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Economic Impact Assessment of Alternative Climate Policy Strategies

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SUMMARY

This paper investigates the world economic implications of climate change policy strategies, especially the evaluation of impacts by an implementation of Clean Development Mechanisms, Joint Implementation and Emissions trading with a world integrated assessment model. Of special interest in this context are the welfare spill over and competitiveness effects that result from diverse climate policy strategies. In particular, this study elaborates and compares multi gas policy strategies and explores the impacts of the inclusion of sinks. Because of the recent decision of an isolated climate policy strategy by the United States of America, we examine the economic impacts of all world regions by a non cooperative and free rider position of the USA. It turns out that Clean Development Mechanisms and Joint Implementation show evidence of improvement in the economic development in the host countries and increase the share of new applied technologies. The decomposition of welfare effects demonstrates that the competitiveness effect including the spill over effects from trade have the strongest importance because of the intense trade relations between countries. Climatic effects have a significant impact within the next 50 years, cause considerable welfare losses to world regions and will intensify if some highly responsible nations like the USA do not reduce their emissions.

Keywords: Impacts of climate change, integrated assessment modelling

JEL: C0, D5, Q0

CONTENTS

1 Introduction

Recent climate policy negotiations confirm that the industrialised countries take the responsibility of climate change by the commitment to binding emissions reduction targets. Emissions reduction targets can be reached by either domestic policy measures or by more flexible, international mechanisms that allow minimised abatement cost options. Almost all countries that committed themselves to reduce greenhouse gas (GHG) emissions project significant emission increases in the absence of measures to tackle their emissions. However, the negotiated emissions reductions obligations do not represent real diminution targets for all countries: Economies in Transition (EIT) already reached their emissions reduction target because of poor economic performance in the aftermath of the transition. Because of that, the economies and emissions declined considerably so that their actual emissions lie far below their 1990 baseline emissions. This effect is mostly known as the so called “hot air” effect , representatives of the EITs however insist on calling it “fair air” because of the economic harms these countries already had and have to suffer.
Clean development projects (CDM) incorporate the option of transfer investment within specific emissions reduction projects from developed to less developed countries. These investment expansions trigger energy efficiency improvements in the host country and increases the share of new technologies. Joint implementation (JI) projects intend to achieve the same purpose as CDM but concentrate their activities within developed nations. The instrument of emissions trading can be implemented at national or international level, both reveal an opportunity to achieve emissions reduction targets at low abatement cost opportunities. Woerdman (2000) explains that JI and CDM are both more effective, efficient and politically acceptable than international emissions trading (IET).
A restriction of emissions trading and a restriction on the price of permits lowers the minimised abatement costs options for the participating countries. Mc Kibbin and Wilcoxen (1999) investigated the impacts of national emissions trading schemes, Bernstein, Montgomery et al. (1999) studied the restrictions of an emissions trading schemes on a global scale. Most analysis of the impacts by the implementation of the Kyoto protocol found that the allowance of international Kyoto mechanisms reduces the global and national costs of abatement significantly, an overview is given by Weyant and Hill (1999) and Edmonds, Scott et al. (1999). Kemfert (2000), Böhringer and Rutherford (1999) and Babiker, Reilly et al. (2000) found that the implementation of the Kyoto protocol induce negative impacts to the developed and developing countries. On the European level, the European Commission presented its green paper in 2000 on implementing an emissions trading scheme in Europe, Ellerman (2000) gives an overview of approaches by national emissions trading in Europe, concrete implementation rules summarise Tietenberg, Grubb et al. (1999) and Zhang (2001). Cap and trade policies studied Fullerton and Metcalf (2001).

The most important indicator of economic impact assessment explains the overall welfare changes measured in real income variations of different world regions. Even more interesting seem the different components and influence factors that shape world welfare changes. This paper sheds some light on this issue and decomposes overall economic welfare of different world regions changes in (1) pure autarkic domestic effects of impacts by domestic actions to reduce emissions and (2) competitiveness effects by the changes in terms of trade and (3) spill over effects that are purely induced neither by domestic action nor by competitiveness effects.
If the USA does not participate in the developed country agreement to shrink emissions, economic implications for all other commitment nations can only be profitable for the

contributing nations if an international emissions trading system is allowed so that a declining permit price will lead to more low cost abatement options. Furthermore, economic implications can merely be beneficial if solely economic impacts are evaluated without the inclusion of climate change impacts. The USA would cover a large share of total demand of emissions permits so that without their participation the permit price would drop significantly with the intention that other industrialised countries could reach their emissions reduction targets at much lower costs. A multi gas investigation reveals that nations face many more options to reduce emissions to that emissions abatement becomes less costly, see also Manne and Richels (2000) and Kemfert (2001). The inclusion of sinks in the analysis lowers the abatement costs considerably but increase the impacts of climate change only if the costs of sinks are not integrated. [1] The inclusion of climatic impacts in our analysis exposes the fact that climatic impacts have a significant impact within the next 50 years, although other studies cannot confirm this result because of restricted impact assessment (see Deke, Hooss et al. (2001)).

This article intends to study the world economic implication of climate change policy strategies, especially the implementation of Joint Implementation, Clean Development Mechanisms and Emissions trading. The assessment of emissions trading is analysed by the inclusion of different baseline assumptions and restrictions on trade. Of special interest in this context are the spill over effects that result from diverse climate policy strategies and the assessment as to whether spill over effects can make a significant contribution to climate mitigation options. Furthermore, the share of new technologies applied by different sectors are investigated. Additionally, climate impact assessment, a multi gas analysis and a sink enhancement strategy are evaluated interactively. Because of the recent decision of an isolated policy strategy by the United States of America, primary economic impacts are compared against a cooperative strategy.
This paper investigates the above mentioned decomposed economic effects of climate policy instruments by a world integrated assessment general equilibrium model WIAGEM**,** that is described briefly in the second part of the paper. The next chapters examine the decomposed economic implications of diverse Kyoto mechanisms, the impacts applied technologies, a multi gas strategy, the inclusion of sinks and the isolated climate policy strategy by the USA. The last chapter concludes.

2 The Model WIAGAM

The multi regional model WIAGEM (**W**orld **I**ntegrated **A**ssessment **G**eneral **E**quilibrium **M**odel) is an integrated economy-energy-climate model that incorporates economic, energetic and climatic modules in an integrated assessment approach. In order to evaluate market and non –market costs and benefits of climate change WIAGEM combines an economic approach with a special focus on the international energy market and integrates climate interrelations by temperature changes and sea level variations. The representation of the economic relations is based on an intertemporal general equilibrium approach and contains the international markets for oil, coal and gas. The model incorporates all greenhouse gases (GHG) which influence the potential global temperature, the sea level variation and the assessed probable impacts in terms of costs and benefits of climate change. Market and non market damages are evaluated due to the damage costs approaches of Tol (2001). Additionally, this model includes net

[1] A first assessment of sink costs and their potential economic impacts assess Missfeldt and Haites (2001)

changes in GHG emissions from sources and removals by sinks resulting from land use change and forest activities.

Figure 1 explains the interrelations of WIAGEM graphically. WIAGEM is an integrated assessment model which combines an economy model based on a dynamic intertemporal general equilibrium approach with an energy market model and a climatic submodel. The model covers a time horizon of 50 years and solves for five years time steps.[2] The basic idea behind this modelling approach is the evaluation of market and non market impacts induced by climate change. The economy is represented by 25 world regions which are aggregated to 11 trading regions (see Table 1), each region covers 14 sectors.

	Regions
ASIA	India and other Asia (Republic of Korea, Indonesia, Malaysia, Philippines, Singapore, Thailand, China, Hong Kong, Taiwan)
CHN	China
CNA	Canada, New Zealand and Australia
EU15	European Union
JPN	Japan
LSA	Latin America (Mexico, Argentina, Brazil, Chile, Rest of Latin America)
MIDE	Middle East and North Africa
REC	Russia , Eastern and Central European Countries
ROW	Other countries
SSA	Sub Saharan Africa
USA	United States of America

Table 1: World regions

The sectoral disaggregation contains five energy sectors: coal, natural gas, crude oil, petroleum, coal products and also electricity. The dynamic international competitive energy market for oil, coal and gas is modelled by global and regional supply and demand, the oil market is characterised by imperfect competition with the intention that the OPEC regions can use their market power to influence market prices. Energy related greenhouse emissions occur as a result of economic and energy consumption and production activities. At the present time, a number of gases have been identified as having a positive effect on radiative forcing (IPCC (1996)) which are included in the Kyoto protocol as “basket” of greenhouse gases. The model includes three of these gases: carbon dioxide (CO2), methane (CH4) and nitrous dioxide (N2O) which are evaluated to be the most influential greenhouse gases within the short term modelling period of 50 years. The exclusion of the other gases is not believed to have substantial impacts on the insights of the analysis. Because of the short term application of the climate submodel, we consider only the first atmospheric lifetime of the greenhouse gases, assuming that the remaining emissions have an infinite life time. The atmospheric concentrations induced by energy related and non energy related emissions of CO2, CH4 and N2O have impacts on radiative forcing which influence the potential and actual surface temperature and sea level. Market and non market damages determine the regional and overall welfare development.

