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Europe's Twenties – A Study Using the WIATEC model[1]

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Abstract:

In this paper, we use a computable general equilibrium model (WIATEC) to study the potential impact of implementing Europe's 20-20-20 climate policy. The results show that the economic costs of implementing the policy are only moderate and within the range of recent empirical evidence. Furthermore, they also indicate that there is a possibility that the existing allocations to the Europena sectors participating in the EU Emissions Trading Scheme (EU ETS) are on the low side, and therefore, there are still rooms for movement in the future.

JEL Classification: C63, C68, D58, F11, F18, H21, O13, P28, Q54, Q58, R13

Keywords: Climate policy, Energy policy, EU 20-20-20 plan, EU Emission Trading System, Computable General Equilibrium

[1] This research is part of the Energy Modelling Forum (EMF22).

1 Introduction

Today's society faces two main challenges: first, to guarantee a secure and affordable energy supply; and second, to reduce and abolish the environmental harm, in particular to the climate, caused by energy consumption. Over 80% of today's primary energy consumption comes from non-renewable fossil fuels such as coal, oil, and gas. If we do not change our behaviour, the share of fossil-fuel resources in the future will remain as high as it is today (see IPCC 2007). As the major oil and gas reserves are located in few areas of the world, importing countries would become more vulnerable to supply disruptions and energy price shocks. Furthermore, fossil-fuel consumption is one of the major sources of greenhouse gas emissions causing significant changes in our climate. To guarantee a more sustainable economic development, we should invest in an energy mix consisting of secure, reliable, and affordable energy resources. To meet these challenges and transform our energy system, we require a better use of existing technologies along with significant scientific innovations to spur the adoption of new energy technologies. Research priorities encompass inter alia photo voltaic, carbon capture and sequestration (CCS), biofuels, and hydrogen generation, storage and use.

The largest share of CO_2 emissions is caused by fossil-fuel combustion for energy production and transportation. Methane is produced by the energy (gas exploration) sector as well as by agriculture. To reduce emissions, technologies based on the intensive use of fossil fuels need to be replaced by CO_2-free energy technologies, energy efficiency needs to be improved considerably, and more sustainable energy and agricultural production needs to become standard. Any future policy option addressing a sustainable future energy mix should be a combination of energy security, competitiveness, and the effect on our climate.

The Kyoto Protocol came into force in 2005 after Russia ratified it in November 2004, and it expires in 2012. The Protocol intends to reduce greenhouse gas emissions by 5.2% compared with the 1990 level of emissions by the commitment period 2008–12.

The main intention of the Kyoto Protocol is to reduce emissions by binding emissions reduction limits on more than 55 countries covering more than 55% of total world emissions. High-income countries such as the EU, Japan, and Canada have committed themselves to reducing emissions by binding emissions cuts, upper-middle economies such as Russia and Ukraine have to stabilise 1990 emissions, and lower-middle and low-income economies such as China and India have no emissions reduction target (see Haites et al.). The USA never ratified the Kyoto Protocol. The Kyoto Protocol allows for flexible mechanisms such as an emissions trading system between the industrialised countries, the Clean Development Mechanism (CDM), and Joint Implementation (JI). Both CDM and JI allow for project transfers between industrialised and developing nations to reduce greenhouse gases.

Europe has taken the lead in combining concrete targets for energy and climate policy (European Commission 2007). Europe intends to cut emissions by 20% by 2020 compared with the 1990 level and to increase the share of renewable energy by 20% in the same period. However, Europe intends to reduce even 30% of their emissions if other nations are willing to accept climate policy commitments. It is important that Europe demonstrates the willingness and ability to cut emissions drastically. The Kyoto protocol needs to be fulfilled, the emissions trading scheme needs to be improved, and a fair burden sharing needs to be implemented. Europe however only has a chance of convincing other nations to agree on any kind of climate commitments only if Europe is willing to reduce 30% by 2020.

This paper considers the consequence of implementing the EU 20-20-20 plan on the EU economy and on the environment. What are the costs of applying this plans to the EU economy, and to the rest of the world? How will it change the existing energy mix in the EU production sectors? Will it have sufficient mitigating effects on the global climate?

The computable general equilibrium model WIATEC is a recursive dynamic extension of the GTAP-E model (see Burniaux and Truong (2004)) to the inclusion of induced technological change. The latter characteristic allows the model to include investments into new, more (energy or emission) efficient technologies.

Section 2 describes the EU Emission Trading System (ETS) into detail and explains its functioning. Section 3 provides a description of the most significant assumptions and innovations underlying the WIATEC computable general equilibrium model. Section 4 concludes the paper by an application of the WIATEC model to provide an answer to the aforementioned questions.

2 The EU Emission Trading System (ETS)

At the beginning of 2005, the European Union launched an emissions trading scheme (the "EU ETS") under which firms operating in the energy and industry sectors of all EU member states are free to buy and sell CO_2 emission allowances. There is a fundamental difference between the EU ETS and the emissions trading scheme as envisaged under the Kyoto Protocol. In the latter case, emissions trading is to occur between the Parties to the protocol at the level of the states. Under the EU ETS, however, trading occurs among individual emitters which comprise of 11,428 installations in 25 Member States. The system covers primarily energy and industrial plants, as combustion installations, oil refineries, coke ovens, iron and steel mills, as well as cement, glas, lime, brick, ceramic, paper and pulp mills. The emission certificates encompass almost 45% of Europe's CO_2 emissions. The emission reduction target of each individual installation is given by the national allocation plans.

Initial experiences with this new instrument indicate that incomplete information and imperfect competition – and subsequent strategic behaviour – have led to an over-allocation of emission allowances in almost all European countries (see Figure 2). Europe allocated national emissions reduction targets by a burden-sharing rule (see Figure 1), see Oberndofer et al.2006) for a literature overview. The emissions trading market almost collapsed as a result, with the price of allowances dropping to almost zero in 2007 (see Kemfert et al. (2006)), Paltsev et al. (2007), Böhringer and Lange

(2005), and Böhringer et al. (2005)). In 2008, the official EU ETS system phase started, the allocation plans have been improved avoiding a substantial over allocation.

