CDM8* are substantially higher than in *NAP_CDM*. Implementing the supplementarity rule of 8% into an emissions trading scheme induces substantially higher compliance costs. The reason is a restriction of low-cost abatement from developing countries.

Looking at the emission aspects of these scenarios which are illustrated in Figure 5 (for detailed quantitative results compare Table 13 of the Appendix), we see that given unlimited CDM emission abatement is drastically shifted to CDM regions. However, in the case of restricted CDM usage the major part of emission reductions is – as intended – undertaken within the respective ETS.

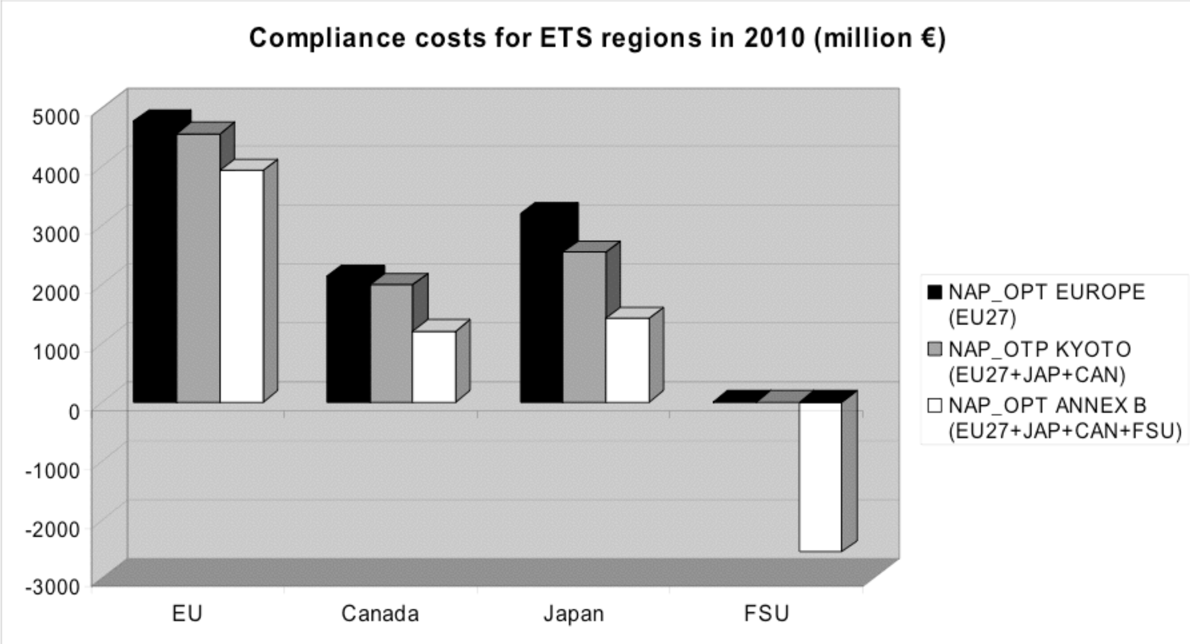
Figure 5: ***Emission reductions in region KYOTO from linking in 2020 (current allocation)***



5.1.3 Effects of linking ETS for all participants

In the following, we describe the impacts of linking ETS on all linking participants, focusing on optimal emission allocation within all ETS and – for transparency – abstracting from the CDM. In order to show the full set of regional scenarios, results for both 2010 and 2020 are presented. Simulation results for the year 2010 are illustrated in Figure 6 (for detailed quantitative results compare Table 10 of the Appendix).

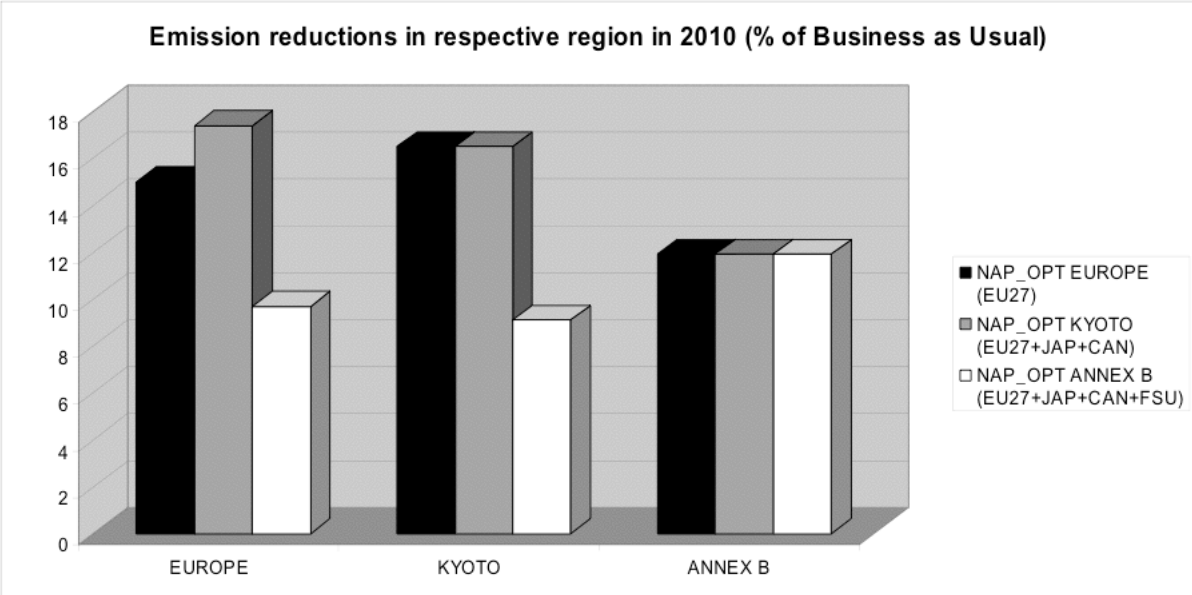
Figure 6: ***Total compliance costs for ETS regions from linking in 2010 (optimal allocation)***



It is shown that – given an optimal emission allocation – all participants benefit strongly from linking ETS. In 2010 the decrease in overall compliance costs is most substantial moving from regional scenario *KYOTO* to *ANNEX B*. Responsible for this beneficial result is linking the European ETS with the Former Soviet Union. Linking other regions to the European ETS also lowers overall compliance costs but is less beneficial than in the case of the Former Soviet Union.

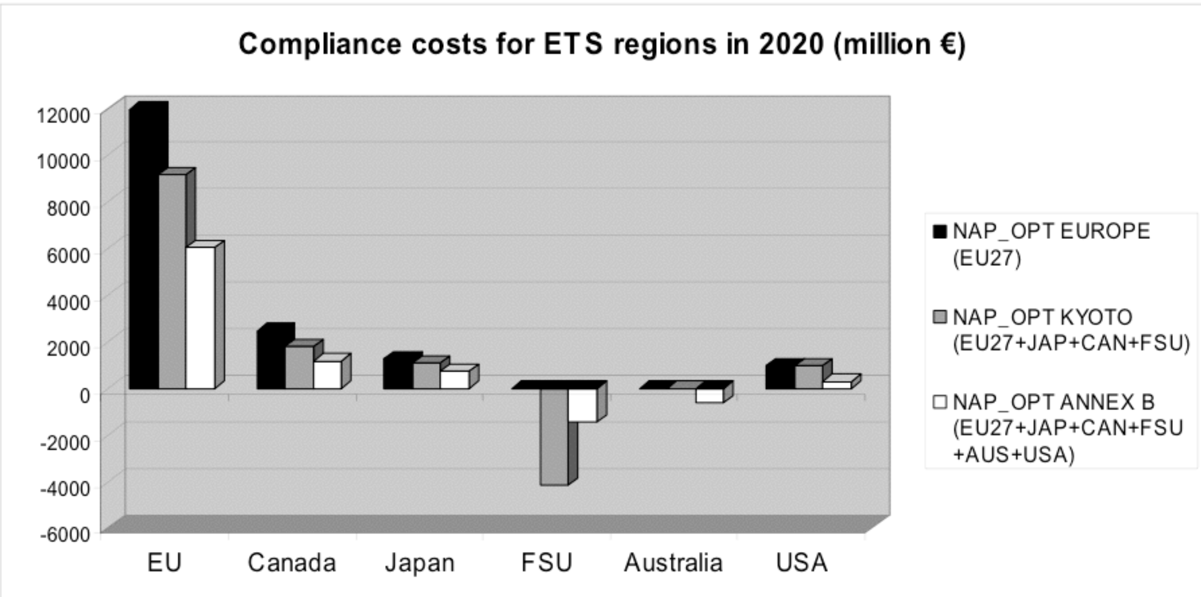
Note again that this result is independent of the supply of potential excess permits from the Former Soviet Union. Although we abstract from "Hot Air", the Former Soviet Union has negative costs (i.e. revenues) from the linking process net of "Hot Air", which result merely from its relatively cheap abatement options and sold permits. At the same time however, emission abatement in the respective ETS is drastically lowered, as can be seen in Figure 7 which shows abatement of the three linked ETS regions in 2010 (for detailed quantitative results compare Table 11 of the Appendix).

Figure 7: ***Emission reductions in respective region from linking in 2010 (optimal allocation)***



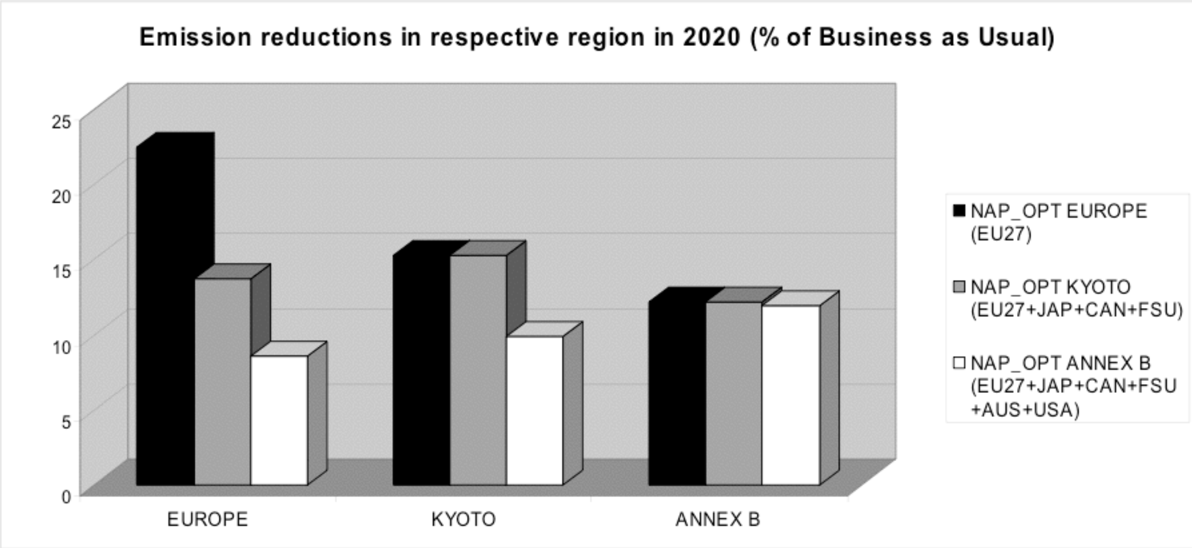
Simulated economic effects for the year 2020 are illustrated in Figure 8 (for detailed quantitative results compare Table 12 of the Appendix).