[2] A detailed model description gives Kemfert (2001)

3 Economic Impacts of International Kyoto Mechanisms

3.1 Decomposed Economic Effects

Although there has been huge criticism and opposition against the ratification of the Kyoto protocol, recent climate change negotiations agreed to jointly reduce global emissions by industrialised countries. Besides the opportunity to reduce emissions domestically, international Kyoto mechanisms allow for low abatement cost options by trading certified emission reductions from investment projects in developed (JI) or developing countries (CDM) or emissions permits (emissions trading). These international mechanisms need to be supplemental to domestic action, so that domestic action constitutes a "significant element" of the effort made by each Annex I country to meet its emissions reduction obligation. The CDM executive board call for a prompt start for the CDM and JI activities, the latter are already implemented by activities implemented jointly (AIJ). The Conference of the Parties (COP) also agreed that all decisions, whether a CDM /JI project activities assist in achieving sustainable development, have to be made by the host countries. Emissions reduction units (ERU) or certified emissions reductions (CER) should not be generated from nuclear facilities to meet their emissions reductions commitments. Because of that, we include in our analysis CDM technologies that cover no nuclear but new, carbon free technologies.

The economic implications of the achievement of the quantified emissions reductions targets accomplished in the Kyoto protocol by the implementation of the Kyoto mechanisms are assessed by the previously described model WIAGEM that simulates world economic relations until 2050. It is assumed that the Kyoto mechanisms are initiated in the first commitment period 2008 – 2012 and last until the end of the projection period. We evaluate the economic impacts of the implementation of the Kyoto mechanisms by a comparison of full welfare effects measured in real income variations (Hicksian equivalent variation) to a so called "Business as Usual" (BAU) scenario where no policy measures take place. The economic assessment of all climate policy instruments depends crucially upon the assumptions on which model calculations are based, especially sensitivity parameter and emissions baseline development conjecture. Emissions baseline projections are particularly important if the economic impacts of climate policies are evaluated after the first commitment period of 2012, the second commitment period 2012- 17 and 2013-2025.[3]

1) The *CDM* scenario simulates the investment projects as additional investment decisions by Annex I countries that increase energy efficiencies in host countries
2) The *CDM with Sinks* scenario includes additional sinks projects like afforestation and reforestation within the first commitment period 2008-2012
3) The *JI* scenario represents the investment projects from industrialised countries to countries in transition (here REC region)
4) The ET scenario demonstrates the Annex I Emissions trading options

Figure 2 summarises the results by revealing the full welfare effects in terms of Hicksian equivalent in comparison to the BAU scenario. The first conclusion that can be drawn from this analysis is that the achievement of the Kyoto reduction targets is costly for the developed regions that have to commit the quantified emissions reduction targets. However, economic costs are much higher if they could only be reached by domestic policy measures without any flexibility as proposed by the Kyoto mechanisms. Because of the high abatement costs of

[3] See Kemfert (2001) for detailed information.

developed nations like Japan, Europe and USA, negative overall economic welfare effects occur in the range of 0.05 for Japan, 0.12 for the USA and 0.27 for the EU as percentage real income losses in comparison to a base case scenario. However, the CDM project transfer to developing nations like China, Asia, Latin South America and Sub Saharan Africa stimulate self enforcing investment processes that additionally augment the energy efficiency by an application of new, carbon free technologies. Both aspects improve the economic situation drastically so that developing regions can benefit considerably, expressed in welfare rises. It has to be stressed that we neglect all kind of transactions costs like search costs, negotiation costs, approval costs, monitoring costs etc. for both JI, CDM and emissions trading. The exclusion of transaction costs is assumed not to distort this analysis because the volume of transaction costs would change the results insignificantly.

If sink options are included in CDM projects negative economic implications in developed regions do not reach that extent as earlier described but cannot stipulate self enforcing investment activities in developing regions that trigger economic growth. Economies in Transition which are represented in this context by the REC region can benefit by the Joint Implementation programme which exhibit large welfare gains in comparison to the BAU case. Both scenarios demonstrate that welfare gains can be reached by host countries that benefit from self enforcing investment activities. This improves the economic development additional to the effect of increasing energy efficiencies that both enhances the distinct production processes. Moreover, this effect augments the competitiveness of developing regions so that all world nations could benefit by advanced terms of trade conditions. The share of new and less carbon intensive technologies is increased, as Figure 4 illustrates. For example, in China the share of hydro power plants can be amplified which intensifies the energy efficiency and forces a less strong emission rise or even an emission reduction. The positive economic effects of self enforcing investment growths by CDM projects succeed in an increasing share of carbon free technologies, the positive spill over effects support the rise of an application of carbon free technologies in developing countries. Positive production effects in fast growing regions like Asia and China occur mainly in industrial sectors that can benefit from new technologies, CDM projects that focus on forestration induce positive economic effects of agricultural sectors in regions like Sub Saharan Africa and Latin South America, as Figure 5 demonstrates.

A positive welfare effect as described before when CDM projects are active in developing countries, appear also in economies in transition because of JI projects that induce self-inflicting investment processes additional to strong economic growth. Emissions trading enables developed regions to minimise abatement costs. Obviously, countries in transition benefit by Annex I permit trading because of the above described “hot air” effect that allows a large purchase of permits which improves the welfare effect drastically.

The Kyoto protocol have been criticised by many scientists, especially after the USA decided to withdraw from their commitment a huge debate has been initiated about the strength and weaknesses of the Kyoto mechanisms.[4] Alternative proposals to the Kyoto mechanisms encompass national permit trading systems or the implementation of a global uniform carbon tax in order to force developing regions that are predicted to reach growth standards quite rapidly to reduce emissions as well. Besides the fact that a uniform emissions tax is neither economically efficient not effective, from the pure “equity” point of view the most responsible nations for climate change should take the lead to cut their emissions drastically. However, the

[4] To the criticism of the Kyoto protocol see Cooper (2001), alternative approaches to the Kyoto mechanisms see Mc Kibbin and Wilcoxen (1999) and Nordhaus 2001; Müller, Michaelowa et al. (2001) consider emission intensity targets (emissions per GDP) and hybrid approaches referred to as price caps. For both instruments they argue that the drawbacks outweigh the advantages and therefore do not offer “a credible replacement”.

best initiative to cover both equity aspects and the responsibility viewpoint is to open the emissions permit trading to *all* world regions. Following simulations confirm this hypothesis.

1) *Annex I permit trade* scenario versus No Trade
2) And the *Full Global Trade* scenario versus No Trade
3) *Uniform reduction target* in comparison to BAU scenario
4) *Supplementarity / Price cap* in comparison to full trade scenario
5) *Supplementarity/Price cap and high baseline* in comparison to a full trade scenario

The first simulations exhibit the effects that both Annex I permit trade and a full global trade scenario can increase regional welfare effects drastically in comparison to a scenario where no trade is allowed and predefined emissions reduction targets have to be reached. Full global trade also expands the welfare impacts of developed regions with high abatement costs like USA, EU and Japan because the permit price decreases due to the larger supply of permits. This, on the other hand, allows not as high welfare upsurges to the selling regions like China or Russia because of less revenues, but opens lower cost emissions reductions opportunities to developed regions. Mainly, positive welfare effects in developing regions occur due to positive terms of trade and spill over effects whereas full global trade raises revenue gains from the trade of permits (see Figure 3). A uniform reduction target of five percent (or a uniform carbon tax) for all world regions obviously leads to welfare losses in all world regions.
The supplementarity criteria initiates the same effect as of a price cap: because of restricted trade of permits (90 percent of full trade) the price of permits is lowered, which is the same effect as if a price cap was introduced. This price cap represents a uniform price ceiling so that no regional different permit prices occur that could trigger huge selling of permits in regions with high price limits. A restriction on permit trade also causes negative welfare implications to developed and developing regions in comparison to a full trade scenario. Especially economic regions with high abatement costs like the USA and Europe could benefit from a reduced carbon price because of lower abatement options. However, because of a lower permit price due to restriction on trade, less revenues can be earned so that Russia suffers welfare losses in comparison to the full permit trade case where it would have sold permits in a larger extent. The model results crucially depend on the assumption and predefinitions of parameter. If a higher baseline development for the first (2008-2012) and second (2013-2017) commitment period is assumed, regional welfare losses are higher if the supplementary criteria leads to a price cap of permits (see Figure 3). From a pure equity point of view, permit allocation should be ruled by either emissions per capita or pure per capita rules; model results confirm that this leads to a positive growth and welfare trend for all developing nations, see Kemfert (2001). The price of permits declines because of the advanced supply of permits. CDM and also JI investors focus almost solely on cost effective opportunities, CDM and JI credits will be cheaper than emissions permits. Because of the lower and more cost effective opportunities through JI projects, JI credits are estimated to be cheaper than CDM credits.