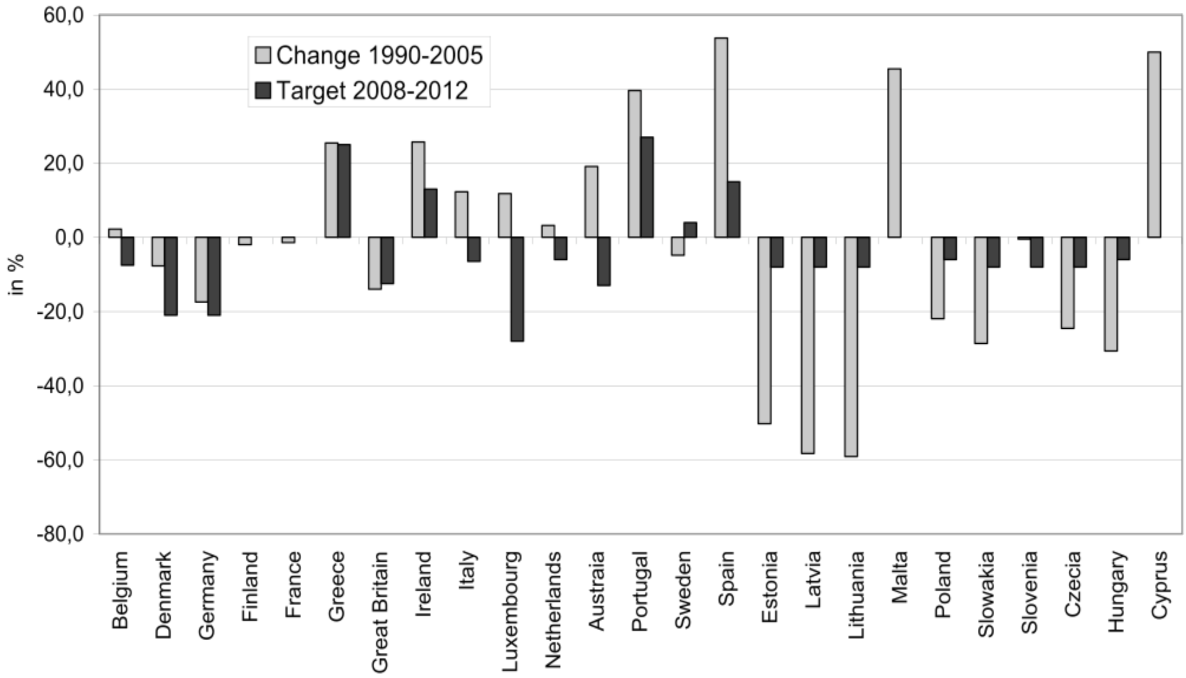


Figure 1: Changes in Greenhouse Gas Emissions and Kyoto Target for EU Countries (*Source*: UNFCCC (2006)).

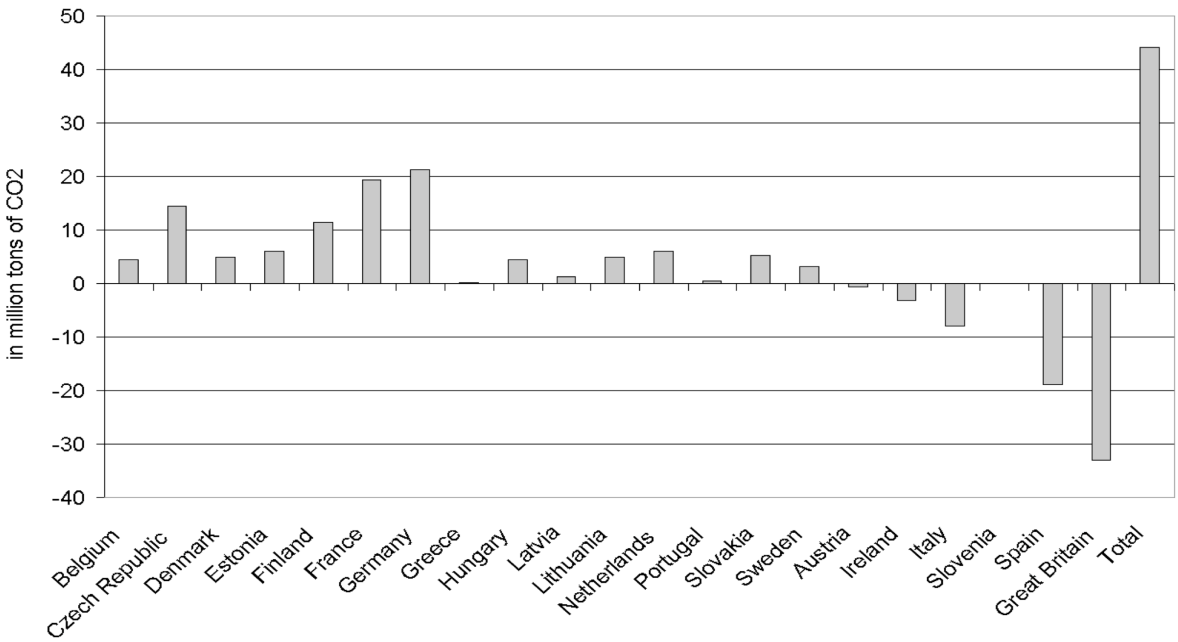


Figure 2: Surplus (+) and deficit (–) of regional emissions permits under the national allocation plans (*Source:* Kemfert et al. (2007)).

Over-allocations are unlikely to be repeated in the future, however, because the member states' national allocation plans (NAPs) for emissions allowances now require the approval of the European Commission. The market price of emission allowances for 2008 currently stands at 20 euros per tonne of CO_2. Some EU countries have decided to auction a small share of their emissions permits (EU member states may auction no more than 10% of their allocated emissions). Given the existence of market imperfections and strategic behaviour, an open auction would probably drive up the price of allowances in order to accomplish that the remaining, freely allocated share of emissions allowances would be valued as highly as possible, and probably closer to the participants willingness to pay. Because of this, the EU intends to increase the share of auctioned permits up to 100 % by 2013. Energy intensive sectors fear economic disadvantages because of carbon leakage and international competitive disadvantaged from those regions which do not implement any climate policy goals. Because of this, exemption rules have been established: depending on the energy costs of a company and the international trade, companies will be exempted form auctioning. Thus, with a view to avoid distortions of this nature, a book-building or fixed-price system is recommended as the most appropriate auction format.