Figure 8: ***Total compliance costs for ETS regions from linking in 2020 (optimal allocation)***



Again it shows that for an optimal emission allocation all participants benefit from linking ETS. In 2020 however, the decrease in overall compliance costs is most substantial moving from regional scenario *EUROPE* to *KYOTO*. Also in this period this result is to be explained by linking of the European ETS with the Former Soviet Union. For simulation results of the emission effects in 2020 see Figure 9 (for detailed quantitative results compare Table 13 of the Appendix).

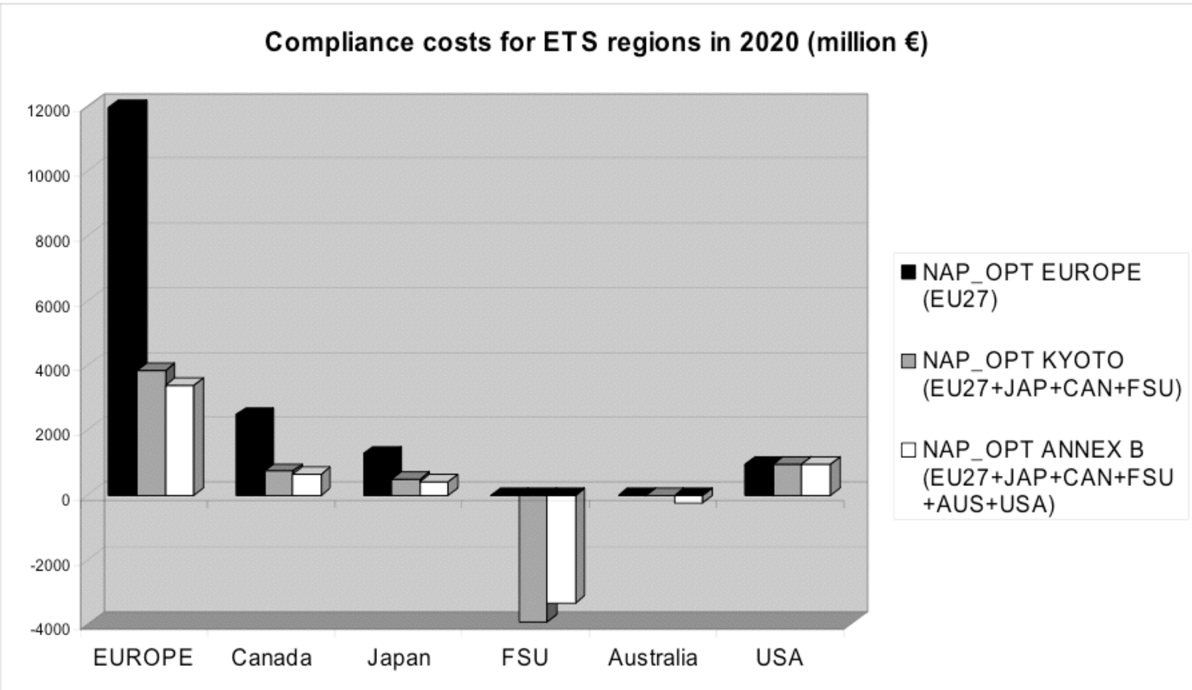
Figure 9: ***Emission reductions in respective region from linking in 2020 (optimal allocation)***



5.1.4 The case of "Hot Air" in the context of linking ETS

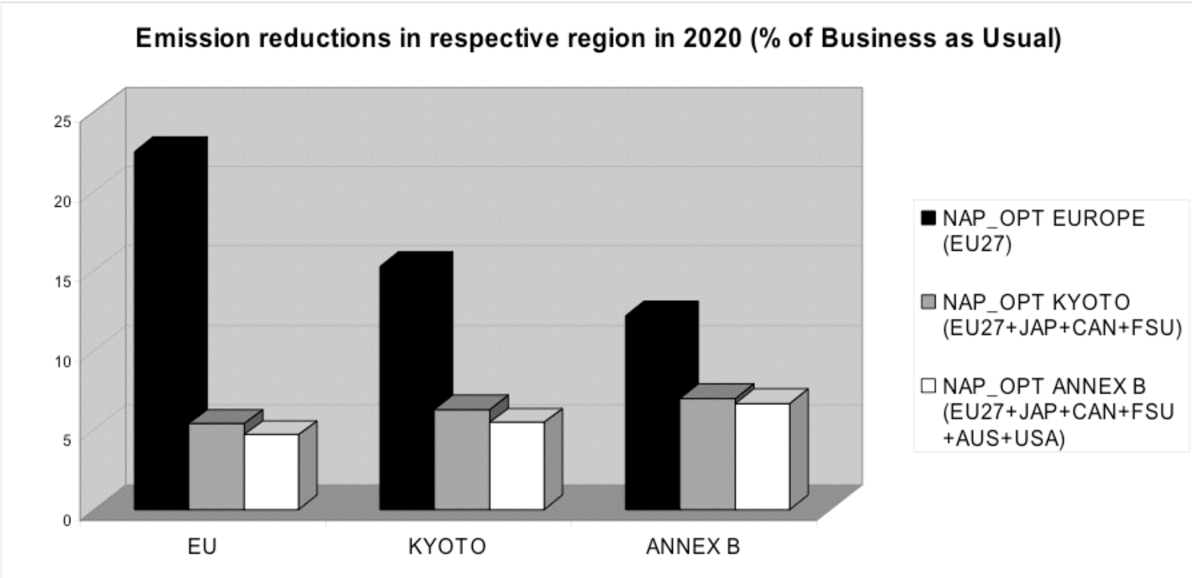
In this section we account for "Hot Air" from the Former Soviet Union in order to analyze the economic implications of a climate policy regime where excess emission permits of governments are allocated for free to the respective national *installations*. Simulation results are illustrated in Figure 10 for detailed quantitative results compare Table 16 of the Appendix).

Figure 10: ***Total compliance costs for ETS regions from linking in 2020 (optimal allocation), accounting for "Hot Air" from FSU***



We see that the above stated beneficial economic effects of linking ETS are robust with respect to the case of "Hot Air" by the Former Soviet Union, but are even more pronounced. Installations from this region are now able to also sell *excess* permits at a positive price, which lowers marginal and overall abatements costs for participants of linked ETS. Concerning emission effects, now even less emission abatement is undertaken within the linked regions – abatement is "consumed" by the "Hot Air" effect. Respective simulation results are illustrated in Figure 11 (for detailed quantitative results compare Table 17 of the Appendix).

Figure 11: ***Emission reductions in respective region from linking in 2020 (optimal allocation), accounting for "Hot Air" from FSU***

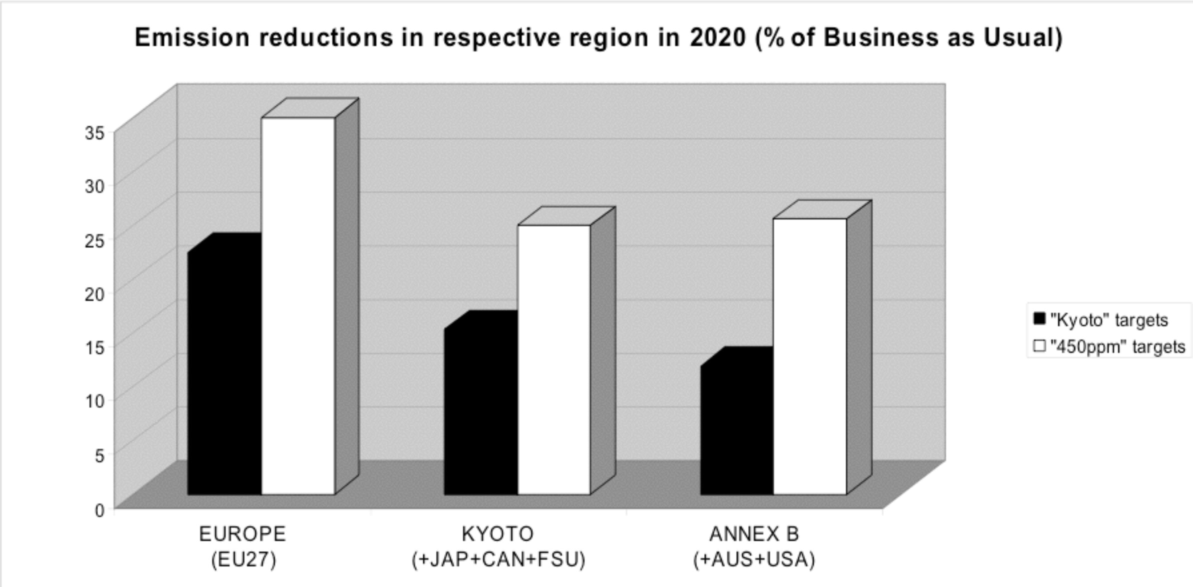


5.2 Linking the EU ETS in the context of "450 ppm" targets

Finally, we analyze the linkage of emissions trading schemes in the context of reduction commitments that relate to a global 450 ppm CO_2 stabilization (see Table 2). This analysis reflects our simulations in section 5.1 with alternative targets. We focus only on the year 2020 here, since the reduction requirements corresponding to "450 ppm" only apply for that year. In our rather compact illustrative analysis, we concentrate on the case without "Hot Air" from the Former Soviet Union and assume optimal allocation and absence of the CDM. Simulation results of emission effects for alternative linked regions are illustrated in Figure 12 (for detailed quantitative results compare Table 19 of the Appendix).[11]

[11] A comprehensive discussion of fairness aspects of linking the European emissions trading system under a long-term stabilization target for CO2 concentrations can be found in Onigkeit et al. (2006).