Year /Scenario	Annex I trade	Full Trade	CDM	JI	Suppl./Price Cap	PA/ Cap
2015	52	35	25	20	14	6

Table 2: Permit prices in US$ per ton of carbon

The decomposition of welfare effects exhibit that the pure domestic emissions abatement effect is determined by the reduction target that Annex I nations have to accomplish. Because of high emissions abatement costs Japan, Europe and the USA suffer welfare losses by domestic action, the only regions which could benefit are the countries in transition (see Table 3). Domestically, the effort that has to be taken by Annex I regions remains the same independently whether further flexible abatement measures are implemented or not. The competitiveness effect demonstrates the composed welfare effect that results from terms of trade changes; the spill over effect shows the welfare effect that is neither influenced by domestic actions nor by terms of trade variations. The Clean Development Mechanism stipulates positive competitiveness effects in the host countries China, Sub Saharan Africa and Asia. The CDM increases investment activities in the host countries so that not only energy efficiency growth but also increased overall economic activities induce an improvement of the trade balance. On the other hand, supporting countries that have to reach their intended emissions reduction target endure export losses because of an increased economic effort and a competitiveness deficit. If we are considering CDM projects with sink opportunities, neither economic advantages nor disadvantages for host and funding countries reach that extent as if sinks would not be included. This is because sink projects are not modelled as additional investment projects but as existing sinks in the host country that could be accounted for by the emissions baseline level. Because of that, investment activities are lower as in the pure CDM case so that favourable effects on the overall economy and on energy efficiency are diminished. In comparison to the case where emissions reduction have to be reached but no emissions trading is allowed, beneficial welfare effects in terms of pure competitiveness effects occur to all world regions without exemption if permit trading is endorsed. The main beneficiary are the regions in transition that also profit by the implementation of Joint Implementation projects. The spill over effects represent only a small fraction of the overall welfare effect. Positive spill over effect mainly occur in host countries of CDM projects and in the emissions trading simulation because of the beneficiary situation in the participating regions which induce competitiveness advantages and profitable spill over effects. The decomposition of welfare effects reveals that the domestic effort to reduce emission competitiveness effects play the dominant role whereas the spill over effects only represent a small fraction. This can be explained by the strong trade relations of world economies that influence the terms of trade variations significantly.

	Domestic				Competitiveness				Spill Over			
	CDM	**CDM with sinks**	**JI**	**ET**	**CDM**	**CDM with sinks**	**JI**	**ET**	**CDM**	**CDM with sinks**	**JI**	**ET**
JPN	-0,016	-0,016	-0,016	-0,016	-0,021	-0,002	-0,007	0,085	-0,002	-0,001	-0,037	0,062
CHN	0,000	0,000	0,000	0,000	0,051	0,039	-0,026	0,024	0,029	0,021	-0,014	0,016
USA	-0,041	-0,041	-0,041	-0,041	-0,031	-0,074	-0,081	0,064	-0,018	0,015	0,013	0,087
SSA	0,000	0,000	0,000	0,000	0,020	0,009	-0,027	0,059	0,010	0,001	-0,003	0,001
ROW	0,000	0,000	0,000	0,000	-0,024	-0,005	-0,026	0,025	-0,026	-0,005	-0,025	0,005
CNA	-0,013	-0,013	-0,013	-0,013	-0,020	-0,011	-0,029	0,011	-0,017	0,005	-0,008	0,092
EU15	-0,045	-0,045	-0,045	-0,045	-0,042	-0,074	-0,099	0,054	-0,044	-0,001	-0,016	0,050
REC	0,020	0,020	0,020	0,020	0,009	0,035	0,087	0,714	0,001	0,005	0,043	0,136
LSA	0,000	0,000	0,000	0,000	0,029	0,018	-0,006	0,018	0,021	0,012	-0,004	0,062
ASIA	0,000	0,000	0,000	0,000	0,075	0,043	-0,049	0,040	0,045	0,037	-0,041	0,000
MIDE	0,000	0,000	0,000	0,000	-0,076	-0,010	-0,076	0,030	-0,004	-0,001	-0,004	0,000

Table 3: Decomposed welfare effects of diverse climate policy strategies

3.2 Climatic impacts

Impacts of climate change cover market and non market damages, the former comprise all sectoral damages, production impacts, loss of welfare etc, the latter contain ecological effects like biodiversity losses, migration, natural disasters etc. In order to assess impacts by climate change we follow the approach of Tol (2001) to include impacts on forestry, agriculture, water resources and ecosystem changes as an approximation of a linear relationship between temperature changes, per capita income or GDP and protection costs due to sea level rise. Tol (2001) estimates vulnerability of climate change, covering a comprehensive evaluation of diverse climate change impacts. Besides sectoral impacts on agriculture, forestry, water resources and energy consumption he comprises impacts on ecosystems and mortality due to vector borne diseases, and cardiovascular and respiratory disorders. We use the assessed protection costs and use an approximation of potential impacts. Impacts are additional costs to the economy lowering other investments (crowding out effect), Kemfert (2001) gives a detailed model description.
In contrast to many other climate impact assessment studies that detect only insignificant economic impacts of climate change, we find considerable climate change impacts in the next 50 years. Model results demonstrate that primarily developing countries have to accept high welfare losses and GDP reductions in comparison to a scenario where no climate change impacts are included. The CC scenario describes the Climate Change (CC) scenario and is compared to a scenario where no climate impacts are evaluated.

	Welfare	GDP	Impacts in%
JPN	-0,08	-0,02	0,12
CHN	-1,14	-0,57	3,44
USA	-0,28	-0,05	0,30
SSA	-0,82	-0,24	1,45
ROW	-1,29	-0,31	1,87
CNA	-0,23	-0,09	0,54
EU15	-0,24	-0,06	0,36
REC	-0,44	-0,08	0,48
LSA	-0,29	-0,12	0,72
ASIA	-0,30	-0,18	1,09
MIDE	-0,04	-0,10	0,60

Table 4: Welfare in HEV, GDP in % and impacts in % of the CC scenario in comparison to no impact assessment

Developing regions suffer economic deficits if climate impacts are included because of their vulnerability and also because of higher percentage impacts of economic values. Relatively poor countries have to spend a significant percentage of their income on protection costs, as a consequence production losses because of less economic investments are much higher. Affluent countries like USA or Europe suffer by economic losses in terms of welfare as real income losses and in terms of GDP reductions, but percentage decreases are not as significant as in developing regions. As these results demonstrate, climate change impacts are significant within the next 50 years, primarily developing regions are affected negatively.

3.3 Multi Gas /Sinks

Regional greenhouse gas emissions differ substantially, the inclusion of the other greenhouse gases CH_4 and N_2O raises reference emissions for the European Union from 1.517 in 2010 to 1.894 billion tons of carbon. For the US, the inclusion of sinks lowers the greenhouse gas emissions from 2.133 to 2.030 in 2010 and 2.686 to 2.496 billion tons of carbon in 2050. Japan has no significant net emissions changes due to the inclusion of sinks. The global CO_2 emissions baseline pathway is assumed to increase from 6 to 12,7 billion tons of carbon in 2050 which is roughly consistent with the carbon emissions projections of the IPCC reference case of medium economic growth (Figure 6 and Figure 7). By including all greenhouse gases total GHG emissions increase from roughly 9 billion ton to 17 billion ton carbon equivalent emissions in 2050 that are in line with recent IPCC emissions scenarios (IPCC (2001)), see Figure 8.

The inclusion of sinks lowers total net GHG emissions to roughly 15.5 bil t. carbon equivalent in 2050 (see Figure 8). Sinks are assumed to be available at no cost which can be explained by the fact that only existing sinks potentials are included without accounting for new investment projects in carbon sinks. Because of the time deceleration of response impacts by potential and actual temperature changes range from 0.15 to 0.25 °C from 2030 to 2050, the inclusion of sinks cause comparatively marginal declines of actual temperature after 2030.