All in all, it can be said that emissions trading is basically an effective and cost-efficient tool for diminishing greenhouse gas emissions. However, its success will depend on the maximum possible number of countries, sectors, and greenhouse gases being included in the scheme and on the freedom of member states to auction 100% of their emissions allowances. Full auctioning of emission allowances would increase transparency; partial auctioning would neither resolve the problems of optimal free allocation nor reflect the real situation on the market.

Recent moves in the USA towards joining the EU ETS at the county level could be a step in the right direction. The revenue from auctions could be used to promote low-emissions technologies and possibly to compensate those sectors that are subject to evident competitive disadvantages on international markets. In the long term, an effort must be made to make emissions trading a global instrument for climate protection.

3 A brief description of the WIATEC model and the simulation experiments

WIATEC is based on a version of the GTAP-E model (Burniaux and Truong, 2002) which in turn is based on the latest version 6.2 of the standard GTAP model (Hertel, 1997). The current model uses version 7 of the GTAP data base which consists of 57 commodities/sectors and 113 regions (Narayanan and Walmsley, 2008). For the purpose

European regions:	
Southern Europe (SEU)	Greece, Italy, Portugal, Spain, Cyprus, Malta
Western Europe (WEU)	Austria, Belgium, Denmark, Finland, France, Germany, United Kingdom, Ireland, Luxembourg, Netherlands, Norway, Sweden, Switzerland, Rest of EFTA
Eastern Europe (EEU)	Albania, Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia, Estonia, Latvia, Lithuania.
Other regions:	
USA	USA
RUS	Russia
JPN	Japan
CHN	China and Hong Kong
IND	India

Table 1: WIATEC regions

of this study, we use an aggregation which includes all of the 25 participating regions of the NAP scheme but aggregated into three main regions: Western Europe (WEU), Southern Europe (SEU), and Eastern Europe (EEU) (see Table 1), and all the 'allocated' sectors (Table 2).

Coa (*)	Coal
Oil (*)	Oil
Gas (*)	Gas and Gas Distribution
P_c (*)	Petroleum & Coal products
Ely (*)	Electricity
CROPS	paddy rice, wheat, cereal grains nec, vegetables, fruit, nuts, oil seeds, sugar cane, sugar beet, plant-based fibers, crops nec.

AGR	bovine cattle, sheep and goats, horses, animal products nec, raw milk, wool, silk-worm cocoons, forestry, fishing, bovine cattle, sheep and goat meat products, meat products, vegetable oils and fats, dairy products, processed rice, sugar, food products nec, beverages and tobacco products.
MIN (*)	minerals nec, mineral products nec.
CRP (*)	chemical, rubber, plastic products
EII (*)	Energy intensive industries: ferrous metals, metals nec, metal products.
OMF	motor vehicles and parts, transport equipment nec, electronic equipment, machinery and equipment nec, manufactures nec.
TRN	transport nec, water transport, air transport.
SER	water, construction, trade, communication, financial services nec, insurance, business services nec, receational and other services, public admin. and defence, education, health, ownership of dwellings

Table 2: WIATEC sectors. (*) allocated sector

An important feature of the WIATEC model as distinguished from the GTAP-E model is that it not only includes energy substitution but also a technology decomposition of the electricity sectors into various technological components (see Figure 1, and also ABARE, 1996).

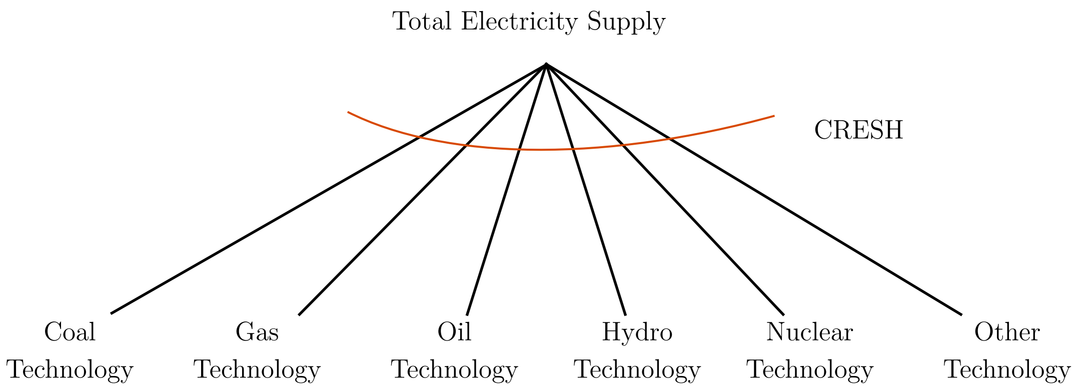
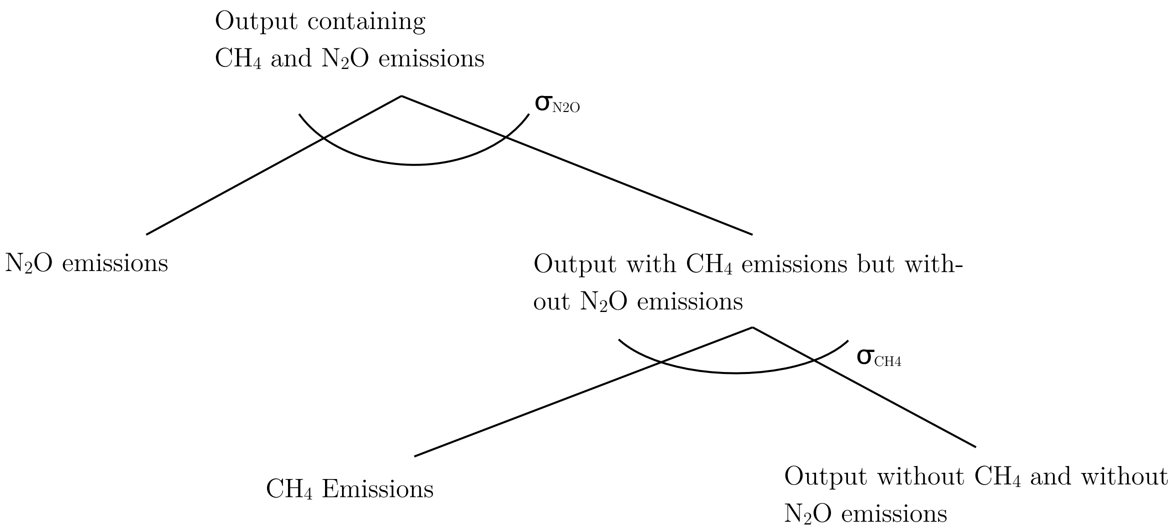