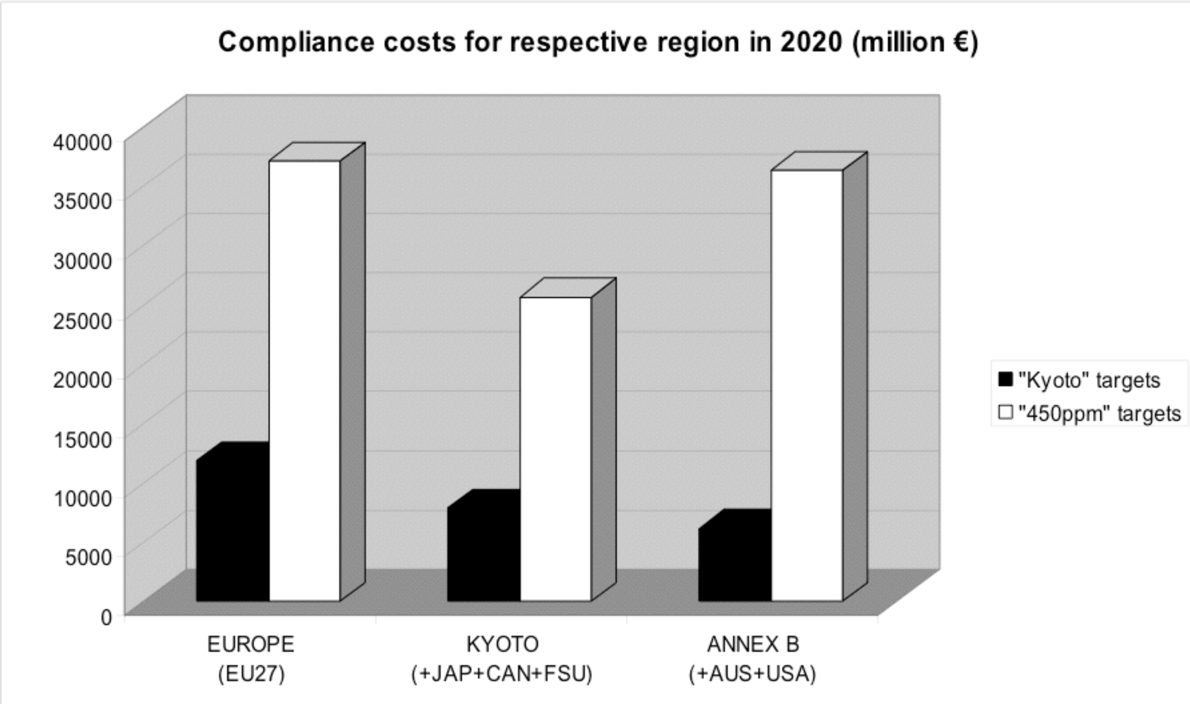
Figure 12: ***Emission reductions in respective region from linking in 2020 (optimal allocation) for "Kyoto" and "450 ppm" targets***



As expected, we find that committing to global reduction targets which are compatible with stabilizing CO_2 concentrations at 450 ppm in 2020 requires much stronger emission abatement vs. Business-as-Usual from each region than committing to the weaker "Kyoto" targets. However, at the same time such a climate policy strategy more than proportionally increases compliance costs for abating regions. Simulation results are illustrated in Figure 13 (for detailed quantitative results compare

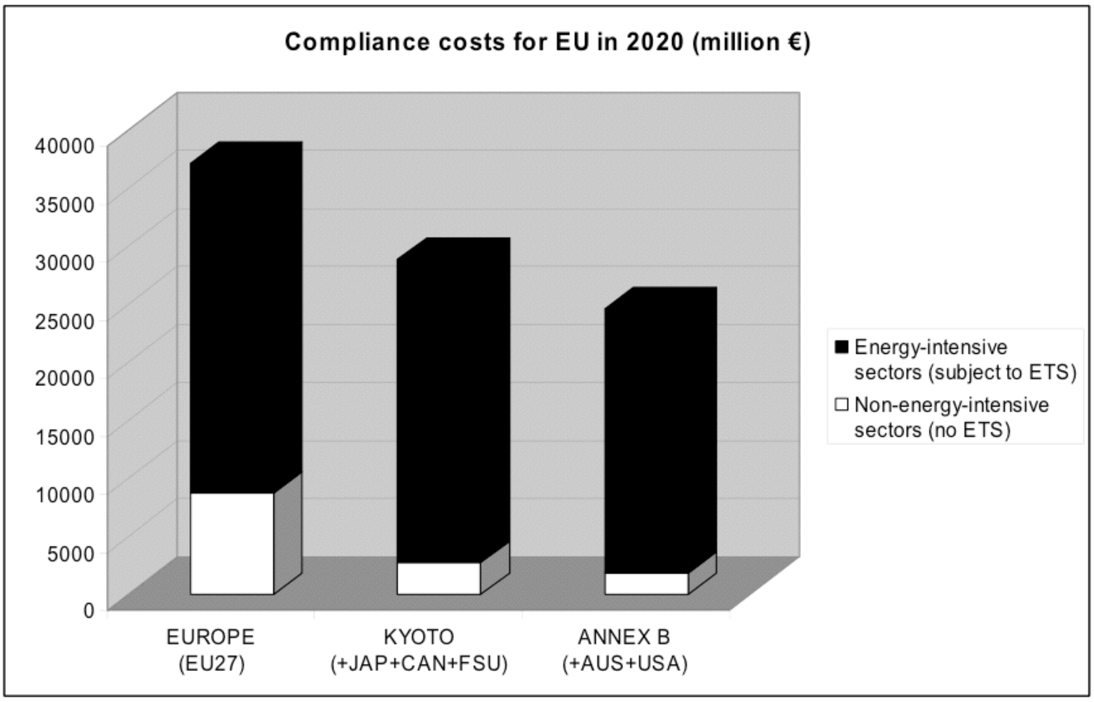
Table 18 of the Appendix). This effect is due to positively sloped marginal abatement cost functions: The higher the emission abatement level is the more expensive abatement becomes at the margin. Comparing compliance costs of regions *KYOTO* and *ANNEX B* under the two environmental scenarios, it shows that while under "Kyoto" targets costs for *ANNEX B* are lower, the region faces higher compliance costs than *KYOTO* under "450 ppm" targets. These reversed effects are due to the relatively heavy tightening of reduction commitments for the linking candidates United States and Pacific OECD implied by "450 ppm" targets as compared to "Kyoto" targets (see again Table 2).

Figure 13: ***Total compliance costs for respective region from linking in 2020 (optimal allocation) for "Kyoto" and "450 ppm" targets***



However, focusing on the economic impacts caused by linking for the EU-27, Figure 14 illustrates that the high compliance costs associated with an ambitious climate policy stabilizing CO_2 concentrations at 450 ppm can be alleviated by linking ETS: Given an efficient domestic allocation of emission entitlements, adjustment costs for the EU are decreased considerably.

Figure 14: ***Compliance costs for EU from linking in 2020 (optimal allocation) for "450 ppm" targets***



6 Partial versus General Equilibrium Analysis

While our fairly transparent approach incorporates explicit marginal abatement cost functions on a regional and sectoral level, the partial equilibrium framework can only provide a restricted description of economic reactions to international climate policy. One potential drawback of partial analysis is the neglect of market interaction and spillover effects (for related studies see Böhringer and Rutherford 2002, Bernard et al. 2003 or Klepper and Peterson 2002). Moreover, terms-of-trade effects on fossil fuel markets induced by carbon abatement policies may substantially alter the direct costs of abatement: A decrease of international fuel prices implies indirect benefits (costs) for fossil fuel importers (exporters). Since most Annex B countries represent fuel importers, for these countries the simulations of our partial equilibrium model might overestimate the level of compliance costs resulting from alternative climate policies. However, these effects generally depend on the extent of global cuts in fossil fuel demand as well as the level of regional fossil fuel supply elasticities and may only be addressed in a multi-market, i.e. general equilibrium framework.

7 Conclusions

This paper assesses the potential linkage of emerging non-European domestic emissions trading schemes (ETS) with the recently established EU ETS. Using a numerical multi-country equilibrium model of the world carbon market based on marginal abatement cost functions, economic and emission effects of alternative linked emissions trading schemes and the usage of the CDM are assessed quantitatively. From the results of our model simulations, we can draw several conclusions.

We find that if designed like the current national allocation plans (NAPs), setting up an emissions trading scheme like the European ETS induces even higher compliance costs than purely domestic action. This effect is due to the currently inefficient emission allocation between sectors, shifting the economic abatement burden to excluded non-energy-intensive industries. An efficient design of NAPs – implying a stricter allocation of emissions to energy-intensive industries – would drastically lower compliance costs compared to the current NAP design, and would be preferable to purely domestic action.

The simulations show that linking the EU ETS to emerging domestic ETS lowers Kyoto compliance costs for the EU, even assuming the current emission allocation – however, the benefits from linking are rather small, as (non-trading) non-energy-intensive industries carry the essential part of the compliance burden. Given an optimal allocation within domestic emissions trading systems, linking ETS causes a much stronger fall in compliance costs for the EU. In this case, also all other participants benefit strongly from linking ETS. Both in 2010 and 2020, the decrease in overall compliance costs is most substantial for linking the EU ETS to Japan, Canada and – most importantly – the Former Soviet Union, even when abstracting from the "Hot Air" effect by assuming that no excess permits will be allocated to the respective national installations. Linking other regions to the European ETS also lowers overall compliance costs but is less beneficial than in the case of the Former Soviet Union. At the same time however, in this case emission abatement in the respective ETS is drastically lowered.

We find that the option of unlimited CDM access substantially lowers compliance costs induced by an inefficient emission allocation within ETS regions by compensating (non-trading) non-energy-intensive industries. This effect is due to low marginal abatement costs of developing countries which then are able to sell emission permits to industrial countries at a low price, generating revenues on the emission market. However, when unlimited usage of the CDM is allowed, emission reduction efforts are substantially shifted from industrial regions (such as the EU) to developing countries. Implementing a supplementarity rule into an emissions trading scheme induces substantially higher compliance costs due to the restriction of low-cost abatement from developing countries, but at the same time shifts less abatement to these regions.

Further simulations show that committing to global reduction targets which are compatible with stabilizing CO_2 concentrations at 450 ppm requires much stronger emission abatement vs. Business-as-Usual than committing to the weaker “Kyoto” targets. At the same time, ceteris paribus these stronger abatement efforts more than proportionally increase compliance costs for abating regions, as the higher the emission abatement level is the more expensive abatement becomes at the margin. Given an efficient emission allocation, the associated compliance costs for the EU can however be substantially alleviated by linking ETS. Finally, the above stated beneficial economic effects of linking ETS are robust with respect to the case of “Hot Air” by the Former Soviet Union – they are even more pronounced.

Potential areas for future research related to the climate policy issues of our analysis include both economic and environmental aspects. From an economic perspective, our partial market approach which assesses the direct economic effects of linked emissions trading systems could be extended by a multi-market approach using a general equilibrium framework. Thereby also macroeconomic impacts of linked emissions trading systems as well as indirect market interaction and spillover effects could be analyzed. From an environmental perspective on alternative emission reduction commitments, our focus on emissions as environmental indicator could be augmented by further assessing CO_2 concentrations or global temperature variations. Such an approach would require an integrated assessment modeling framework.

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9 Appendix A: Analytical Framework

9.1 Algebraic Model Summary

This appendix provides an algebraic summary of the equilibrium conditions for a simple partial equilibrium model designed to investigate the economic implications of emission allocation and emissions trading in a multi-sector, multi-region framework. Emission mitigation options are captured through marginal abatement cost curves that are differentiated by sectors and regions.

Cast as a planning problem, our model corresponds to a nonlinear program that seeks a cost-minimizing abatement scheme subject to initial emission allocation and institutional restrictions for emissions trading between sectors and regions. The nonlinear optimization problem can be interpreted as a market equilibrium problem where prices and quantities are defined using duality theory. In this case, a system of (weak) inequalities and complementary slackness conditions replace the minimization operator yielding a so-called mixed complementarity problem (see e.g. Rutherford (1995)).[12]

Two classes of conditions characterize the (competitive) equilibrium for our model: zero profit conditions and market clearance conditions. The former class determines activity levels (quantities) and the latter determines prices. The economic equilibrium features complementarity between equilibrium variables and equilibrium conditions: activities will be operated as long as they break even, positive market prices imply market clearance – otherwise commodities are in excess supply and the respective prices fall to zero.[13]

Numerically, the algebraic MCP formulation of our model is implemented in GAMS (Brooke, Kendrick and Meeraus (1987)) using PATH (Dirkse and Ferris (1995)) as a solver. Below, we present the GAMS code to replicate the results reported in the paper. The GAMS file and the EXCEL reporting sheet can be downloaded from the web-site (http://brw.zew.de/simac/).