Because of the assumed linearity between temperature changes and sea level rise, the potential sea level increases by 1 cm in 2025 to roughly 1.8 cm in 2050. As seen before, the incorporation of sinks by land use change and forestry tends to lower this increase marginally after 2030. These changes are low in comparison to other projected studies (IPCC (2001)) and can be explained mainly by the short term time horizon considered and because of the time deceleration of response impacts (Figure 10).

Potential impacts by climate change are measured in percentage of global GDP which cover impacts on forestry, agriculture, water resources and ecosystem changes as an approximation of a linear relationship between temperature changes, per capita income or GDP and protection costs due to sea level rise. Emissions upsurge augments climate change impacts through warming and sea level rise. Figure 11 compares the impacts of climate change through the emissions reductions induced by the Kyoto protocol. The emissions reductions attempt prescribed by the Kyoto protocol causes hugh economic effort by drastic GHG emissions reductions which induce lower economic impacts of climate change measured in percentage of GDP. In terms of economic effect this means that with the inclusion of sinks, global impacts increase because of less economic welfare losses. Because of hugh economic efforts that have to be undertaken in order to reach the emissions targets of the Kyoto protocol, regional welfare declines especially for those regions which have high emissions reduction targets (Table 5). By the inclusion of sinks net emissions and therefore emissions reduction targets are reduced which cause impact increases because of less GHG emissions reduction needs and hence less income and GDP losses.

Developing regions suffer from the implementation of the Kyoto protocol and emissions reduction targets mainly because of negative international trade spill over effects due to the loss of competitiveness as it was explained before in this paper. Although we allow international emissions permits trading, economic welfare in terms of the Hicksian equivalent which explains the real income variation decreases in developed and developing regions in comparison to the base case. A drastic emissions reduction lowers the demand for energy which induce a energy price diminution. Regions with high energy import shares could benefit by this development but countries that face a high share of energy exports will suffer, as for example the coal exporting region China.

	Kyoto ALL GHG	Kyoto CO2	Kyoto GHG trade	Kyoto CO2 trade	sinks
JPN	-0,09	-0,15	-0,05	-0,08	-0,01
CHN	-0,08	-0,14	-0,04	-0,09	-0,06
USA	-0,35	-0,42	*-0,12*	*-0,19*	-0,10
SSA	-0,02	-0,01	-0,03	-0,01	-0,05
ROW	-0,14	-0,18	-0,05	-0,08	-0,01
CNA	-0,08	-0,10	-0,05	-0,07	-0,02
EU15	-0,28	-0,39	*-0,18*	*-0,24*	-0,12
REC	-0,08	-0,12	*0,24*	*0,33*	*0,11*
LSA	-0,02	-0,01	-0,01	-0,01	-0,03
ASIA	-0,12	-0,18	-0,09	-0,11	-0,08
MIDE	-0,13	-0,19	-0,08	-0,10	-0,01

Table 5: Welfare effects measured in Hicksian equivalent in comparison to the base case

If no emissions permit trading is allowed, one main seller of emissions permits Russia will suffer due to high economic deficits. This negative welfare effect for Russia and Eastern Europe can be explained as follows: because of poor economic performances the Russian economy endured a substantial economic recession, substantial production and trade efforts are necessary in order to regain their economic potential. If the Kyoto protocol is implemented, substantial welfare losses occur to Annex I regions resulting in terms of trade deterioration. In comparison to the BAU case where no emissions reduction measures are active, Russia`s positive export trends of, for example selling more gas than before, cannot overcompensate negative trade spill over effects coming from economic declines of other robust Annex I countries. Developed regions like EU15 or Japan face significant abatement costs which leads to higher economic losses by meeting the Kyoto emissions reduction target. If all GHG are included, the number of low costs abatement options are increased improving the economic situation for OECD regions. Without the allowance of permit trade, regional welfare impacts are much higher if only CO2 emissions are considered.

A comparison of a trade versus no trade scenario demonstrates that all countries can benefit from Annex B permit trading, mainly countries in transition as REC because of the “hot air” effect. Emissions permit trading better off all Annex B countries as well as non Annex B or developing countries owing to an improvement of the competitiveness. Annex B countries facing high emissions reduction targets and high domestic marginal abatement costs like Japan and USA will certainly benefit by Annex B emissions permit trading. Essentially, USA and EU 15 will trade permits within a full trade scenario because of their high share on total carbon emissions. The option of permit trade lowers negative welfare impacts, the inclusion of all GHG bring about a decreasing international permit price which also leads to more benefits for OECD regions by making imports more attractive relative to domestic emissions abatement.

The inclusion of sinks and the parallel GHG emissions reduction target forced by the Kyoto protocol improves the welfare effects in comparison to the Kyoto emissions reduction scenario without the inclusion of sinks. Especially USA and also Canada are benefiting by the inclusion of sinks because of their high sinks potential as well as the oil exporting region OPEC due to less severe emissions reductions targets. It also improves the economic welfare impacts in comparison to the cases where trade is allowed.

4 Non Cooperative Climate Policies

The process towards an establishment of international environmental agreements as the implementation of the Kyoto protocol comprises enormous effort of international negotiation and bargaining policies and strategies. International cooperative negotiation solutions can be reached if all negotiation partners and players expect improved results in comparison to a non cooperative approach and independent initiatives controlled by pure self interests. More precisely, individual nations will not cooperate in order to reach a common target if the difference of net benefits by non cooperative and cooperative strategies is very high. Whether an agreement can be reached depends on the opportunities to reduce interest conflicts towards a minimum agreement, a bargaining situation contains opportunities to collaborate for mutual benefits. As real negotiation processes demonstrate, a full agreement of all players is unlikely to exist, more realistic would seem to be that some player may act independently or unilaterally in order to maximise their own welfare and self interests, some other player join small and stable coalitions (Carraro and Siniscalo (1992), Carraro and Siniscalco (1993) and Hoel (1994)), others act as free riders, i.e. they stay outside instead of participating in it. The encouragement of countries to join a partial coalition can be enforced by capital or technology transfer Tol, Lise et al. (2000) that can be interpreted as side payments. The assessment of partial coalition games investigate Kemfert and Tol (2001). Applied model results demonstrate that the partial coalition of Japan and the USA is the only internally and externally stable coalition.

However, although the USA is the greatest emitter of greenhouse gases, recent statements by the US governments confirm that the USA will almost certainly not ratify the Kyoto protocol in its current state. Their main argument against the emissions reductions commitment agreed in Kyoto is that it is ineffective and unfair to the US due to the lack of meaningful participation by key developing nations. Any agreement should also include significant commitments from these countries. However, no developing country is projected to surpass total USA carbon emissions in the next 20 years.

As there is no concrete alternative from the US government to decrease emissions drastically, the USA seems to act as a singleton and free rider. Other countries in contrast stick to their previous commitment of greenhouse gas reduction targets which leads to the question of what economic impacts will result for all other Annex I countries and especially to what extent the US economy will be affected. If the USA does not participate in the developed country agreement to shrink emissions, economic implications for all other commitment nations can only be profitable for the contributing nations if an international emissions trading system is allowed so that a declining permit price will lead to more low cost abatement options. The USA would cover a large share of total demand of emissions permits so that without their participation the permit price would drop significantly with the intention that other industrialised countries could reach their emissions reduction targets at lower costs. If Annex I emissions trading is allowed without any supplementarity and banking options the permit price would drop to $US 8 per ton of carbon. However, economic implications can merely be beneficial if only economic impacts are evaluated without the inclusion of climate change impacts. The loss of welfare of other Annex I countries can be explained by the higher climatic change impacts.

If the US withdraw its support to the Kyoto protocol, all other countries have to support the proposal of GHG emissions reduction declared by the Kyoto protocol in order to reach the required 55 % of Annex I emissions. Model simulations demonstrate that the US could benefit substantially if the other countries reduce their emissions as declared within the Kyoto protocol; the economic benefits are higher if the other countries have additionally diminished the US emissions as declared as the global reduction target of roughly 5.2 percent. We compare our model results against a scenario where the American act cooperatively and meet their greenhouse gas reduction target. For Russia, the US withdrawal induce less economic benefits because of the reduced emissions permits demand which leads to less economic revenues and earnings for Russia. A smaller amount of emission permits demand induces a significant decline of the permit price inducing fewer economic revenues for selling regions like Russia. By including all greenhouse gases in our analysis global GHG raise from in 2020 13.7 to 17.1 bil. tons of carbon equivalent in 2050. If the USA will not reduce GHG emissions and the other Annex I regions decide to reach the Kyoto target even though and developing countries will not reduce their GHG emissions, all other Annex regions have to reduce emissions by 30 % which induce substantial welfare losses.