Figure 1: Decomposition of the electricity sector in WIATEC

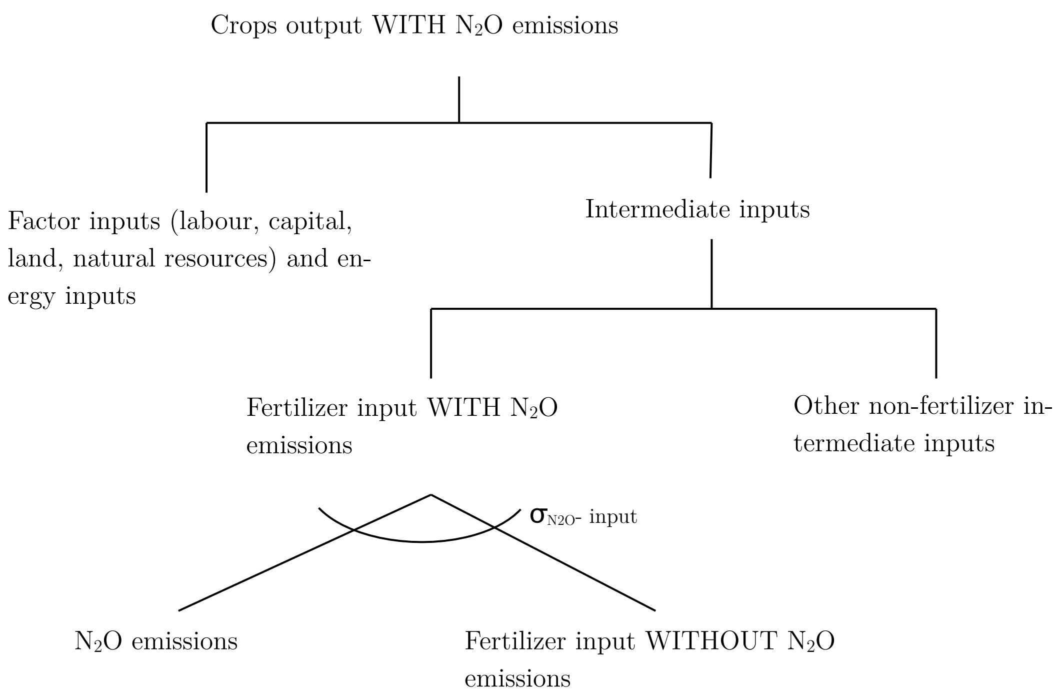
We first use the information on cost structures of the various technologies in electricity generation published by the Nuclear Energy Agency/International Energy Agency/ Organisation for Economic Cooperation and Development publications (NEA/IEA/ OECD, 1998; 2005; NEA/OECD, 2006; IEA/OECD, 2006) to disaggregate the electricity sector in the GTAP version 7 data base into various components, each one standing for a particular 'technology'. We thus have: (ElyCoal), (ElyGas), (ElyOill), (ElyNu), and (ElyHydro), and (ElyOth), which stand for electricity generation from coal, natural gas, oil, nuclear energy, hydro, and other renewable resources respectively. Each technology is assumed to use a different combination of energy and non-energy inputs, as well as other factors of production (capital, labour, land, and natural resources). We thus first distribute the fuels used in the electricity sector to various technologies, and then using information on fuel cost shares, the capital/labour ratio, as well as the output shares of various technologies, to distribute the non-energy intermediate inputs, the factors, and the total output of the electricity sector into the various technologies. Technology outputs are then recombined into the output of the (aggregate) electricity sector rather than being used directly as final outputs (Figure 1). Depicted in Figure 2,



Sectors	Coa	Oil	Gas	P_C	Ely	Crops	AGR	MIN	CRP	EII	OMF	TRN	SER
σ_{CH4}	0.03	0.11	0.12	0.11	0.11	0.11	0.11	0.50	0.11	0.11	0.11	0.11	0.11
σ_{N2O}	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

Figure 2: Substitution between CH_4 and N_2O emissions with and other economic factors at the output level. The table provides the CH_4 and N_2O abatement elasticities at the output level associated with each production sector.

the model then estimates the amount of emissions of CO_2 due to fossil fuel usage in both production and consumption activities and the emissions of non-CO_2 Greenhouse Gases (GHGs) such as methane (CH_4) and nitrous oxide (N_2O) due to activities in the energy and agricultural sectors. Methane and nitrous oxide emissions are treated as a kind of environmental input into these activities, and therefore, there is a degree of substitutability between these environmental inputs and economic inputs. The elasticities of substitution between these inputs are calibrated using 'bottom-up' information (Hyman, 2001; Hyman et al., 2002; Burniaux, 2002). Details of the substitution structure and their substitution elasticities are given in Figure 3.



	USA	WEU	SEU	EEU	RUS	JPN	CHN	IND	RoW
σ_{N2O}	0.04	0.04	0.04	0.04	0.02	0.04	0.02	0.02	0.02

Figure 3: Substitution between N_2O emissions and other economic factor at the input level. The table provides the N_2O abatement elasticities at the input level for each production sector.

For the experiments, we first establish a reference scenario. This scenario provides a benchmark against which other results can be compared. Details on the reference scenario are given in Table 3. In designing the reference scenario, we make independent macroeconomic assumptions but take into account the assumptions made by other modelers participating in EMF22. In Table 3, we list the main assumptions regarding gross domestic product (GDP) and population levels which are also regarded as the main economic drivers for the emissions levels in various regions.