[12] The MCP formulation provides a general format for economic equilibrium problems that may not be easily studied in an optimization context. Only if the complementarity problem is "integrable" (see Takayma and Judge (1971)), the solution corresponds to the first-order conditions for a (primal or dual) programming problem. Taxes, income effects, spillovers and other externalities, however, interfere with the skew symmetry property which characterizes first order conditions for nonlinear programs.

[13] In this context, the term „*mixed complementarity problem*" (MCP) is straightforward: „*mixed*" indicates that the mathematical formulation is based on weak inequalities that may include a mixture of equalities and inequalities; „*complementarity*" refers to complementary slackness between system variables and system conditions.

In our algebraic exposition of equilibrium conditions, we use *i* as an index for sectors and *r* as an index for regions.[14] Table 8 explains the notations for variables and parameters.

Table 8*: Variables and parameters*

	Variables: Activity levels
D_{ir}	Emission abatement by sector *i* in region *r*
MD_{ir}	Imports of emission permits by sector *i* in region *r* from domestic market
XD_{ir}	Exports of emission permits by sector *i* in region *r* to domestic market
M_{ir}	Imports of emission permits by sector *i* in region *r* from international market
X_{ir}	Exports of emission permits by sector *i* in region *r* to international market
$MCDM_{ir}$	Imports of Certified Emission Reductions by sector *i* in region *r* from CDM world market
$XCDM_{ir}$	Exports of Certified Emission Reductions by sector *i* in region *r* to CDM world market
	Variables: Price levels
P_{ir}	Marginal abatement cost by sector *i* in region *r*
PD_r	Price of domestically tradable permits in region *r*
PFX	Price of internationally tradable permits
$PCDM$	Price of Certified Emission Reductions from CDM world market
	Parameters
$target_{ir}$	Effective carbon emission reduction requirement for sector *i* in region *r*
$a_{1,ir}, a_{2,ir}, a_{3,ir}$	Coefficients of marginal abatement cost function for sector *i* in region *r*

Zero Profit Conditions

1. Abatement by sector *i* in region *r* ($\perp D_{ir}$):

$$a_{1,ir} \cdot D_{ir} + a_{2,ir} \cdot D_{ir}^2 + a_{3,ir} \cdot D_{ir}^3 \geq P_{ir}$$

2. Permit imports by sector *i* in region *r* from domestic market ($\perp MD_{ir}$)

$$PD_r \geq P_{ir}$$

[14] The variable associated with each equilibrium condition is added in brackets and denoted with an orthogonality symbol ($\perp$).

3. Permit exports by sector i in region r to domestic market ($\perp XD_{ir}$)

$$P_{ir} \geq PD_r$$

4. Permit imports by sector i in region r from international market ($\perp M_{ir}$)

$$PFX \geq P_{ir}$$

5. Permit exports by sector i in region r to international market ($\perp X_{ir}$)

$$P_{ir} \geq PFX$$

6. CER imports by sector i in region r from CDM world market ($\perp MCDM_{ir}$)

$$PCDM \geq P_{ir}$$

7. CER exports by sector i in region r to CDM world market ($\perp XCDM_{ir}$)

$$P_{ir} \geq PCDM$$

Market Clearance Conditions

8. Market clearance for abatement by sector i in region r ($\perp P_{ir}$):

$$D_{ir} + M_{ir} + MD_{ir} + MCDM_{ir} \geq \text{target}_{ir} + X_{ir} + XD_{ir} + XCDM_{ir}$$

9. Market clearance for domestically tradable permits ($\perp PD_r$)

$$\sum_i XD_{ir} \geq \sum_i MD_{ir}$$

10. Market clearance for internationally tradable permits ($\perp PFX$)

$$\sum_i X_{ir} \geq \sum_i M_{ir}$$

11. Market clearance for Certified Emission Reductions ($\perp PCDM$)

$$\sum_i XCDM_{ir} \geq \sum_i MCDM_{ir}$$

9.2 Analytical basis of future "Kyoto" emission targets

This section provides an analytical background for "Kyoto targets" as emission reduction commitments assumed in the model simulations. In general, the "Kyoto" targets of modeled regions were calculated based on

- historical emission data as reported to the UNFCCC (1990 or base year levels)
- targets included in Annex B to the Protocol and the EU burden sharing agreement
- assumptions on future "political willingness" indicated by already adopted mid- and long-term emission targets within the European Union

9.2.1 Calculating emission targets for 2010

The emission targets assigned to modelled regions for the year 2010 are listed in Table 9. The underlying assumptions are the following:

- All industrialized countries that have ratified the Kyoto Protocol comply with their quantified emission limitation and reduction commitments as outlined in Annex B to the Protocol and in the EU burden sharing agreement, respectively.
- The target for the United States – as a non-ratifier – is calculated on the basis of its national intensity target to reduce greenhouse gas intensity by 18 percent by 2012 (White House 2002) assuming GDP growth figures of the IMAGE-B2 scenario.
- For Australia (included in region "Pacific OECD without Japan"), compliance with its Annex B Kyoto target is assumed as the Australian government repeatedly emphasized that it aims at fulfilling its Kyoto commitment despite non-ratification of the Protocol (Australia 2002).
- Up to now, developing (non-Annex I) countries do not have any quantified mitigation commitments under the Kyoto Protocol. Therefore, a "business-as-usual" emission path according to the IMAGE-B2 scenario is assumed.

Table 9: ***Emission reduction requirements of modeled regions (% versus 1990 levels)***

Regions	2010	2020
Austria	13	19.7
Belgium	7.5	14.7
Denmark	21	27.1
Spain	-15	-6.1
Finland	0	7.7
France	0	7.7
United Kingdom	12.5	19.3
Greece	-25	-15.3
Ireland	-13	-4.3
Italy	6.5	13.7
Netherlands	6	13.3
Portugal	-27	-17.2
Germany	21	27.1
Sweden	-4	4.0
Central Europe[1]	7	14.2
United States	-27.3	-23.8
Canada	6	8.6
Japan	6	8.6
Pacific OECD without Japan[2]	-7	-4.1
Former Soviet Union[3]	0	2.7
Brazil	BAU	BAU
China	BAU	BAU
South Korea	BAU	BAU
Mexico	BAU	BAU
India	BAU	BAU

Source: Own calculation based on data from UNFCCC (2004).

1: Calculations included Eastern European EU-25 member states as well as applicant countries (apart from Croatia due to a lack of data).

2: Calculations only considered Australia and New Zealand that represent almost all emissions from this group (> 97 % in 2000).

3: Calculations only considered the Russian Federation and Ukraine.

9.2.2 Calculating emission targets for 2020

To define reduction targets for 2020 the modeled countries/regions were divided into three groups: EU-27 member states (incl. applicant countries15), other industrialized countries, and developing countries. The differentiation between EU and non-EU industrialized countries is based on the assumption of their "political willingness": on the one hand, the European Union

[15] Turkey was not considered as it is not included in the SIMAC model.

which repeatedly announced its willingness to demonstrate leadership in climate change mitigation policy and, on the other hand, countries like the U.S., Australia and Japan that act rather "cautious" in debates on post-2012 reduction targets. Finally, developing (non-Annex B) countries formed a separate group in the Climate Convention and the Kyoto Protocol and are assumed to be treated differently in the mid-term future. Within these groups the same approach for calculating emission targets was used.

EU-27 member countries

At its spring session in March 2005, the Council of the European Union concluded that "reduction targets for the group of developed countries in the order of 15-30% by 2020, compared to the baseline envisaged in the Kyoto Protocol (…) should be considered" (Council of the European Union 2005). Bearing this decision in mind it is reasonable to assume that the European Union will aim at a reduction of 15 percent by the year 2020 compared to its Kyoto baseline emissions. It is further assumed that all EU member states have to contribute the same (relative) proportion towards achieving this mid-term goal. However, considering fairness aspects the base year was changed to 2010, thereby taking into account the different treatment of countries within the EU burden sharing agreement (and the Kyoto-Protocol targets for non-EU-15 countries). Each EU-27 country is assumed to reduce its 2010 emissions by 7.7 percent so that the European Union as a whole would achieve its minus 15 percent target (compared to Kyoto baseline). This approach maintains to a certain extent the 2010 differentiation of targets resulting in 2020 emission targets that range from reduction in the order of 27 percent (Denmark, Germany) to increases of about 15-17 percent (Greece, Portugal) compared to Kyoto baseline levels (*see* Table 9).

Non-EU industrialized countries

For industrialized countries that are not member of the EU (or applicant countries) a similar approach is being used. This means that countries within this group are assumed to reduce their emissions by the same percentage compared to 2010 and 2020 emission levels, respectively. The rate of reduction is derived from the respective EU figures minus 5 percentage points, i.e. by 2020, emission targets are 2.7 percent below 2010 levels. Applying this approach results in slightly less ambitious targets than those of economically comparable EU countries, although the resulting targets are still within the broad range of EU targets. This is valid for all non-EU industrialized countries apart from the U.S..

Developing countries

As in the first commitment period, developing countries are not assumed to take on any quantitative mitigation commitment by 2020 but to follow a "business-as-usual" emission path according to the IMAGE-B2 scenario.

9.2.3 Conclusions

Based on these "political willingness" assumptions future emission targets of modeled regions cover a broad range, thereby continuing the Kyoto path – apart from U.S. targets which reflect the status as a non-ratifying country and the corresponding lacking action in implementing mitigation policies. It should be emphasized that these targets are not in line with mitigation efforts most probably required to meet the objective of the Climate Convention to "prevent dangerous anthropogenic interference with the climate system" (den Elzen and Meinshausen 2005). Moreover, the calculated emission targets are quite moderate even if compared to "political willingness scenarios" in other assessments (e.g. den Elzen 2005; Höhne and Ullrich 2005) due to rather conservative assumptions.

9.3 Quantitative simulation results

The following tables show our quantitative simulation results for the years 2010 and 2020, for alternative global emission reduction targets as well as for the cases with and without "Hot Air".