	US no reduction less global target	US no reduction global target 5.2
JPN	0,00	-0,30
CHN	0,05	-0,15
USA	0,08	0,08
SSA	0,04	-0,26
ROW	0,00	-0,06
CAN	0,02	-0,74
EU15	-0,18	-0,41
REC	-0,21	+0,12
LSA	-0,07	-0,10
ASIA	-0,03	-0,01
MIDE	0,12	-0,62

Table 6: Welfare effects measured in Hicksian equivalent

If the USA decides not to reach its GHG emissions reduction target, it could increase the welfare development significantly whereas other regions have to accept welfare losses which are especially high if the other regions have to diminish its emissions by 30 percent in order to reach the global target negotiated in Kyoto. The welfare losses especially for the EU results from the higher climate impacts that are caused by less emissions reduction. The demand of permits drastically decreases by the US withdrawal so that mainly Russia has to accept welfare losses. But, if all nations have to meet the global reduction target negotiated in Kyoto, permit demand increases considerably so that Russia could sell its excess supply of permits, even if Russia has to accept higher emissions reduction targets it will not meet their 1990 baseline emissions because of their poor economic performances. Because of that, Russia is the only region that could benefit by a higher emissions reduction target if the US will not ratify the Kyoto protocol. All other Annex I regions suffer by higher emissions reduction targets in comparison to the previous mentioned scenario because of the additional climate change impacts that induce welfare losses.

5 Conclusion

Several conclusions can be drawn from this analysis. The attainment of specific emissions reductions targets is costly for those countries that have to meet its obligations. Clean Development Mechanisms and Joint Implementation show evidence that these measures can improve the economic development in the host countries by mainly self enforcing investment processes that induce positive production effects and the application of new and carbon free technologies in industrial sectors. The decomposition of welfare effects demonstrate that the competitiveness effect including the spill over effects from trade have a more significant share than other spill over effects because of the large trade relations between world nations. Climatic effects have a significant impact within the next 50 years that cause substantial welfare losses to world regions and become higher if some high responsible nations like the USA do not reduce their emissions. The additional inclusion of sinks improves the welfare impacts in comparison to all other scenarios which leads to higher economic impacts and damages. The conclusion from this analysis is that on the one hand pure economic effects demonstrate positive impacts of the inclusion of sinks but on the other hand positive income effects also lead to higher non market impacts according to the temperature and seal level variations.