GDP	base year				**Population**	base year			
2005EUx10^9	2005	2005-2010	2010-2015	2015-2020	106	2005	2005-2010	2010-2015	2015-2020
USA	9.92	9.56	8.96	8.14	USA	0.296	0.310	0.326	0.341
WEU	8.20	7.49	6.84	6.19	WEU	0.212	0.215	0.217	0.218
SEU	2.62	2.39	2.18	1.98	SEU	0.121	0.121	0.121	0.120
EEU	0.66	0.61	0.55	0.50	EEU	0.104	0.103	0.103	0.102
RUS	0.49	0.50	0.51	0.49	RUS	0.143	0.139	0.136	0.132
JPN	3.94	3.67	3.33	2.95	JPN	0.128	0.127	0.125	0.122
CHN	1.63	1.89	2.19	2.36	CHN	1.313	1.355	1.401	1.438
IND	0.56	0.60	0.65	0.66	IND	1.094	1.184	1.274	1.362
RoW	6.81	6.66	6.30	5.77	RoW	3.067	3.315	3.570	3.827
world	34.8	33.4	31.5	29.0	world	6.477	6.870	7.271	7.663

CO_2	base year				**CH_4**	base year			
$GtCO_2$/year	2005	2005-2010	2010-2015	2015-2020	Mt CH_4	2005	2005-2010	2010-2015	2015-2020
USA	2.62	2.90	3.17	3.41	USA	158.4	185.6	214.0	242.7
WEU	1.04	1.15	1.25	1.35	WEU	91.0	100.5	111.5	124.0
SEU	0.74	0.82	0.89	0.96	SEU	50.0	55.4	61.7	68.6
EEU	1.70	2.06	2.49	2.91	EEU	335.7	372.6	418.6	473.6
RUS	1.25	1.40	1.54	1.64	RUS	50.9	61.3	73.0	83.8
JPN	5.51	7.49	10.11	12.71	JPN	6.1	6.8	7.4	8.0
CHN	1.19	1.54	1.96	2.37	CHN	369.0	496.9	665.1	826.0
IND	8.43	9.91	11.40	12.73	IND	181.1	229.4	290.0	347.7
RoW	28.49	34.19	40.61	46.62	RoW	600.2	702.6	800.2	884.9
world	5.99	6.92	7.80	8.54	world	1842.5	2211.2	2641.6	3059.2

N_2O	base year			
Mt N_2O	2005	2005-2010	2010-2015	2015-2020
USA	171.5	202.9	233.3	259.7
WEU	130.9	145.4	161.6	178.1
SEU	59.8	66.6	74.0	81.4
EEU	82.4	90.8	100.0	108.9
RUS	7.8	9.4	11.1	12.6
JPN	8.7	9.8	10.8	11.7
CHN	205.6	286.4	397.9	514.9
IND	159.4	211.2	278.9	347.5
RoW	293.5	347.8	399.1	441.6
world	1119.7	1370.3	1666.5	1956.4

Table 3: Reference Scenario (*Source:* EMF22eu).

Next, we consider an experiment (refered to as EU Scenario 1, or EU1) whereby the emissions level of the total EU regions as a whole will be reduced by 20 percent below the 1990 level by the year 2020. This requires a uniform 'emission tax' being imposed on all regions and sectors (which stands also for the uniform marginal abatement cost (MAC) if emissions are to be reduced and if emissions trading is allowed between all sectors and all regions within the EU regions). The EU Scenario 1 represents the ideal situation when the EU's 2020 emissions target is to be achieved in a most cost-effective way; that is, assuming a full EU trading scheme with no split between ETS and non-ETS sectors. Results from this scenario are given in Table 4. Quite clearly, if all other regions except the EU are conducting their 'business as usual' as in the reference scenario while the EU follows this objective of cutting back on emissions, then there will be some 'leakage' of emissions from the EU to these regions. These leakage rates are also shown in Table 4.

CO_2	base year				**CH_4**	base year			
$GtCO_2$/year	2005	2005-2010	2010-2015	2015-2020	Mt CH_4	2005	2005-2010	2010-2015	2015-2020
USA	5.99	6.95	7.88	8.67	USA	158.4	184.4	211.7	239.0
WEU	2.62	2.47	2.32	2.18	WEU	91.0	97.7	105.8	115.4
SEU	1.04	0.99	0.94	0.89	SEU	50.0	54.1	59.1	64.8
EEU	0.74	0.69	0.65	0.62	EEU	335.7	297.5	277.9	273.9
RUS	1.70	2.09	2.54	2.99	RUS	50.9	60.8	72.2	82.9
JPN	1.25	1.41	1.56	1.67	JPN	6.1	6.7	7.4	8.0
CHN	5.51	7.52	10.18	12.85	CHN	369.0	495.7	663.2	823.8
IND	1.19	1.55	1.98	2.40	IND	181.1	229.4	290.1	347.7
RoW	8.43	9.98	11.55	12.97	RoW	600.2	699.4	794.6	877.6
world	28.49	33.65	39.60	45.25	world	1842.5	2125.8	2481.8	2833.2

N_2O	base year				**CTAX**	base year			
Mt N_2O	2005	2005-2010	2010-2015	2015-2020	2005EU/tCO_2	2005	2005-2010	2010-2015	2015-2020
USA	171.5	203.4	234.6	261.9	USA	0.0	0.0	0.0	0.0
WEU	130.9	144.8	160.2	176.0	WEU	0.0	28.5	46.5	61.0
SEU	59.8	66.3	73.5	80.8	SEU	0.0	28.5	46.5	61.0
EEU	82.4	90.6	99.6	108.5	EEU	0.0	28.5	46.5	61.0
RUS	7.8	9.4	11.2	12.7	RUS	0.0	0.0	0.0	0.0
JPN	8.7	9.8	10.9	11.7	JPN	0.0	0.0	0.0	0.0
CHN	205.6	286.6	398.6	516.5	CHN	0.0	0.0	0.0	0.0
IND	159.4	211.6	279.8	349.3	IND	0.0	0.0	0.0	0.0
RoW	293.5	348.8	401.4	445.4	RoW	0.0	0.0	0.0	0.0

world	1119.7	1371.5	1669.8	1962.9					

CO_2 leakage	base year			
%	2005	2005-2010	2010-2015	2015-2020
USA	0%	0.51%	1.02%	1.57%
WEU (*)	0%	-15%	-27%	-36%
SEU (*)	0%	-14%	-25%	-34%
EEU (*)	0%	-15%	-27%	-35%
RUS	0%	1.17%	2.09%	2.77%
JPN	0%	0.61%	1.19%	1.77%
CHN	0%	0.37%	0.71%	1.10%
IND	0%	0.45%	0.81%	1.25%
RoW	0%	0.70%	1.32%	1.92%
world	0%	-1.57%	-2.50%	-2.94%

Table 4: EU Scenario 1.

(*) for EU regions and the world as a whole, the figure shows percentage reduction from Reference scenario. For non-EU regions, the figures indicate the "leakage" rates.