Table 10*: Simulation results for "Kyoto" targets (no Hot Air) – Total compliance costs of alternative scenarios in 2010 (million €2002)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM8 ANNEX B
Austria	1796.3	259	312.6	152.2	39352.6	120.9	22808.9	39354.9	122.7	22810.9	39348.1	115.9	22804.1
Belgium	454.6	331.6	377.4	215.2	4325.5	190.4	2136.1	4324.6	188.7	2134.3	4324.8	188.9	2134.5
Denmark	517.5	234.2	282	135.3	2038.8	89.6	863.7	2045.9	96.4	870.4	2027.6	78.1	852.1
Spain	1431.7	949.1	1090.4	606.7	10457.9	483.2	5496.6	10471.4	494.9	5507.9	10430.8	454.3	5467.3
Finland	44.2	38.1	25.3	42.5	113.6	38.4	36	114.9	39.6	36.7	109.9	34.6	31.7
France	157.1	121.7	54.1	152.8	155.1	126.3	117.6	162.1	133.1	123.2	140.4	111.4	101.5
United Kingdom	1039.9	1005.5	1039.9	758	4494.1	707.7	2637.6	4489.7	700.5	2629.5	4486.2	697	2626
Greece	16	15.8	13.1	13.7	27.5	27.5	27.5	34.6	34.6	34.6	16.4	16.4	16.4
Ireland	56	39.9	18.7	55.9	913.1	70.2	440.1	910.1	66.9	436.8	914	70.8	440.7
Italy	3042.9	1363.4	1611.7	830	64123.4	723.4	29358.4	64119.3	716.1	29350.8	64124.3	721.1	29355.8
Netherlands	848.1	588.8	674.2	374.2	5227.9	319.7	3397.4	5229	319.5	3397.3	5223.3	313.8	3391.6
Portugal	985.9	199.4	246	111.4	2406	81.7	607.9	2409.1	84.5	610.4	2401	76.4	602.3
Germany	1736.9	1619.8	1721.3	1157.5	6827.8	986.3	3087.8	6842.4	997.2	3096.1	6789.5	944.3	3043.2
Sweden	0	-70.7	-106	-22.4	-0.5	-0.5	-0.5	-0.8	-0.8	-0.8	-0.2	-0.2	-0.2
Central Europe	0	-1923.2	-2810.9	-656.9	-117.3	-117.3	-117.3	-182.2	-182.2	-182.2	-42.8	-42.8	-42.8
United States	0	0	0	0	0	0	0	0	0	0	0	0	0
Canada	2138	2138	1985.1	1205.4	2138	1034.5	1381	6157.7	1033.6	4137.6	6128.2	1004.1	4108.1
Japan	3196.6	3196.6	2536	1418.8	3196.6	1209	1191.2	113054.4	1139.5	19125.7	112939.4	1024.5	19010.7
Pacifc OECD (without Japan)	0	0	0	0	0	0	0	0	0	0	0	0	0
Former Soviet Union	0	0	0	-2545.2	0	0	0	0	0	0	-163.5	-163.5	-163.5
Brazil	0	0	0	0	0	-90.7	-21	0	-87.9	-13.5	0	-87.9	-13.5
China	0	0	0	0	0	-3918.6	-1374	0	-3840.9	-994	0	-3840.9	-994
South Corea	0	0	0	0	0	-42.2	-15.4	0	-41.3	-11.6	0	-41.3	-11.6
Mexico	0	0	0	0	0	-34.7	-10.2	0	-33.9	-6.8	0	-33.9	-6.8
India	0	0	0	0	0	-508.9	-155.2	0	-497.8	-103.6	0	-497.8	-103.6
EUROPE	12127.1	4772.4	4549.8	3926.1	140345.5	3847.5	70897.8	140325	3811.7	70855.9	140293.3	3780	70824.2
KYOTO	17461.7	10107	9070.9	6550.3	145680.1	6091	73470	259537.1	5984.8	94119.2	259360.9	5808.6	93943
ANNEX B	17461.7	10107	9070.9	4005.1	145680.1	6091	73470	259537.1	5984.8	94119.2	259197.4	5645.1	93779.5

Table 11*: Simulation results for "Kyoto" targets (no Hot Air) – Emission reduction of alternative scenarios in 2010 (% of BaU emissions)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM8 ANNEX B
Austria	27.7	8.3	9.3	5.5	24.2	1.6	19.7	24.7	1.6	19.7	23.2	1.4	19.6
Belgium	23.1	13.7	15.9	9	23.4	3	17.2	24.1	3	17.2	22.2	2.6	17.1
Denmark	29.1	6.9	9.2	3.3	16.5	0.7	12.2	16.8	0.7	12.2	16.1	0.6	12.2
Spain	25.4	13.8	16	8.8	20.9	2.4	14.4	21.9	2.4	14.4	19.4	2.1	14.3
Finland	13.2	16.8	19.2	11.1	10.6	2.8	2.2	11.9	2.8	2.3	8.6	2.5	2.1
France	7.5	10.4	12.4	6.4	5.6	1.7	1.7	6.1	1.7	1.7	4.9	1.5	1.6
United Kingdom	20.2	17.6	20.1	11.9	20.3	3.6	13	21.4	3.6	13.1	18.4	3.2	12.9
Greece	2.2	2.5	3.1	1.3	0.3	0.1	0.1	0.3	0.1	0.1	0.2	0.1	0.1
Ireland	27.4	36.4	40.2	26.7	31.7	5.8	17.4	35.5	5.8	17.5	25.7	5	17.2
Italy	22.1	9.1	10.5	5.9	22.7	1.7	16.9	23.2	1.7	17	21.8	1.5	16.9
Netherlands	26	13.6	16.3	7.6	25.1	1.7	19.1	25.8	1.7	19.1	23.9	1.5	19
Portugal	17.4	1.8	2.3	1	13.2	0.2	8.3	13.3	0.2	8.3	13.2	0.2	8.3
Germany	18.1	14.3	16.8	8.9	16.2	2.4	10.1	17	2.4	10.1	15	2.2	10
Sweden	0	13	15.2	7.8	0.4	0.2	0.1	0.5	0.2	0.1	0.3	0.2	0.1
Central Europe	0	22.9	26.1	15.2	6.5	3.8	1.7	7.8	3.8	1.7	4.1	3.4	1.6
United States	0	0	0	0	0	0	0	0	0	0	0	0	0
Canada	26.7	26.7	20.9	10.6	26.7	2.6	20	26	2.6	19.4	23.9	2.3	19.3
Japan	16.5	16.5	10.7	5.9	16.5	1.8	7.9	13.6	1.8	6.9	12	1.6	6.8
Pacifc OECD (without Japan)	0	0	0	0	0	0	0	0	0	0	0	0	0
Former Soviet Union	0	0	0	19.2	0	0	0	0	0	0	5.6	4.7	2.1
Brazil	0	0	0	0	0	2.8	0.9	0	2.8	0.9	0	2.3	0.8
China	0	0	0	0	0	15.6	7.1	0	15.6	7.3	0	14	6.5
South Corea	0	0	0	0	0	1.4	0.6	0	1.4	0.6	0	1.2	0.6
Mexico	0	0	0	0	0	2.1	0.9	0	2.1	0.9	0	1.8	0.8
India	0	0	0	0	0	6	2.6	0	6	2.7	0	5.3	2.4
EUROPE	15	15	17.4	9.7	15.1	2.6	9.5	16	2.6	9.5	13.6	2.3	9.4
KYOTO	16.5	16.5	16.5	9.1	16.5	2.4	10.2	16.5	2.4	10	14.4	2.2	9.9
ANNEX B	11.9	11.9	11.9	11.9	11.9	1.8	7.4	11.9	1.8	7.2	11.9	2.9	7.7

Table 12*: Simulation results for "Kyoto" targets (no Hot Air) – Total compliance costs of alternative scenarios in 2020 (million €2002)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM8 ANNEX B
Austria	2125.1	533.4	275.4	157.7	2119.5	176.6	1642.8	2093	161.5	1637	2087.5	156	1635.4
Belgium	476.5	475.9	370.9	240.3	1792.5	264.6	1184.8	1796.4	247.8	1181.6	1792.8	244.2	1179.9
Denmark	480.2	385.6	221.3	129.2	4453.2	144.4	1966	4414.7	130.1	1957.2	4406.3	121.7	1954.8
Spain	2404.4	1821.9	1078.4	652.1	11352	723.9	6889.2	11258.5	665	6863.6	11233.4	639.9	6855.5
Finland	123.8	117.3	108.9	76.9	438.2	83.3	87.9	429	77.5	84.3	425.2	73.7	82.9
France	600.5	533.7	541	378.4	1107.3	411.4	620.6	1090.4	385.5	609.9	1078.9	374	605.2
United Kingdom	2375.9	2296.3	1586.2	1022.2	8110.3	1123.2	5241.7	8103.7	1052.2	5226.6	8086.9	1035.4	5219.1
Greece	151.1	63.2	147.7	108	213.9	117.1	104.2	194.1	107.7	97.2	186.7	100.3	94.6
Ireland	109.1	81.3	104.5	78	766.5	83.9	468.9	785.8	81.4	470.9	787.3	82.9	471
Italy	5697.8	2894.5	1587.8	933.8	54330.8	1041.1	29120.7	54258.7	962.2	29100.8	54238.4	941.9	29092.9
Netherlands	1281.3	1033.6	629.1	383.9	13681.2	425.8	7731.2	13674.2	396.3	7725.5	13668.1	390.2	7722.9
Portugal	1161.6	467.5	233.2	130.8	2101	147	751.3	2062.6	132.4	743.3	2055	124.8	741
Germany	3523	3440.3	2394.2	1536.1	14190.6	1689.7	7600.5	14117.7	1574.9	7565.3	14080.5	1537.7	7550.4
Sweden	46.1	13.8	46.2	36.5	70.4	53.4	47.7	47.3	47.3	43.1	41.6	41.6	41.6
Central Europe	215.4	-2214.1	-170.3	184.6	483.8	486.9	450.2	464.2	464.2	443	434.7	434.7	434.7
United States	956.1	956.1	956.1	300.3	956.1	956.1	956.1	956.1	956.1	956.1	1723.7	1723.7	1723.7
Canada	2476.8	2476.8	1806.9	1170.5	2476.8	1286.1	1728.5	4977.5	1206.1	3537.9	4961	1189.6	3530.3
Japan	1277.8	1277.8	1085.7	741.5	1277.8	808.2	706.9	819.6	729.5	664.6	750.4	660.3	644.9
Pacifc OECD (without Japan)	0	0	0	-628.2	0	0	0	0	0	0	-194.9	-194.9	-194.9
Former Soviet Union	0	0	-4161.1	-1441.6	0	0	0	-964.5	-964.5	-785.9	-728.6	-728.6	-728.6
Brazil	0	0	0	0	0	-79.1	-26	0	-54.5	-11.1	0	-54.5	-7.1
China	0	0	0	0	0	-4765.5	-1964.1	0	-3560.9	-1004.9	0	-3560.9	-732.9
South Corea	0	0	0	0	0	-153.7	-63	0	-113.8	-33.8	0	-113.8	-25.6
Mexico	0	0	0	0	0	-67.7	-25.2	0	-49.1	-11.2	0	-49.1	-7.3
India	0	0	0	0	0	-962.7	-350.9	0	-692.6	-155.1	0	-692.6	-100.9
EUROPE	20771.8	11944.2	9154.5	6048.5	115211.2	6972.3	63907.7	114790.3	6486	63749.3	114603.3	6299	63681.9
KYOTO	24526.4	15698.8	7886	6518.9	118965.8	9066.6	66343.1	119622.9	7457.1	67165.9	119586.1	7420.3	67128.5
ANNEX B	25482.5	16654.9	8842.1	6191	119921.9	10022.7	67299.2	120579	8413.2	68122	121114.9	8949.1	68657.3