Acknowledgement

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Annex: Figures

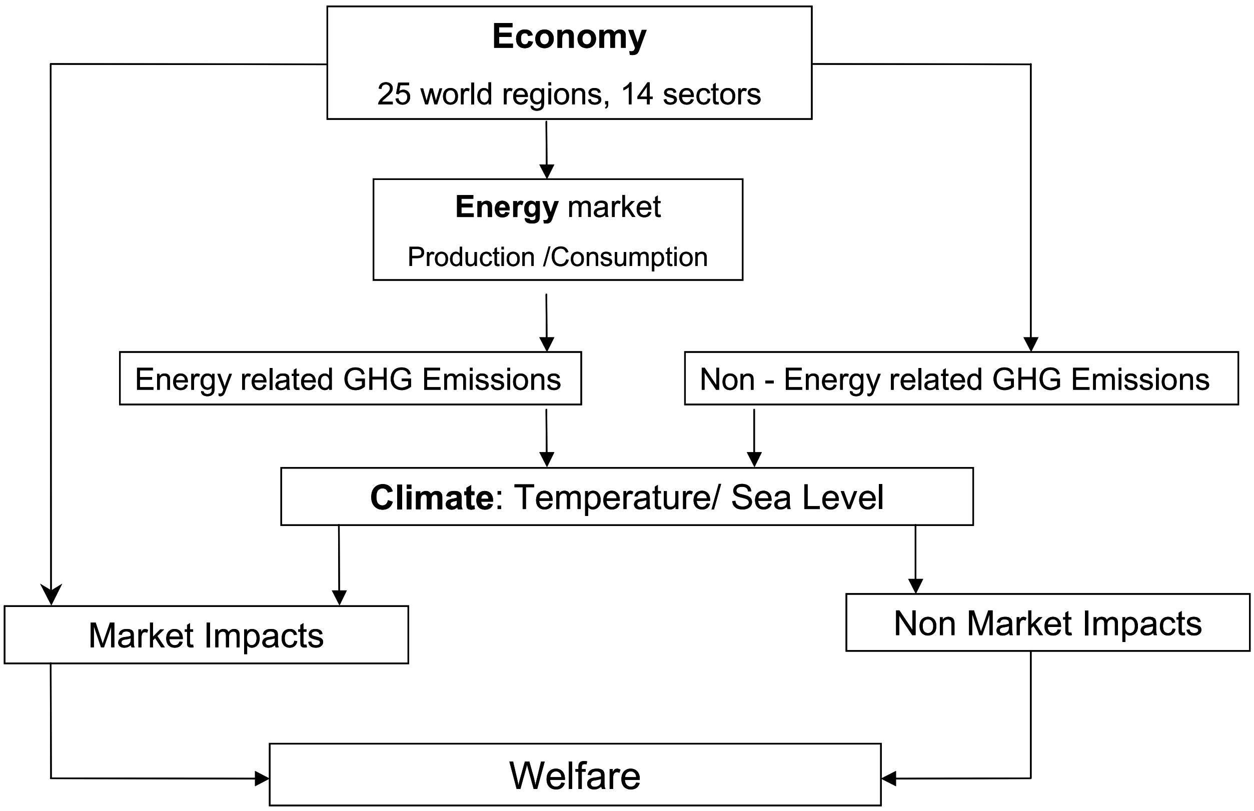

Figure 1: Interrelations in WIAGEM

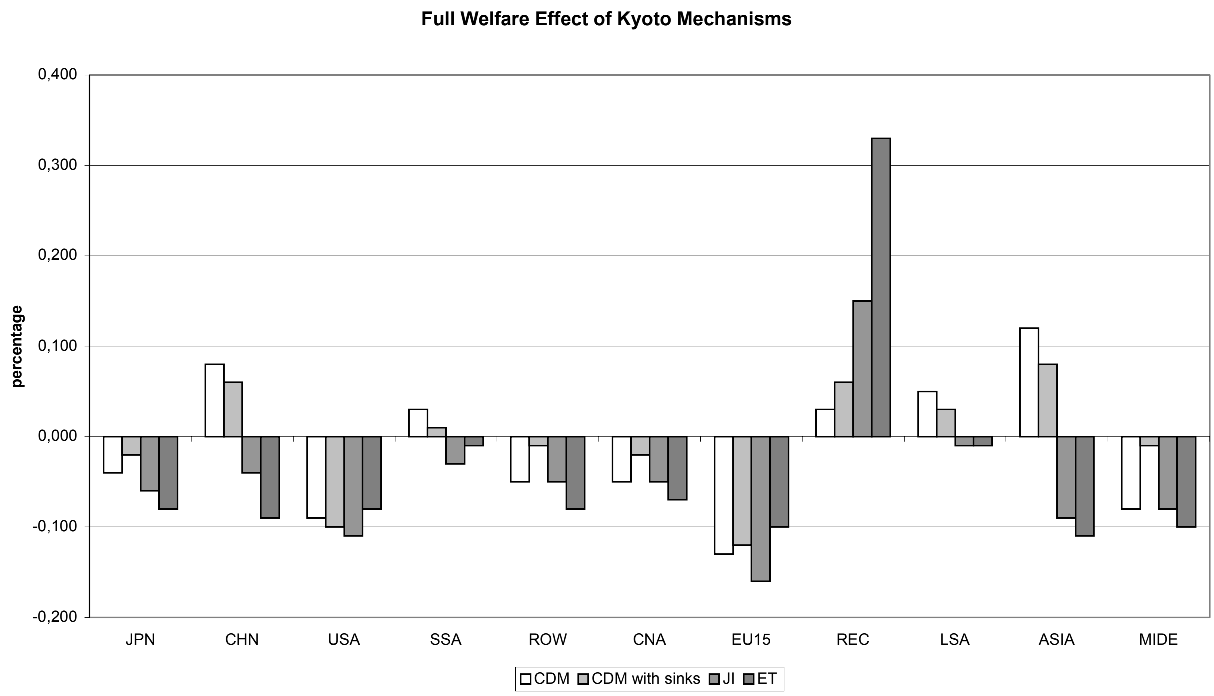

Figure 2: Full Welfare Effect of Kyoto Mechanisms in percentage to BAU Scenario

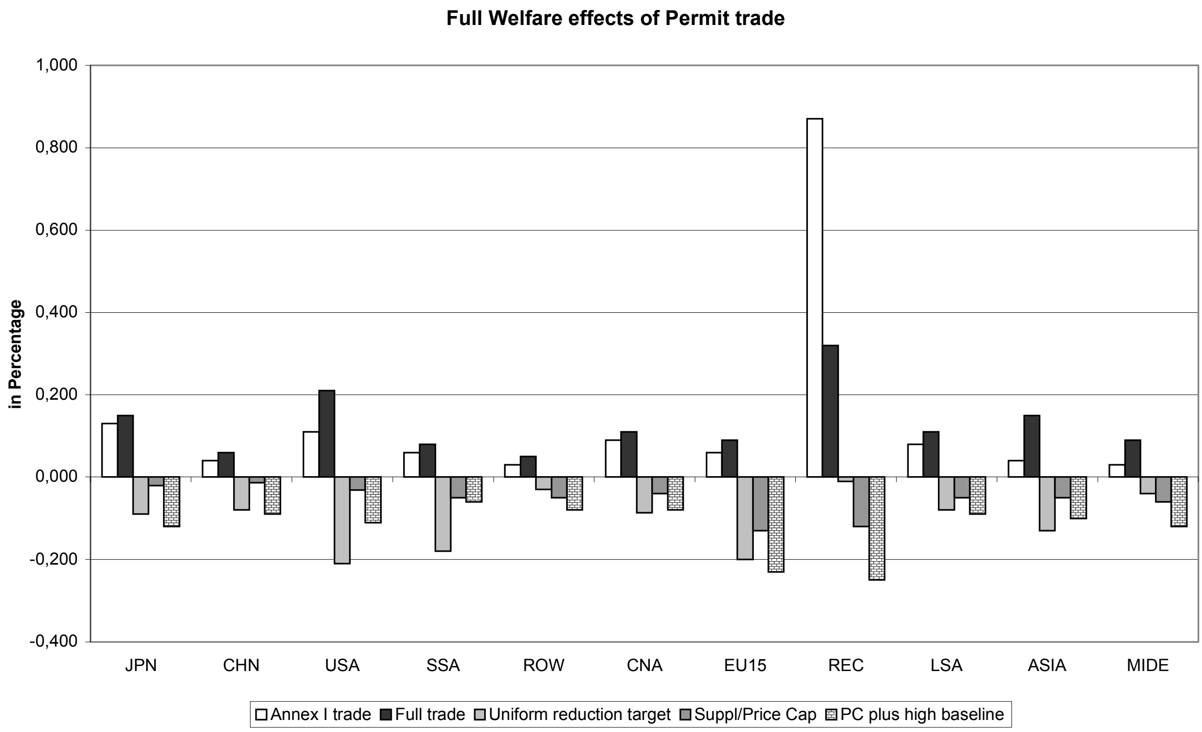

Figure 3: Full Welfare Gains of Permit Trading in comparison to a no trade /BAU/ full trade scenario

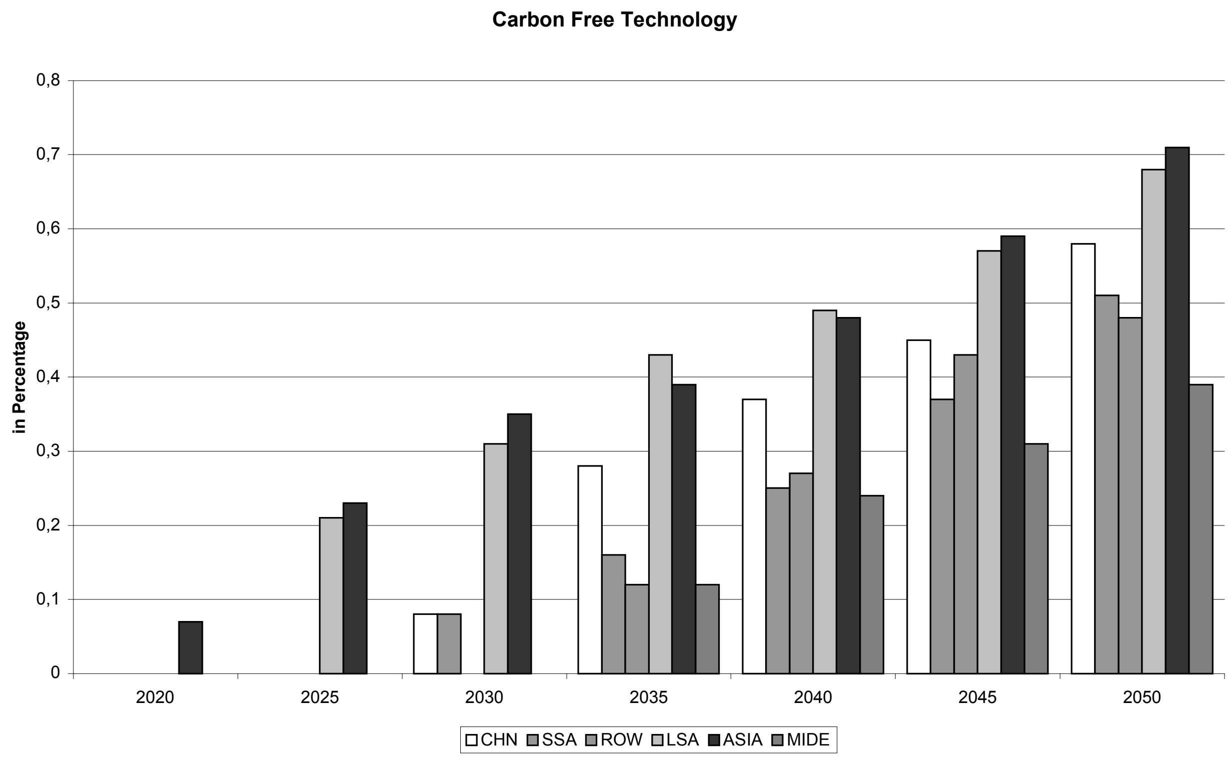

Figure 4: Share of regional applied carbon free technologies in the CDM scenario

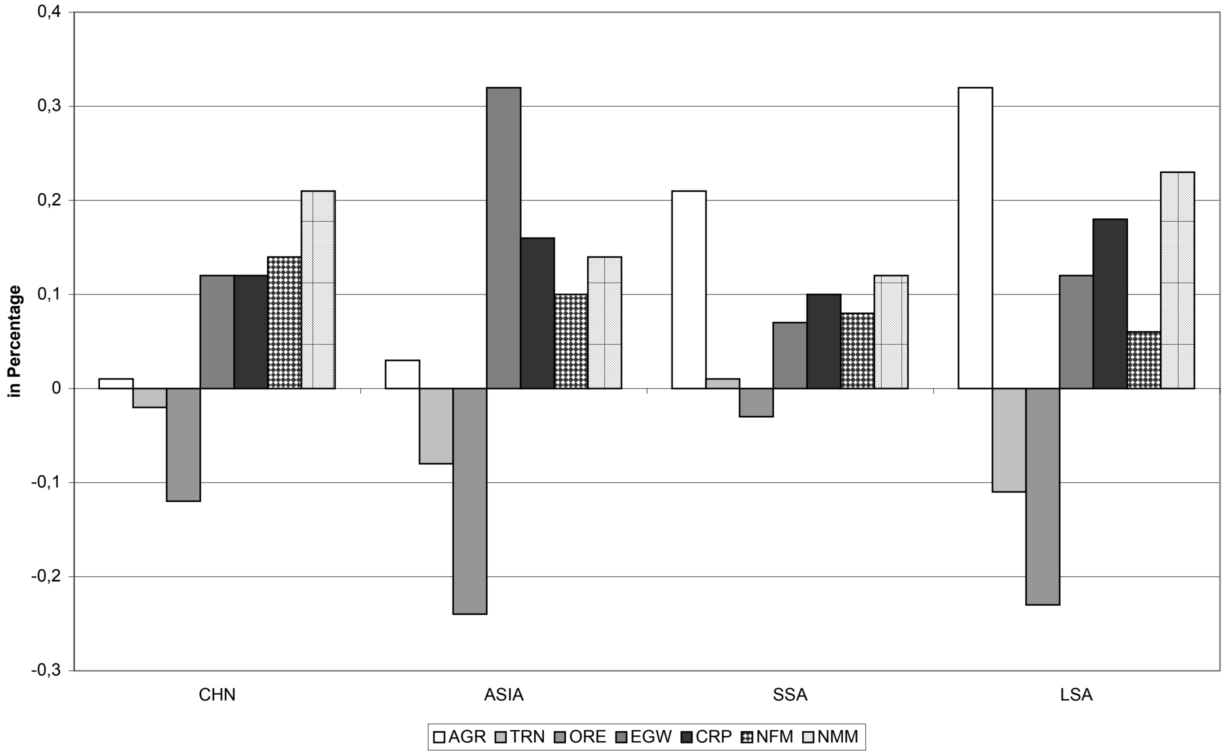

Figure 5: Sectoral production effects in 2040 in percentage from the baseline in the CDM scenario