In Table 5, we show the results of EU Scenario 2. In this scenario, only the 'allocated sectors' of the EU regions are engaged in emissions trading, and it is assumed that their permit allocations (per year) remain constant until 2020 with no banking. The non-ETS sectors of all EU regions together have to make up the 'residual' so that total EU will meet the 2020 target. This requires some policy on the non-ETS sectors which ultimately will result in a marginal abatement cost for these sectors (assumed to be uniform for all EU regions). This uniform MAC is shown as an equivalent CTAX shown in Table 5. This is compared to the emissions permit price for the ETS trading sectors, which is also shown as an equivalent CTAX shown in Table 5. The CTAX for ETS sectors is lower than the equivalent CTAX for the non-ETS sectors, which imply the total allocations for the trading sectors is higher than the optimal level (i.e. as defined by Scenario 1).

CO_2	base year				**CH_4**	base year			
$GtCO_2$/year	2005	2005-2010	2010-2015	2015-2020	Mt CH_4	2005	2005-2010	2010-2015	2015-2020
USA	5.99	6.96	7.90	8.70	USA	158.4	184.3	211.5	238.7
WEU	2.62	2.46	2.30	2.15	WEU	91.0	98.5	107.5	118.1

SEU	1.04	0.99	0.94	0.88	SEU	50.0	54.2	59.3	65.1
EEU	0.74	0.70	0.68	0.66	EEU	335.7	298.1	283.2	283.9
RUS	1.70	2.09	2.54	3.00	RUS	50.9	60.8	72.3	83.0
JPN	1.25	1.41	1.56	1.67	JPN	6.1	6.7	7.4	8.0
CHN	5.51	7.52	10.17	12.84	CHN	369.0	496.0	663.7	824.5
IND	1.19	1.55	1.98	2.40	IND	181.1	229.5	290.2	347.8
RoW	8.43	9.99	11.57	13.01	RoW	600.2	699.2	794.2	877.1
world	28.49	33.66	39.63	45.31	world	1842.5	2127.3	2489.3	2846.1

N_2O	base year				**CO_2 Leakage**	base year			
Mt N_2O	2005	2005-2010	2010-2015	2015-2020	%	2005	2005-2010	2010-2015	2015-2020
USA	171.5	203.5	234.8	262.2	USA	0%	0.61%	1.26%	1.92%
WEU	130.9	144.9	160.3	176.2	WEU (*)	0%	-15%	-28%	-37%
SEU	59.8	66.3	73.3	80.6	SEU (*)	0%	-13%	-25%	-34%
EEU	82.4	90.4	99.2	108.0	EEU (*)	0%	-14%	-24%	-32%
RUS	7.8	9.4	11.2	12.8	RUS	0%	1.25%	2.22%	2.93%
JPN	8.7	9.8	10.8	11.7	JPN	0%	0.70%	1.38%	2.07%
CHN	205.6	286.6	398.7	516.6	CHN	0%	0.31%	0.64%	1.01%
IND	159.4	211.5	279.8	349.2	IND	0%	0.38%	0.70%	1.10%
RoW	293.5	349.0	401.9	446.3	RoW	0%	0.76%	1.49%	2.19%
world	1119.7	1371.5	1670.1	1963.5	world	0%	-1.54%	-2.42%	-2.81%

CTAX ETS sectors	base year				**CTAX Non-ETS sectors**	base year			
2005EU/tCO_2	2005	2005-2010	2010-2015	2015-2020	2005EU/tCO_2	2005	2005-2010	2010-2015	2015-2020
USA	0.0	0.0	0.0	0.0	USA	0.0	0.0	0.0	0.0
WEU	0.0	17.7	27.5	35.2	WEU	0.0	42.8	74.9	104.5
SEU	0.0	17.7	27.5	35.2	SEU	0.0	42.8	74.9	104.5
EEU	0.0	17.7	27.5	35.2	EEU	0.0	42.8	74.9	104.5
RUS	0.0	0.0	0.0	0.0	RUS	0.0	0.0	0.0	0.0
JPN	0.0	0.0	0.0	0.0	JPN	0.0	0.0	0.0	0.0
CHN	0.0	0.0	0.0	0.0	CHN	0.0	0.0	0.0	0.0
IND	0.0	0.0	0.0	0.0	IND	0.0	0.0	0.0	0.0
RoW	0.0	0.0	0.0	0.0	RoW	0.0	0.0	0.0	0.0

Table 5: EU Scenario 2.

(*) for EU regions and the world as a whole, the figure shows percentage reduction from Reference scenario. For non-EU regions, the figures indicate the "leakage" rates.

In Table 6, we show the results for experiment EU Scenario 3. In this scenario, the objective for the EU is to increase the percentage of 'renewable' electricity output to 20% by the year 2020. In the base year 2005, hydroelectricity in the EU actually takes up about 17% of the total electricity output, with about 3% taken up by "other renewables" such as solar, wind, geothermal. This means, if we exclude hydroelectricity, the percentage of 'renewables' in total electricity generation in the EU is currently (base year 2005) rather small, and to increase this to a target of 20% by the year 2020 is a rather substantial task. To achieve this target, in Scenario 3, we assume that (ElyOth) will be subsidised by a kind of (negative) 'output tax', to reduce its cost relative to other technologies, and hence encouraging its adoption by the electricity sector. The cost of these subsidies are automatically borne by the regional economies, and in theory, they could be linked to the 'savings' generated by the amount of CO_2 emissions reduced. To do so however, requires some explicit policy on how to allocate the revenue from carbon emissions trading (or carbon taxes) to various activities such as research and development and including the subsidy to renewable technologies. This is beyond the scope of the present paper.