Table 13*: Simulation results for "Kyoto" targets (no Hot Air) – Emission reduction of alternative scenarios in 2020 (% of BaU emissions)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM8 ANNEX B
Austria	33.9	9.8	5.6	3.3	26.9	1.5	23.5	25.8	1.3	22.6	25.5	1.5	22.8
Belgium	29.7	30.5	16.7	9	33	3.8	24.3	27.5	3.4	20	26.4	4	21
Denmark	35.1	20.4	8.4	4.3	23	1.8	16.9	19.9	1.6	14.6	19.3	1.9	15.2
Spain	31.6	19.6	11.3	6.7	27.7	3.1	21.1	24.1	2.8	17.7	23.3	3.2	18.6
Finland	22	25.1	16.3	10.6	21.4	5	12.6	16.7	4.5	7	15.5	5.3	8.7
France	16.5	20.5	12.1	7.4	17.2	3.4	11.9	14	3.1	8.8	13.4	3.6	9.7
United Kingdom	27.9	24.4	15.2	9.8	29.6	4.8	22.8	25.7	4.4	18.6	24.8	5	19.8
Greece	18.9	32.4	16	8.6	18.2	3.6	8.2	12.1	3.3	3.4	11	3.8	4.6
Ireland	33.7	44.4	28.6	19	45.3	9.7	34.8	37.8	8.9	26.1	36	10.1	28.7
Italy	29.1	13.3	7.7	4.7	27.3	2.2	21.6	25.1	2	19.6	24.7	2.3	20.2
Netherlands	32.3	21.5	12.3	7	33.6	3	26.2	29.3	2.7	22.4	28.5	3.1	23.4
Portugal	25.3	4.7	2.1	1.1	15.4	0.5	10.7	14.9	0.4	10.3	14.8	0.5	10.4
Germany	26.6	23.7	14.2	8.9	27	4.3	20.1	23.2	3.9	16.2	22.3	4.5	17.3
Sweden	11.2	17.9	10.9	5.8	7.2	1.4	3.9	3.7	1.3	1.4	3.1	1.5	2
Central Europe	8.6	25.7	16.9	11.2	12.6	4.8	9.1	8.8	4.4	4.7	7.9	5	6
United States	8.4	8.4	8.4	14.3	8.4	8.4	8.4	8.4	8.4	8.4	10.7	6.7	8.1
Canada	31.1	31.1	17.4	10.7	31.1	5.1	24.7	28.9	4.7	21.8	28	5.4	23
Japan	12.4	12.4	8.5	5.4	12.4	2.8	5.6	6.3	2.5	2.4	5.7	2.9	3.1
Pacifc OECD (without Japan)	0	0	0	17.8	0	0	0	0	0	0	12.8	8.6	10.1
Former Soviet Union	0	0	20.5	13.9	0	0	0	9.5	4.6	4.9	8.5	5.3	6.4
Brazil	0	0	0	0	0	1.8	0.6	0	1.6	0.8	0	1.9	0.8
China	0	0	0	0	0	15	5.1	0	13.8	6.4	0	15.6	6.4
South Corea	0	0	0	0	0	3.9	1.2	0	3.5	1.5	0	4	1.5
Mexico	0	0	0	0	0	2.7	0.9	0	2.5	1.1	0	2.8	1.1
India	0	0	0	0	0	7.2	2.2	0	6.5	2.8	0	7.5	2.8
EUROPE	22.5	22.5	13.7	8.6	23.1	3.9	17.3	19.5	3.6	13.5	18.7	4.1	14.6
KYOTO	15.3	15.3	15.3	9.9	15.7	2.7	11.4	15.7	3.8	10.3	14.8	4.4	11.4
ANNEX B	12.2	12.2	12.2	11.9	12.3	4.9	9.9	12.3	5.6	9.3	13.1	5.4	10

Table 14*: Simulation results for "Kyoto" targets (Hot Air) – Total compliance costs of alternative scenarios in 2010 (million €2002)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM8 ANNEX B
Austria	1796.3	167.9	239.2	0	39352.6	120.9	22808.9	39354.9	122.7	22810.9	39348.1	115.9	22804.1
Belgium	454.6	234.3	312.4	0	4325.5	190.4	2136.1	4324.6	188.7	2134.3	4324.8	188.9	2134.5
Denmark	517.5	149.8	216	0	2038.8	89.6	863.7	2045.9	96.4	870.4	2027.6	78.1	852.1
Spain	1431.7	661.9	891.3	0	10457.9	483.2	5496.6	10471.4	494.9	5507.9	10430.8	454.3	5467.3
Finland	44.2	43.7	41	0	113.6	38.4	36	114.9	39.6	36.7	109.9	34.6	31.7
France	157.1	156.2	137.5	0	155.1	126.3	117.6	162.1	133.1	123.2	140.4	111.4	101.5
United Kingdom	1039.9	809	977.3	0	4494.1	707.7	2637.6	4489.7	700.5	2629.5	4486.2	697	2626
Greece	16	14.5	16	0	27.5	27.5	27.5	34.6	34.6	34.6	16.4	16.4	16.4
Ireland	56	55.9	45.6	0	913.1	70.2	440.1	910.1	66.9	436.8	914	70.8	440.7
Italy	3042.9	911.4	1267.8	0	64123.4	723.4	29358.4	64119.3	716.1	29350.8	64124.3	721.1	29355.8
Netherlands	848.1	409.2	553.1	0	5227.9	319.7	3397.4	5229	319.5	3397.3	5223.3	313.8	3391.6
Portugal	985.9	123.9	182.5	0	2406	81.7	607.9	2409.1	84.5	610.4	2401	76.4	602.3
Germany	1736.9	1245.7	1558.9	0	6827.8	986.3	3087.8	6842.4	997.2	3096.1	6789.5	944.3	3043.2
Sweden	0	-27.7	-59.5	0	-0.5	-0.5	-0.5	-0.8	-0.8	-0.8	-0.2	-0.2	-0.2
Central Europe	0	-2807.1	-4640.7	0	-117.3	-117.3	-117.3	-182.2	-182.2	-182.2	-42.8	-42.8	-42.8
United States	0	0	0	0	0	0	0	0	0	0	0	0	0
Canada	2138	2138	1704	0	2138	1034.5	1381	6157.7	1033.6	4137.6	6128.2	1004.1	4108.1
Japan	3196.6	3196.6	2080.8	0	3196.6	1209	1191.2	113054.4	1139.5	19125.7	112939.4	1024.5	19010.7
Pacifc OECD (without Japan)	0	0	0	0	0	0	0	0	0	0	0	0	0
Former Soviet Union	0	0	0	0	0	0	0	0	0	0	-163.5	-163.5	-163.5
Brazil	0	0	0	0	0	-90.7	-21	0	-87.9	-13.5	0	-87.9	-13.5
China	0	0	0	0	0	-3918.6	-1374	0	-3840.9	-994	0	-3840.9	-994
South Corea	0	0	0	0	0	-42.2	-15.4	0	-41.3	-11.6	0	-41.3	-11.6
Mexico	0	0	0	0	0	-34.7	-10.2	0	-33.9	-6.8	0	-33.9	-6.8
India	0	0	0	0	0	-508.9	-155.2	0	-497.8	-103.6	0	-497.8	-103.6
EUROPE	12127.1	2148.6	1738.4	0	140345.5	3847.5	70897.8	140325	3811.7	70855.9	140293.3	3780	70824.2
KYOTO	17461.7	7483.2	5523.2	0	145680.1	6091	73470	259537.1	5984.8	94119.2	259360.9	5808.6	93943
ANNEX B	17461.7	7483.2	5523.2	0	145680.1	6091	73470	259537.1	5984.8	94119.2	259197.4	5645.1	93779.5

Table 15*: Simulation results for "Kyoto" targets (Hot Air) – Emission reduction of alternative scenarios in 2010 (% of BaU emissions)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM8 ANNEX B
Austria	27.7	5.9	7.8	0	24.2	1.6	19.7	24.7	1.6	19.7	23.2	1.4	19.6
Belgium	23.1	9.8	12.9	0	23.4	3	17.2	24.1	3	17.2	22.2	2.6	17.1
Denmark	29.1	3.8	6.1	0	16.5	0.7	12.2	16.8	0.7	12.2	16.1	0.6	12.2
Spain	25.4	9.6	12.9	0	20.9	2.4	14.4	21.9	2.4	14.4	19.4	2.1	14.3
Finland	13.2	12.1	15.8	0	10.6	2.8	2.2	11.9	2.8	2.3	8.6	2.5	2.1
France	7.5	7	9.7	0	5.6	1.7	1.7	6.1	1.7	1.7	4.9	1.5	1.6
United Kingdom	20.2	12.8	16.6	0	20.3	3.6	13	21.4	3.6	13.1	18.4	3.2	12.9
Greece	2.2	1.5	2.2	0	0.3	0.1	0.1	0.3	0.1	0.1	0.2	0.1	0.1
Ireland	27.4	28.4	34.9	0	31.7	5.8	17.4	35.5	5.8	17.5	25.7	5	17.2
Italy	22.1	6.4	8.5	0	22.7	1.7	16.9	23.2	1.7	17	21.8	1.5	16.9
Netherlands	26	8.5	12.5	0	25.1	1.7	19.1	25.8	1.7	19.1	23.9	1.5	19
Portugal	17.4	1.1	1.6	0	13.2	0.2	8.3	13.3	0.2	8.3	13.2	0.2	8.3
Germany	18.1	9.7	13.3	0	16.2	2.4	10.1	17	2.4	10.1	15	2.2	10
Sweden	0	8.7	12.1	0	0.4	0.2	0.1	0.5	0.2	0.1	0.3	0.2	0.1
Central Europe	0	16.5	21.6	0	6.5	3.8	1.7	7.8	3.8	1.7	4.1	3.4	1.5
United States	0	0	0	0	0	0	0	0	0	0	0	0	0
Canada	26.7	26.7	16.4	0	26.7	2.6	20	26	2.6	19.4	23.9	2.3	19.3
Japan	16.5	16.5	8.6	0	16.5	1.8	7.9	13.6	1.8	6.9	12	1.6	6.8
Pacifc OECD (without Japan)	0	0	0	0	0	0	0	0	0	0	0	0	0
Former Soviet Union	0	0	0	0	0	0	0	0	0	0	5.6	4.7	2.1
Brazil	0	0	0	0	0	2.8	0.9	0	2.8	0.9	0	2.3	0.8
China	0	0	0	0	0	15.6	7.1	0	15.6	7.3	0	14	6.5
South Corea	0	0	0	0	0	1.4	0.6	0	1.4	0.6	0	1.2	0.6
Mexico	0	0	0	0	0	2.1	0.9	0	2.1	0.9	0	1.8	0.8
India	0	0	0	0	0	6	2.6	0	6	2.7	0	5.3	2.4
EUROPE	15	10.5	14.1	0	15.1	2.6	9.5	16	2.6	9.5	13.6	2.3	9.4
KYOTO	16.5	13.3	13.3	0	16.5	2.4	10.2	16.5	2.4	10	14.4	2.2	9.9
ANNEX B	11.9	9.6	9.6	0	11.9	1.8	7.4	11.9	1.8	7.2	11.9	2.9	7.7