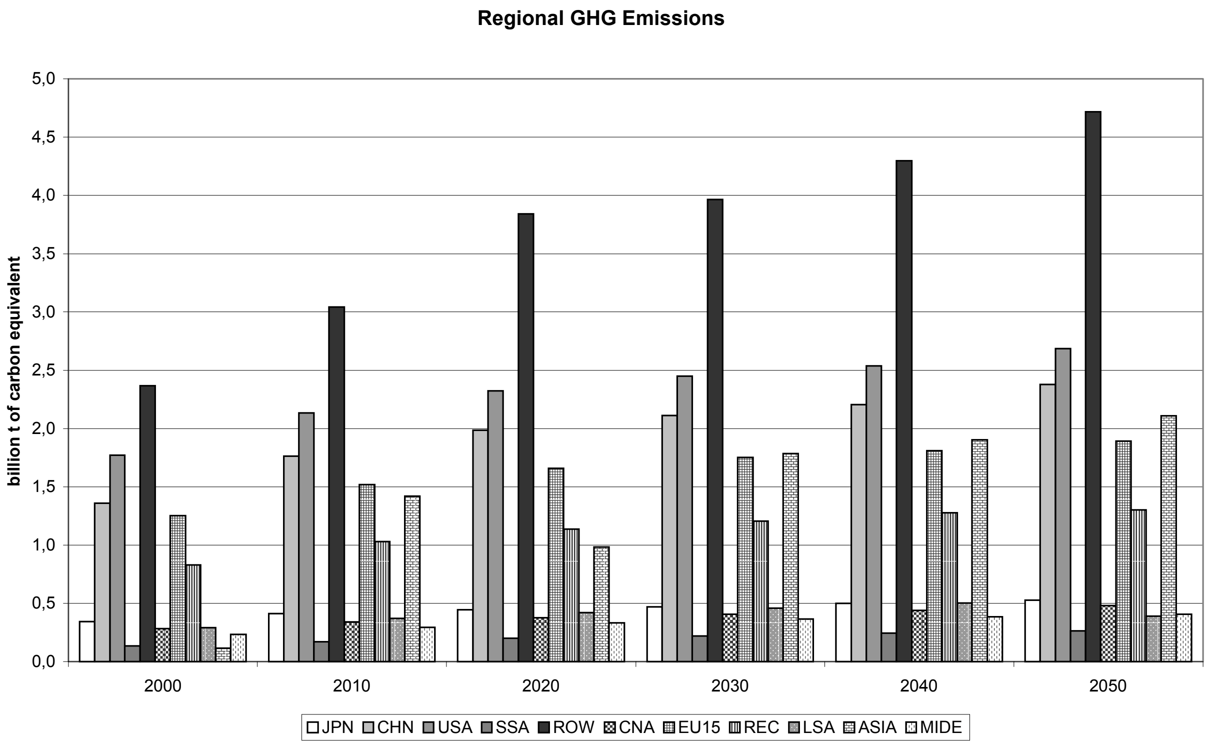

Figure 6: Regional greenhouse (GHG) emissions

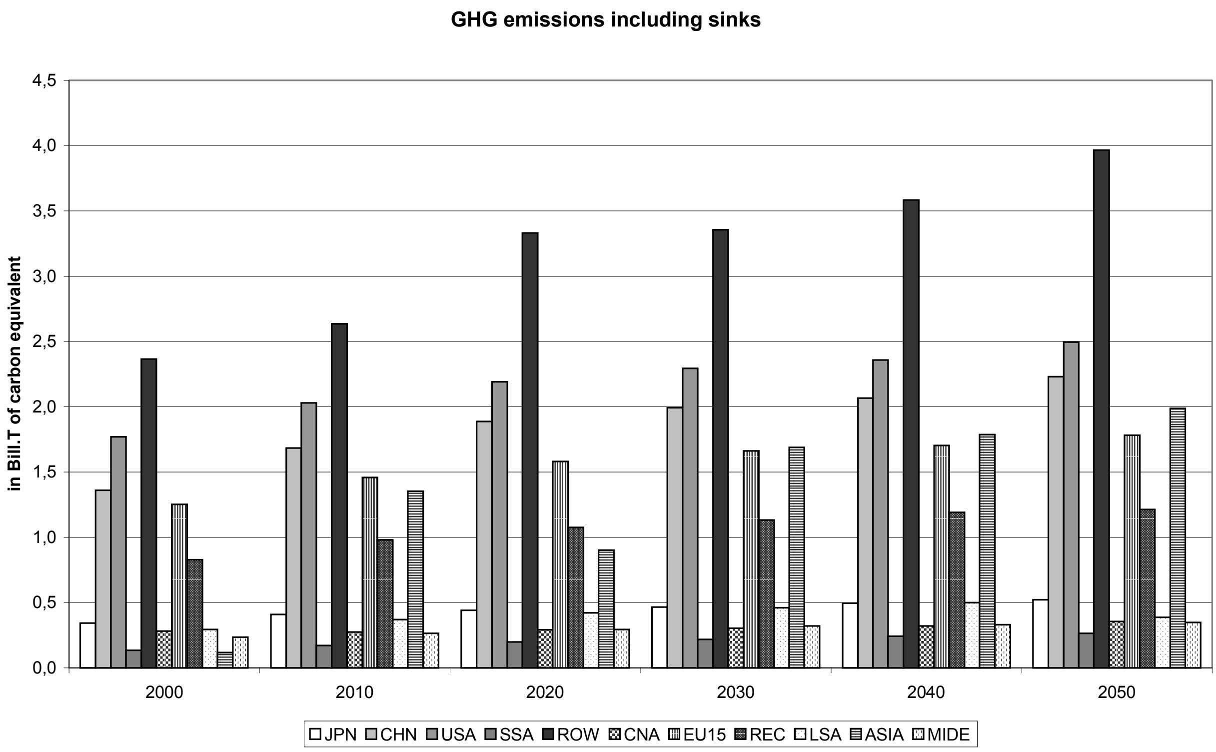

Figure 7: Regional GHG emissions including sinks

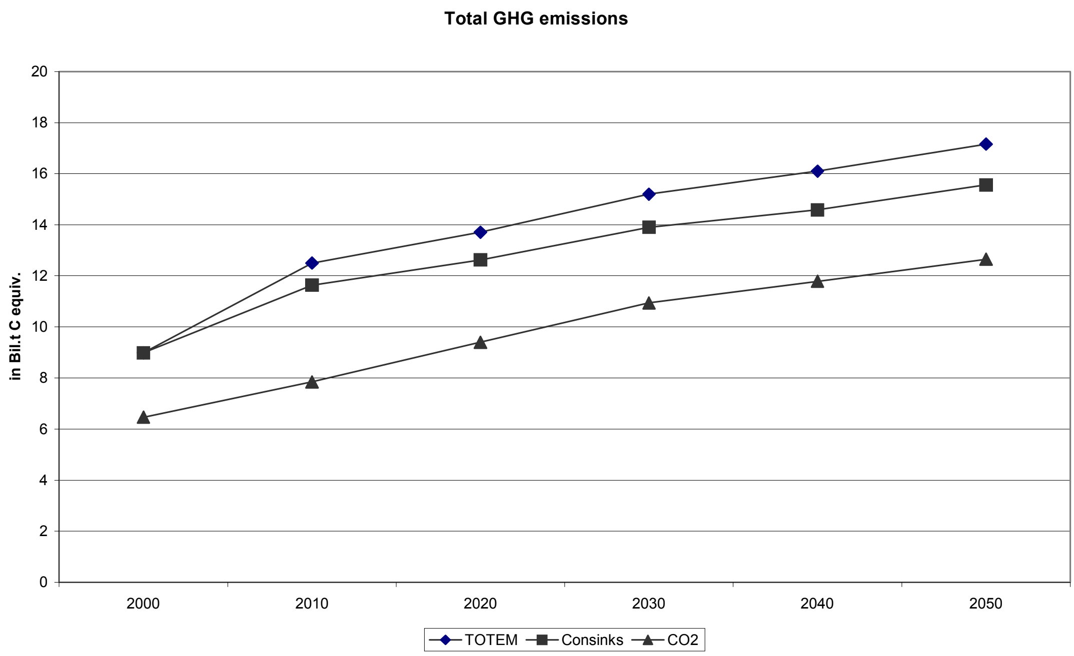

Figure 8: Total CO2 and greenhouse gas emissions with and without the inclusion of sinks