CO_2 emissions and leakage rates									
CO_2	base year				**CO_2 Leakage**	base year			
$GtCO_2$/year	2005	2005-2010	2010-2015	2015-2020	%	2005	2005-2010	2010-2015	2015-2020
USA	5.99	6.51	7.54	8.34	USA	0.0%	-5.9%	-3.3%	-2.2%
WEU	2.62	2.45	2.29	2.14	WEU (*)	0.0%	-15.1%	-27.5%	-36.9%
SEU	1.04	0.98	0.93	0.87	SEU (*)	0.0%	-14.6%	-26.0%	-35.0%
EEU	0.74	0.72	0.70	0.68	EEU (*)	0.0%	-11.2%	-21.5%	-28.9%
RUS	1.70	1.92	2.38	2.86	RUS	0.0%	-6.5%	-3.7%	-0.4%
JPN	1.25	1.34	1.50	1.62	JPN	0.0%	-4.2%	-1.9%	-1.0%
CHN	5.51	6.86	9.45	12.23	CHN	0.0%	-8.7%	-7.0%	-3.9%
IND	1.19	1.40	1.84	2.30	IND	0.0%	-10.2%	-8.9%	-7.0%
RoW	8.43	9.31	11.03	12.55	RoW	0.0%	-6.0%	-3.0%	-0.9%
world	28.49	31.49	37.66	43.60	world	0.0%	-7.9%	-7.4%	-6.4%
CH_4 and N_2O emissions									
CH_4	base year				**N_2O**	base year			
Mt CH_4	2005	2005-2010	2010-2015	2015-2020	Mt N_2O	2005	2005-2010	2010-2015	2015-2020
USA	158.4	170.0	198.9	225.4	USA	171.4	190.7	225.6	251.1
WEU	91.0	94.6	102.7	116.3	WEU	130.7	141.0	159.4	183.9
SEU	50.0	52.7	58.1	64.5	SEU	59.8	65.0	72.6	80.3
EEU	335.7	335.0	344.2	372.5	EEU	82.9	90.2	100.9	112.4
RUS	50.9	57.6	69.3	79.9	RUS	7.8	9.0	10.8	12.3
JPN	6.1	6.4	7.2	7.7	JPN	8.7	9.4	10.6	11.5
CHN	369.1	468.7	632.1	794.3	CHN	205.6	267.8	373.2	482.2
IND	181.2	218.9	277.9	333.8	IND	159.4	195.8	260.0	324.7
RoW	600.2	659.2	771.7	856.2	RoW	293.2	328.4	390.8	434.6
world	1842.7	2063.1	2462.1	2850.6	world	1119.4	1297.4	1603.9	1893.0
MAC, carbon-tax, or CO_2 emissions permit price									

CTAX ETS sectors	base year				**CTAX Non-ETS sectors**	base year			
2005EU/tCO_2	2005	2005-2010	2010-2015	2015-2020	2005EU/tCO_2	2005	2005-2010	2010-2015	2015-2020
WEU	0.0	20.6	36.1	51.6	WEU	0.0	20.6	36.1	51.6
SEU	0.0	13.1	3.0	1.6	SEU	0.0	13.1	3.0	1.6
EEU	0.0	9.4	11.0	11.4	EEU	0.0	9.4	11.0	11.4
CO_2 emissions by EU ETS and EU non-ETS sectors									
CO_2 ETS sectors	base year				**CO_2 Non-ETS sectors**	base year			
GtCO_2/year	2005	2005-2010	2010-2015	2015-2020	GtCO_2/year	2005	2005-2010	2010-2015	2015-2020
WEU	1.06	1.04	0.99	1.03	WEU	1.57	1.41	1.30	1.12
SEU	0.46	0.47	0.53	0.58	SEU	0.58	0.50	0.39	0.29
EEU	0.46	0.44	0.44	0.44	EEU	0.28	0.28	0.26	0.25
Total EU	1.98	1.95	1.96	2.04	Total EU	2.43	2.20	1.96	1.66
Share of electricity generation output by various technologies									
Year 2005	WEU	SEU	EEU	Total EU	**Year 2020**	WEU	SEU	EEU	Total EU
ElyCoa	20.4%	23.4%	60.6%	25.5%	ElyCoa	16.9%	19.4%	48.6%	20.9%
ElyOil	3.1%	12.4%	1.6%	4.7%	ElyOil	2.6%	10.3%	1.3%	4.0%
ELyGas	17.0%	32.4%	9.0%	18.9%	ELyGas	14.0%	26.9%	7.2%	15.9%
ElyLWR	37.9%	10.4%	19.9%	30.8%	ElyLWR	31.2%	8.7%	16.0%	24.9%
ElyHydro	18.7%	17.7%	8.5%	17.3%	ElyHydro	15.4%	14.7%	6.8%	14.3%
ElyOth	2.9%	3.6%	0.4%	2.7%	ElyOth	20.0%	20.0%	20.0%	20.0%

Table 6: EU Scenario 3.

(*) for EU regions and the world as a whole, the figure shows percentage reduction from Reference scenario. For non-EU regions, the figures indicate the "leakage" rates.

Because of the 20% renewable energy objective, the 20% emissions reduction target will be made somewhat 'easier' to achieve because there are now less emissions to be reduced than before. We therefore expect that the MAC for Scenario 3 will be generally smaller than that in Scenario 2 (at least for the regions where the renewable target is relatively easier to achieve than others. This is confirmed in Table 6. We note that for simplicity, we have assumed that there will be a uniform CTAX between allocated and non-allocated sectors – which implies total allocation to the ETS sectors will have to be adjusted over time to reflect the 'optimal' level. It turns out that this is only slightly lower than the actual allocation for period 2005-2010, (1.95 GtCO_2/year compared to 1.98 GtCO_2/year) and remains unchanged until 2015-2020 when it can increase slightly. Because of the assumption of 'optimal' allocation to the ETS sectors, the MAC for the ETS and non-ETS are the same as shown in Table 6.

4 An analysis of the EU 20-20-20 plan

In this paper, we have attempted to answer the questions: what are the consequences for Europe of implementing the EU 20-20-20 plan? Results of the simulation run for Scenario 1 indicate that in an ideal situation where a full emissions trading scheme can be implemented for the whole of the economy rather than for some selected sectors and in the whole of Europe, the cost of achieving the emissions reduction target in 2020 are relatively low. They range from a level of around 24 euros[2] per tonne of CO_2 in 2010 to a high of 47 euros per tonne of CO_2 in 2020. These figures are in accordance with empirical evidence which indicate a market price for emissions of around 20 euros per tonne of CO_2 in 2008. The costs would be much lower for the trading sectors if current allocations are to be maintained from now until 2020. Table 5 which shows the results for scenario 2 indicates that a permit price can be as low as 12.4 euros per tonne of CO_2 in 2005-2010 to 21 euros per tonne of CO_2 in 2020. However, this is possible only if the non-trading sector is to carry the full burden of any 'left-over' from the total emission reduction target for Europe as a whole. The effective emission reduction costs for the non-trading sector in that case would be around 39.2 euros per tonne of CO_2 in 2005-2010 climbing to a high of 101.8 euros per tonne of CO_2 in 2020. The discrepancies in emissions permit price for the trading and non-trading sector indicates that current allocation for the trading sectors are very much on the high side and could be much reduced. Currently, they are about 1.98 $GtCO_2$/year or around 47.6% of the total European emissions, From scenario results (Table 4), the optimal level should be around 1.78 $GtCO_2$/year or 42.8% of the total European total, and reduced even further to 1.65 $GtCO_2$/year by the year 2020 (at which time, it will make up 44.7% of the total European. Up to now, we have assumed that emission trading can occur between all all