Table 16*: Simulation results for "Kyoto" targets (Hot Air) – Total compliance costs of alternative scenarios in 2020 (million €2002)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM 8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM 8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM 8 ANNEX B
Austria	2125.1	533.4	93.3	81	2119.5	176.6	1642.8	2093	161.5	1637	2087.5	156	1635.4
Belgium	476.5	475.9	149.7	131.1	1792.5	264.6	1184.8	1796.4	247.8	1181.6	1792.8	244.2	1179.9
Denmark	480.2	385.6	76.9	66.8	4453.2	144.4	1966	4414.7	130.1	1957.2	4406.3	121.7	1954.8
Spain	2404.4	1821.9	396.8	346.3	11352	723.9	6889.2	11258.5	665	6863.6	11233.4	639.9	6855.5
Finland	123.8	117.3	50.7	44.8	438.2	83.3	87.9	429	77.5	84.3	425.2	73.7	82.9
France	600.5	533.7	245.9	217.1	1107.3	411.4	620.6	1090.4	385.5	609.9	1078.9	374	605.2
United Kingdom	2375.9	2296.3	645.1	567	8110.3	1123.2	5241.7	8103.7	1052.2	5226.6	8086.9	1035.4	5219.1
Greece	151.1	63.2	70.3	62.1	213.9	117.1	104.2	194.1	107.7	97.2	186.7	100.3	94.6
Ireland	109.1	81.3	52.8	47	766.5	83.9	468.9	785.8	81.4	470.9	787.3	82.9	471
Italy	5697.8	2894.5	560.9	488.3	54330.8	1041.1	29120.7	54258.7	962.2	29100.8	54238.4	941.9	29092.9
Netherlands	1281.3	1033.6	233.9	204.1	13681.2	425.8	7731.2	13674.2	396.3	7725.5	13668.1	390.2	7722.9
Portugal	1161.6	467.5	76.5	66.3	2101	147	751.3	2062.6	132.4	743.3	2055	124.8	741
Germany	3523	3440.3	965	847.4	14190.6	1689.7	7600.5	14117.7	1574.9	7565.3	14080.5	1537.7	7550.4
Sweden	46.1	13.8	24.3	21.4	70.4	53.4	47.7	47.3	47.3	43.1	41.6	41.6	41.6
Central Europe	215.4	-2214.1	209.4	199.3	483.8	486.9	450.2	464.2	464.2	443	434.7	434.7	434.7
United States	956.1	956.1	956.1	954.3	956.1	956.1	956.1	956.1	956.1	956.1	1723.7	1723.7	1723.7
Canada	2476.8	2476.8	737.5	647.9	2476.8	1286.1	1728.5	4977.5	1206.1	3537.9	4961	1189.6	3530.3
Japan	1277.8	1277.8	479.8	423.8	1277.8	808.2	706.9	819.6	729.5	664.6	750.4	660.3	644.9
Pacifc OECD (without Japan)	0	0	0	-248.4	0	0	0	0	0	0	-194.9	-194.9	-194.9
Former Soviet Union	0	0	-3923.1	-3335.5	0	0	0	-964.5	-964.5	-785.9	-728.6	-728.6	-728.6
Brazil	0	0	0	0	0	-79.1	-26	0	-54.5	-11.1	0	-54.5	-7.1
China	0	0	0	0	0	-4765.5	-1964.1	0	-3560.9	-1004.9	0	-3560.9	-732.9
South Corea	0	0	0	0	0	-153.7	-63	0	-113.8	-33.8	0	-113.8	-25.6
Mexico	0	0	0	0	0	-67.7	-25.2	0	-49.1	-11.2	0	-49.1	-7.3
India	0	0	0	0	0	-962.7	-350.9	0	-692.6	-155.1	0	-692.6	-100.9
EUROPE	20771.8	11944.2	3851.5	3390	115211.2	6972.3	63907.7	114790.3	6486	63749.3	114603.3	6299	63681.9
KYOTO	24526.4	15698.8	1145.7	1126.2	118965.8	9066.6	66343.1	119622.9	7457.1	67165.9	119586.1	7420.3	67128.5
ANNEX B	25482.5	16654.9	2101.8	1832.1	119921.9	10022.7	67299.2	120579	8413.2	68122	121114.9	8949.1	68657.3

Table 17*: Simulation results for "Kyoto" targets (Hot Air) – Emission reduction of alternative scenarios in 2020 (% of BaU emissions)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM 8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM 8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM 8 ANNEX B
Austria	33.9	9.8	1.9	1.7	26.9	1.5	23.5	25.8	1.3	22.6	25.5	1.5	22.8
Belgium	29.7	30.5	5.1	4.3	33	3.8	24.3	27.5	3.4	20	26.4	4	21
Denmark	35.1	20.4	2.4	2	23	1.8	16.9	19.9	1.6	14.6	19.3	1.9	15.2
Spain	31.6	19.6	4	3.5	27.7	3.1	21.1	24.1	2.8	17.7	23.3	3.2	18.6
Finland	22	25.1	6.6	5.7	21.4	5	12.6	16.7	4.5	7	15.5	5.3	8.7
France	16.5	20.5	4.5	3.9	17.2	3.4	11.9	14	3.1	8.8	13.4	3.6	9.7
United Kingdom	27.9	24.4	6.2	5.5	29.6	4.8	22.8	25.7	4.4	18.6	24.8	5	19.8
Greece	18.9	32.4	4.9	4.2	18.2	3.6	8.2	12.1	3.3	3.4	11	3.8	4.6
Ireland	33.7	44.4	12.3	10.9	45.3	9.7	34.8	37.8	8.9	26.1	36	10.1	28.7
Italy	29.1	13.3	2.9	2.5	27.3	2.2	21.6	25.1	2	19.6	24.7	2.3	20.2
Netherlands	32.3	21.5	4	3.4	33.6	3	26.2	29.3	2.7	22.4	28.5	3.1	23.4
Portugal	25.3	4.7	0.7	0.6	15.4	0.5	10.7	14.9	0.4	10.3	14.8	0.5	10.4
Germany	26.6	23.7	5.6	4.9	27	4.3	20.1	23.2	3.9	16.2	22.3	4.5	17.3
Sweden	11.2	17.9	3.2	2.7	7.2	1.4	3.9	3.7	1.3	1.4	3.1	1.5	2
Central Europe	8.6	25.7	7.3	6.4	12.6	4.8	9.1	8.8	4.4	4.7	7.9	5	6
United States	8.4	8.4	8.4	8.1	8.4	8.4	8.4	8.4	8.4	8.4	10.7	6.7	8.1
Canada	31.1	31.1	6.6	5.8	31.1	5.1	24.7	28.9	4.7	21.8	28	5.4	23
Japan	12.4	12.4	3.5	3.1	12.4	2.8	5.6	6.3	2.5	2.4	5.7	2.9	3.1
Pacifc OECD (without Japan)	0	0	0	10.9	0	0	0	0	0	0	12.8	8.6	10.1
Former Soviet Union	0	0	9	7.9	0	0	0	9.5	4.6	4.9	8.5	5.3	6.4
Brazil	0	0	0	0	0	1.8	0.6	0	1.6	0.8	0	1.9	0.8
China	0	0	0	0	0	15	5.1	0	13.8	6.4	0	15.6	6.4
South Corea	0	0	0	0	0	3.9	1.2	0	3.5	1.5	0	4	1.5
Mexico	0	0	0	0	0	2.7	0.9	0	2.5	1.1	0	2.8	1.1
India	0	0	0	0	0	7.2	2.2	0	6.5	2.8	0	7.5	2.8
EUROPE	22.5	22.5	5.4	4.7	23.1	3.9	17.3	19.5	3.6	13.5	18.7	4.1	14.6
KYOTO	15.3	15.3	6.3	5.5	15.7	2.7	11.4	15.7	3.8	10.3	14.8	4.4	11.4
ANNEX B	12.2	12.2	7	6.7	12.3	4.9	9.9	12.3	5.6	9.3	13.1	5.4	10

Table 18*: Simulation results for 450 ppm-targets (no Hot Air) – Total compliance costs of alternative scenarios in 2020 (million €2002)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM8 ANNEX B
Austria	4156.6	1397.7	734.5	579.6	4616.4	800.9	3874.4	4589.9	862.4	3849.9	4586.1	858.6	3846.1
Belgium	1024.2	952.8	920.4	810.1	5281.1	1390.1	4027.2	5285	1548.6	4019.7	5282.6	1546.2	4017.3
Denmark	895.4	836.1	566.8	466.8	32797.3	602.7	19819.2	32758.8	626.3	19784.4	32753	620.5	19778.6
Spain	5438.2	4655.7	2935	2405.5	43370.8	3570	30996.9	43277.3	3882	30898.9	43260.1	3864.8	30881.7
Finland	435.1	433.4	359.2	311.7	30509.4	485.1	10540.8	30500.2	528.2	10527.4	30497.6	525.6	10524.8
France	2638.4	2610.8	2181.2	1876.7	17339.7	3003	12079.5	17322.8	3309.5	12044.4	17315.1	3301.8	12036.7
United Kingdom	6143.8	6102	4489.4	3790.1	28688.6	6187	21931.9	28682	6877.2	21885.1	28670.9	6866.1	21874
Greece	280.8	-430.8	248.3	280.3	1237.8	457.1	443	1218	476.8	416.6	1213	471.8	411.6
Ireland	222.9	37.3	222.7	216.1	3106.8	460.1	2085.1	3126.1	532.9	2096.9	3127.2	534	2098
Italy	15535.5	8335	4668.4	3735.7	251576.4	5761.4	165931.7	251504.3	6381.6	165839.7	251490.4	6367.7	165825.8
Netherlands	2868.2	2548.8	1663.9	1375.3	63325.9	2258.6	41846.9	63318.9	2519.4	41827.9	63314.8	2515.3	41823.8
Portugal	2276.6	1461.8	753.2	587.1	20040.7	763.8	10287.8	20002.3	808.8	10251.2	19997	803.5	10245.9
Germany	9286.9	9264.4	6938.2	5862.7	81427.8	9346.4	54181.3	81354.9	10321.1	54053.8	81329.8	10296	54028.7
Sweden	333.2	333.2	267	231.3	497.5	274	236.3	474.4	270.2	212.5	470.5	266.3	208.6
Central Europe	2086.7	-1390.1	1946.8	2086.4	4800.7	3309.6	2417.9	4781.1	3508.1	2324.1	4761.5	3488.5	2304.5
United States	13036	13036	13036	12582.5	13036	13036	13036	13036	13036	13036	94542.2	94542.2	94542.2
Canada	6313.6	6313.6	5147.9	4405.7	6313.6	5697.5	4767.6	20398.5	7646.2	15595.3	20387.6	7635.3	15584.4
Japan	13168	13168	6970.8	5702.6	13168	8106.6	7442.6	456476.4	8888.5	234406.3	456428.8	8840.9	234358.7
Pacifc OECD (without Japan)	116.5	116.5	116.5	-868.5	116.5	116.5	116.5	116.5	116.5	116.5	116	116	116
Former Soviet Union	0	0	-15303	-10059.4	0	0	0	-964.5	-964.5	-964.5	-797.5	-797.5	-797.5
Brazil													
China													
South Corea													
Mexico													
India	0	0	0	0	0	-27171.4	-2630	0	-33471.7	-1682.6	0	-33471.7	-1682.6
EUROPE	53622.5	37148.1	28895	24615.4	588616.9	38669.8	380699.9	588196	42453.1	380032.5	588069.6	42326.7	379906.1
KYOTO	73104.1	56629.7	25710.7	24664.3	608098.5	52473.9	392910.1	1064106.4	58023.3	629069.6	1064088.5	58005.4	629051.7
ANNEX B	86256.6	69782.2	38863.2	36378.3	621251	65626.4	406062.6	1077258.9	71175.8	642222.1	1158746.7	152663.6	723709.9

Table 19*: Simulation results for 450 ppm-targets (no Hot Air) – Emission reduction of alternative scenarios in 2020 (% of BaU emissions)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM8 ANNEX B
Austria	42.9	15.7	10.1	8.5	35.9	7.9	32.5	34.7	7.2	32.1	34.6	7.1	32.1
Belgium	41.3	48	31.5	26.3	44.6	19	36	39.1	14	34	38.3	13.3	34.1
Denmark	45.9	37.9	21.5	16	33.8	9.3	27.7	30.6	6.5	26.6	30.2	6.1	26.7
Spain	42.9	31.9	20.3	17	39	12.1	32.5	35.4	8.8	31	34.8	8.2	31
Finland	34.9	36	25.8	22.4	34.4	17.1	25.7	29.6	12.6	23.4	28.8	11.8	23.5
France	30.3	32.2	21.1	17.8	31.1	14	25.8	27.9	11.2	24.5	27.4	10.8	24.5
United Kingdom	39.8	37.8	25.2	21.5	41.5	17.3	34.8	37.6	13.8	33	36.9	13.2	33.1
Greece	25.8	56.1	33.8	26.9	25.1	16.4	14.9	19.1	10.7	12.7	18.3	9.9	12.8
Ireland	44.7	66.2	45.6	39.4	56.3	31.1	46	48.8	24.2	42.5	47.6	23	42.7
Italy	40.9	21.4	13.7	11.5	39	8.8	33.4	36.9	6.9	32.6	36.6	6.6	32.6
Netherlands	43.4	34.3	22.3	18.6	44.7	13.6	37.5	40.5	9.8	35.8	39.9	9.2	35.9
Portugal	37.7	11.6	5	3.8	27.8	3.4	23.1	27.3	3.2	22.9	27.2	3.2	22.9
Germany	38.8	37.6	24.4	20.6	39.2	16	32.4	35.4	12.5	30.7	34.8	11.9	30.8
Sweden	25.9	25.9	18.4	15.9	20.2	12.8	12.8	16.7	9.7	11.6	16.2	9.2	11.6
Central Europe	22.8	37.3	26.4	23	24.3	19.2	17.3	20.5	15.8	15.5	19.9	15.2	15.6
United States	27.3	27.3	27.3	30.7	27.3	27.3	27.3	27.3	27.3	27.3	28	28	27.1
Canada	45.4	45.4	30.8	25.7	45.4	32.1	39	43.2	19.5	38.7	42.6	18.9	38.8
Japan	30.6	30.6	14.6	12.3	30.6	15.2	23.8	24.5	6.5	20.3	24.1	6.1	20.3
Pacifc OECD (without Japan)	13.2	13.2	13.2	36	13.2	13.2	13.2	13.2	13.2	13.2	14.7	14.7	13.8
Former Soviet Union	0	0	31	27.3	0	0	0	9.5	9.5	8	8.8	8.8	8.1
Brazil													
China													
South Corea													
Mexico													
India	0	0	0	0	0	42.1	15.4	0	44.8	11.9	0	44.8	12.1
EUROPE	35	35	23.2	19.7	35	15.4	28.3	31.3	12.2	26.7	30.8	11.6	26.8
KYOTO	25	25	25	21.5	25	12.1	20.3	25	11.2	21.3	24.4	10.7	21.4
ANNEX B	25.6	25.6	25.6	25.6	25.6	18.2	22.9	25.6	17.7	23.5	25.6	17.7	23.5

Table 20*: Simulation results for 450 ppm-targets (Hot Air) – Total compliance costs of alternative scenarios in 2020 (million €2002)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM8 ANNEX B
Austria	4156.6	1397.7	685.5	558.5	4616.4	800.9	3874.4	4589.9	862.4	3849.9	4586.1	858.6	3846.1
Belgium	1024.2	952.8	890	791.8	5281.1	1390.1	4027.2	5285	1548.6	4019.7	5282.6	1546.2	4017.3
Denmark	895.4	836.1	536.9	452	32797.3	602.7	19819.2	32758.8	626.3	19784.4	32753	620.5	19778.6
Spain	5438.2	4655.7	2772.8	2329.8	43370.8	3570	30996.9	43277.3	3882	30898.9	43260.1	3864.8	30881.7
Finland	435.1	433.4	345.6	304.2	30509.4	485.1	10540.8	30500.2	528.2	10527.4	30497.6	525.6	10524.8
France	2638.4	2610.8	2093.5	1829.1	17339.7	3003	12079.5	17322.8	3309.5	12044.4	17315.1	3301.8	12036.7
United Kingdom	6143.8	6102	4281.4	3685.5	28688.6	6187	21931.9	28682	6877.2	21885.1	28670.9	6866.1	21874
Greece	280.8	-430.8	263.8	280.8	1237.8	457.1	443	1218	476.8	416.6	1213	471.8	411.6
Ireland	222.9	37.3	222.7	213.7	3106.8	460.1	2085.1	3126.1	532.9	2096.9	3127.2	534	2098
Italy	15535.5	8335	4376.6	3606.5	251576.4	5761.4	165931.7	251504.3	6381.6	165839.7	251490.4	6367.7	165825.8
Netherlands	2868.2	2548.8	1576.1	1333.6	63325.9	2258.6	41846.9	63318.9	2519.4	41827.9	63314.8	2515.3	41823.8
Portugal	2276.6	1461.8	700.5	564.7	20040.7	763.8	10287.8	20002.3	808.8	10251.2	19997	803.5	10245.9
Germany	9286.9	9264.4	6619.8	5700.9	81427.8	9346.4	54181.3	81354.9	10321.1	54053.8	81329.8	10296	54028.7
Sweden	333.2	333.2	256.7	225.7	497.5	274	236.3	474.4	270.2	212.5	470.5	266.3	208.6
Central Europe	2086.7	-1390.1	2018	2085.7	4800.7	3309.6	2417.9	4781.1	3508.1	2324.1	4761.5	3488.5	2304.5
United States	13036	13036	13036	12757.9	13036	13036	13036	13036	13036	13036	94542.2	94542.2	94542.2
Canada	6313.6	6313.6	4933	4290.6	6313.6	5697.5	4767.6	20398.5	7646.2	15595.3	20387.6	7635.3	15584.4
Japan	13168	13168	6581.4	5521.9	13168	8106.6	7442.6	456476.4	8888.5	234406.3	456428.8	8840.9	234358.7
Pacifc OECD (without Japan)	116.5	116.5	116.5	-780.6	116.5	116.5	116.5	116.5	116.5	116.5	116	116	116
Former Soviet Union	0	0	-16132.5	-11473.8	0	0	0	-964.5	-964.5	-964.5	-797.5	-797.5	-797.5
Brazil													
China													
South Corea													
Mexico													
India	0	0	0	0	0	-27171.4	-2630	0	-33471.7	-1682.6	0	-33471.7	-1682.6
EUROPE	53622.5	37148.1	27639.9	23962.5	588616.9	38669.8	380699.9	588196	42453.1	380032.5	588069.6	42326.7	379906.1
KYOTO	73104.1	56629.7	23021.8	22301.2	608098.5	52473.9	392910.1	1064106.4	58023.3	629069.6	1064088.5	58005.4	629051.7
ANNEX B	86256.6	69782.2	36174.3	34278.5	621251	65626.4	406062.6	1077258.9	71175.8	642222.1	1158746.7	152663.6	723709.9

Table 21*: Simulation results for 450 ppm-targets (Hot Air) – Emission reduction of alternative scenarios in 2020 (% of BaU emissions)*

	NOTRADE	NAP_OPT EUROPE	NAP_OPT KYOTO	NAP_OPT ANNEX B	NAP EUROPE	NAP_CDM EUROPE	NAP_CDM8 EUROPE	NAP KYOTO	NAP_CDM KYOTO	NAP_CDM8 KYOTO	NAP ANNEX B	NAP_CDM ANNEX B	NAP_CDM8 ANNEX B
Austria	42.9	15.7	9.6	8.2	35.9	7.9	32.5	34.7	7.2	32.1	34.6	7.1	32.1
Belgium	41.3	48	30	25.5	44.6	19	36	39.1	14	34	38.3	13.3	34.1
Denmark	45.9	37.9	19.8	15.2	33.8	9.3	27.7	30.6	6.5	26.6	30.2	6.1	26.7
Spain	42.9	31.9	19.3	16.5	39	12.1	32.5	35.4	8.8	31	34.8	8.2	31
Finland	34.9	36	24.8	21.9	34.4	17.1	25.7	29.6	12.6	23.4	28.8	11.8	23.5
France	30.3	32.2	20.1	17.3	31.1	14	25.8	27.9	11.2	24.5	27.4	10.8	24.5
United Kingdom	39.8	37.8	24	21	41.5	17.3	34.8	37.6	13.8	33	36.9	13.2	33.1
Greece	25.8	56.1	31.7	25.9	25.1	16.4	14.9	19.1	10.7	12.7	18.3	9.9	12.8
Ireland	44.7	66.2	43.8	38.5	56.3	31.1	46	48.8	24.2	42.5	47.6	23	42.7
Italy	40.9	21.4	13.1	11.2	39	8.8	33.4	36.9	6.9	32.6	36.6	6.6	32.6
Netherlands	43.4	34.3	21.2	18.1	44.7	13.6	37.5	40.5	9.8	35.8	39.9	9.2	35.9
Portugal	37.7	11.6	4.6	3.6	27.8	3.4	23.1	27.3	3.2	22.9	27.2	3.2	22.9
Germany	38.8	37.6	23.3	20.1	39.2	16	32.4	35.4	12.5	30.7	34.8	11.9	30.8
Sweden	25.9	25.9	17.6	15.5	20.2	12.8	12.8	16.7	9.7	11.6	16.2	9.2	11.6
Central Europe	22.8	37.3	25.4	22.5	24.3	19.2	17.3	20.5	15.8	15.5	19.9	15.2	15.6
United States	27.3	27.3	27.3	30	27.3	27.3	27.3	27.3	27.3	27.3	28	28	27.1
Canada	45.4	45.4	29.2	25	45.4	32.1	39	43.2	19.5	38.7	42.6	18.9	38.8
Japan	30.6	30.6	13.9	12	30.6	15.2	23.8	24.5	6.5	20.3	24.1	6.1	20.3
Pacifc OECD (without Japan)	13.2	13.2	13.2	35.1	13.2	13.2	13.2	13.2	13.2	13.2	14.7	14.7	13.8
Former Soviet Union	0	0	29.9	26.8	0	0	0	9.5	9.5	8	8.8	8.8	8.1
Brazil													
China													
South Corea													
Mexico													
India	0	0	0	0	0	42.1	15.4	0	44.8	11.9	0	44.8	12.1
EUROPE	35	35	22.2	19.2	35	15.4	28.3	31.3	12.2	26.7	30.8	11.6	26.8
KYOTO	25	25	23.9	20.9	25	12.1	20.3	25	11.2	21.3	24.4	10.7	21.4
ANNEX B	25.6	25.6	25	25	25.6	18.2	22.9	25.6	17.7	23.5	25.6	17.7	23.5