[2] All values are measured in 2005 euro value

sectors and all regions of Europe. If Europe is to be distinguished according some geographical classification (WEU, SEU, EEU), then in the absence of a full European-wide emission trading scheme, SEU and EEU will enjoy a much lower cost of emissions reductions than WEU (see Table 6), as is to be expected, and especially if the '20% renewable electricity' target is also to be implemented for all regions of Europe. Table 6 indicates that the emissions reduction cost for WEU in that scenario (scenario 3) will be around 20.6 euros per tonne of CO_2 in 2010 and increasing to 51.66 euros per tonne of CO_2 in 2020. This is compared to just 9.4 and 13.16 euros per tonne of CO_2 respectively for SEU and EEU in 2010 and declining to just 1.6 euros per tonne of CO_2 in 2020 for SEU, or climbing to just 11.4 euros per tonne of CO_2 in 2020 for EEU. In total, this means that the cost of achieving the current climate policy for Europe is relatively modest, even if going alone. However, quite obviously, if other regions are not following Europe's example, the effect of the European action when going alone on the global environment is not as effective as it should be if other regions are also pursuing some similar climate policy. Tables 4 and 5 show that the total reduction in world CO_2 emissions is only about -1.4% to -2.7%. as compared to the significant reduction in e-missions in the European regions of at least -15% in 2010 and increasing to 36% in 2020 (as compared to the reference scenario). This is due to what is referred to as 'leakage' i.e. increases of emissions over and above the reference scenario level for non-European regions due to a shift of economic activities from Europe to these regions. The leakage rate is highest for Russia and USA ranging from about 2% in 2010 to 4.6% in 2020 (in the case of Russia), and 0.5% in 2010 increasing to 1.54% in 2020 (in the case of USA). Interestingly, when Europe is implementing the 20% renewable target at the same time as 20% CO_2 emissions reduction target, the lower cost of emissions reductions in Europe will also mean lower leakgage rate to other regions, and hence in this case, there is effectively no leakage: all other regions are also experiencing a reduction rather than an increase in emissions compared to the reference scenario. This can be explained by the fact that trade activities (especially in energy commodities) are now (scenario 3) much reduced as compared to the reference scenario – due to the 'efficiency' of the renewable policy. Table 7 shows the rates of growth for exports and imports by commodities for the world as a whole in scenario 3 as compared to the reference scenario.

Growth rate (%) of the value of global merchandise export at world prices									
Scenario 3					**Reference Scenario**				
	base year					base year			
	2005	2005-2010	2010-2015	2015-2020		2005	2005-2010	2010-2015	2015-2020
coa	3.15	-10.53	9.35	15.26	coa	3.15	18.82	21.50	29.10
Oil	3.65	5.74	18.08	16.84	Oil	3.65	18.48	18.36	17.44
gas	2.82	0.13	6.91	4.89	gas	2.82	13.39	12.14	10.65
p_c	3.69	6.07	17.83	16.87	p_c	3.69	17.91	17.78	16.97
ely	2.43	12.38	32.25	60.77	ely	2.43	14.47	14.32	13.72
CROPS	-1.81	10.03	28.14	35.99	CROPS	-1.81	22.28	31.36	43.20
AGR	2.77	9.90	17.67	16.29	AGR	2.77	15.58	15.03	14.11
min	3.90	12.72	19.01	14.49	min	3.90	17.78	16.36	13.25
CRP	4.12	11.91	18.02	14.47	CRP	4.12	16.66	15.34	12.62
EII	1.50	12.72	16.92	10.61	EII	1.50	17.21	15.31	12.12
OMF	0.98	12.93	17.25	10.96	OMF	0.98	18.08	16.36	13.33
TRN	3.24	11.88	19.04	15.49	TRN	3.24	17.40	16.28	13.89
SER	4.07	11.87	17.09	13.28	SER	4.07	16.31	14.82	11.83
Growth rate (%) of the value of global merchandise imports at world prices									
Scenario 3					**Reference Scenario**				
	base year					base year			
	2005	2005-2010	2010-2015	2015-2020		2005	2005-2010	2010-2015	2015-2020
coa	3.16	-8.93	9.50	13.97	coa	3.16	18.46	20.52	26.75
Oil	3.65	5.92	18.05	16.60	Oil	3.65	18.38	18.14	17.08
gas	2.85	0.13	6.92	4.91	gas	2.85	13.41	12.13	10.59
p_c	3.70	6.28	17.83	16.66	p_c	3.70	17.82	17.58	16.61
ely	2.43	12.38	32.25	60.77	ely	2.43	14.47	14.32	13.72
CROPS	-1.86	9.86	27.18	34.68	CROPS	-1.86	21.45	30.19	41.57
AGR	2.81	9.99	17.66	16.12	AGR	2.81	15.59	14.95	13.94
min	3.97	12.81	19.30	14.78	min	3.97	18.00	16.60	13.51
CRP	4.16	12.03	18.23	14.61	CRP	4.16	16.83	15.51	12.75
EII	1.55	12.75	17.07	10.81	EII	1.55	17.31	15.45	12.29
OMF	1.01	12.97	17.38	11.11	OMF	1.01	18.17	16.47	13.45
TRN	3.67	11.20	17.87	15.15	TRN	3.67	15.91	14.56	12.02
SER	4.07	11.87	17.09	13.28	SER	4.07	16.31	14.82	11.83
coa	3.16	-8.93	9.50	13.97	coa	3.16	18.46	20.52	26.75
Oil	3.65	5.92	18.05	16.60	Oil	3.65	18.38	18.14	17.08
gas	2.85	0.13	6.92	4.91	gas	2.85	13.41	12.13	10.59

Table 7: The rates of growth for exports and imports by commodities for the world as a whole in scenario 3 as compared to the reference scenario.

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