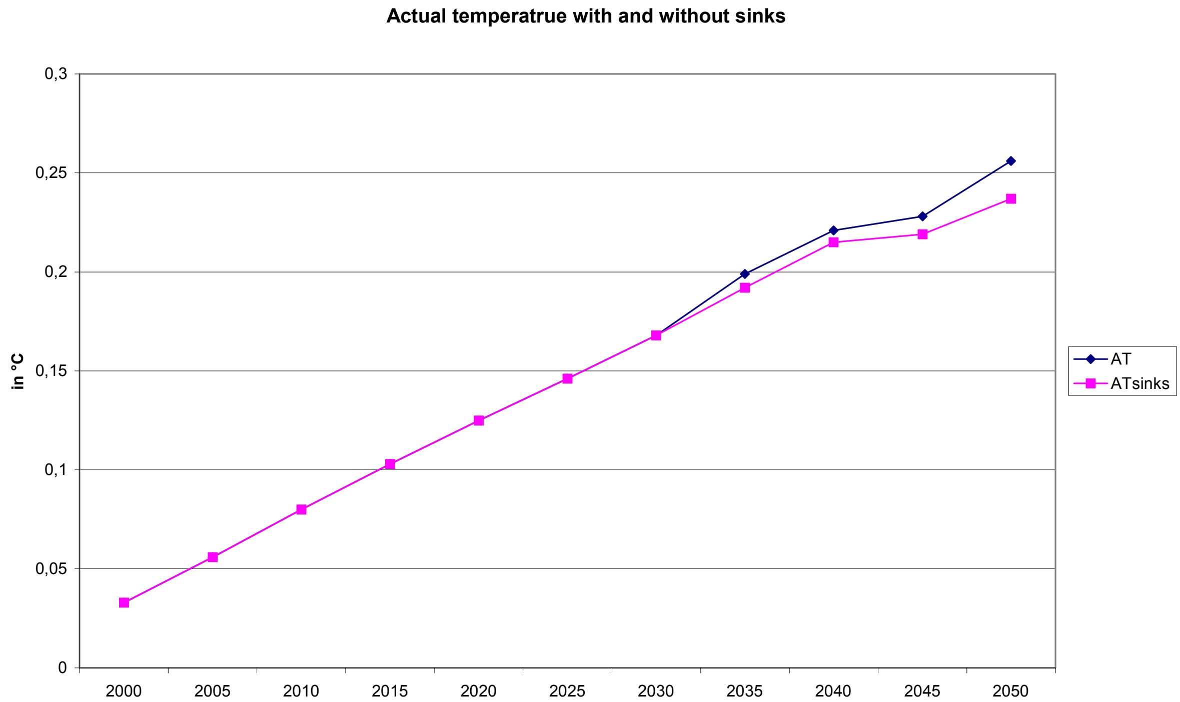

Figure 9: Actual temperature changes with and without including sinks

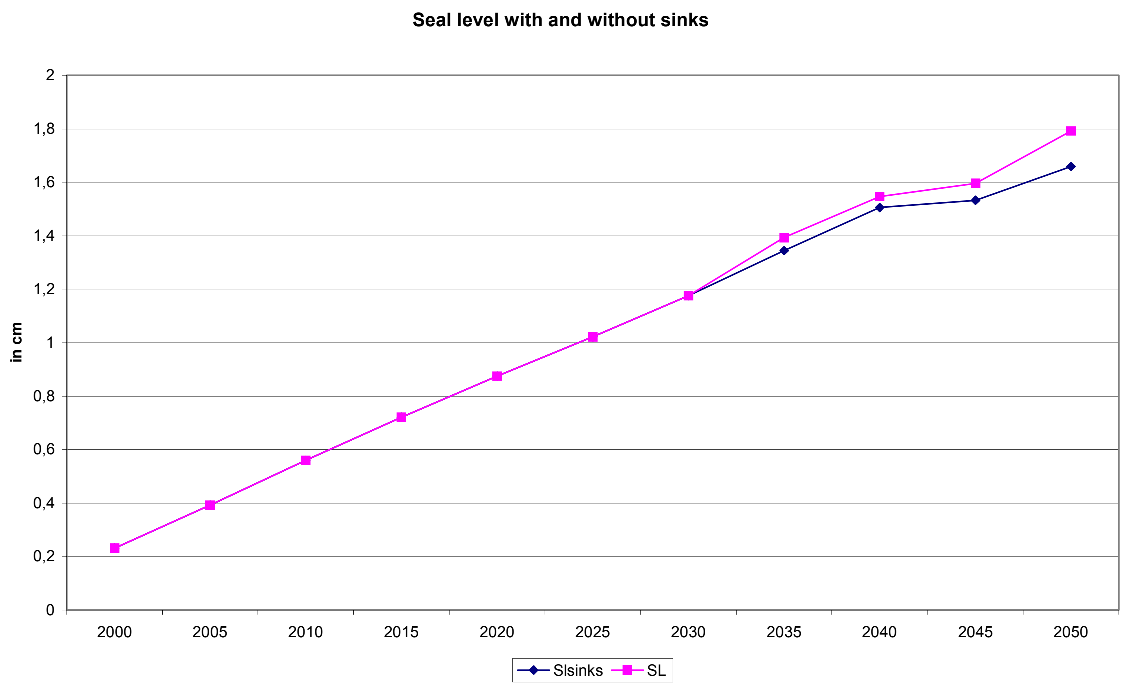

Figure 10: Sea level changes without and without the inclusion of sinks, in cm

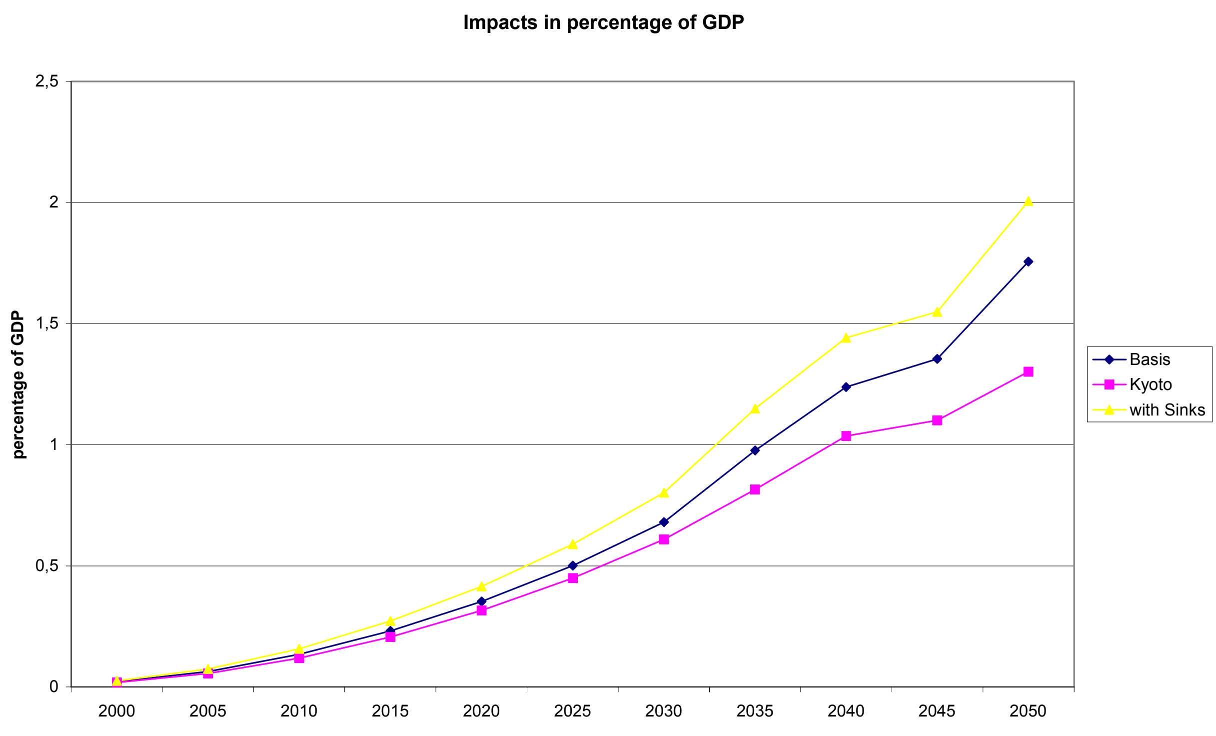

Figure 11: Impacts of climate change in percentage of global GDP

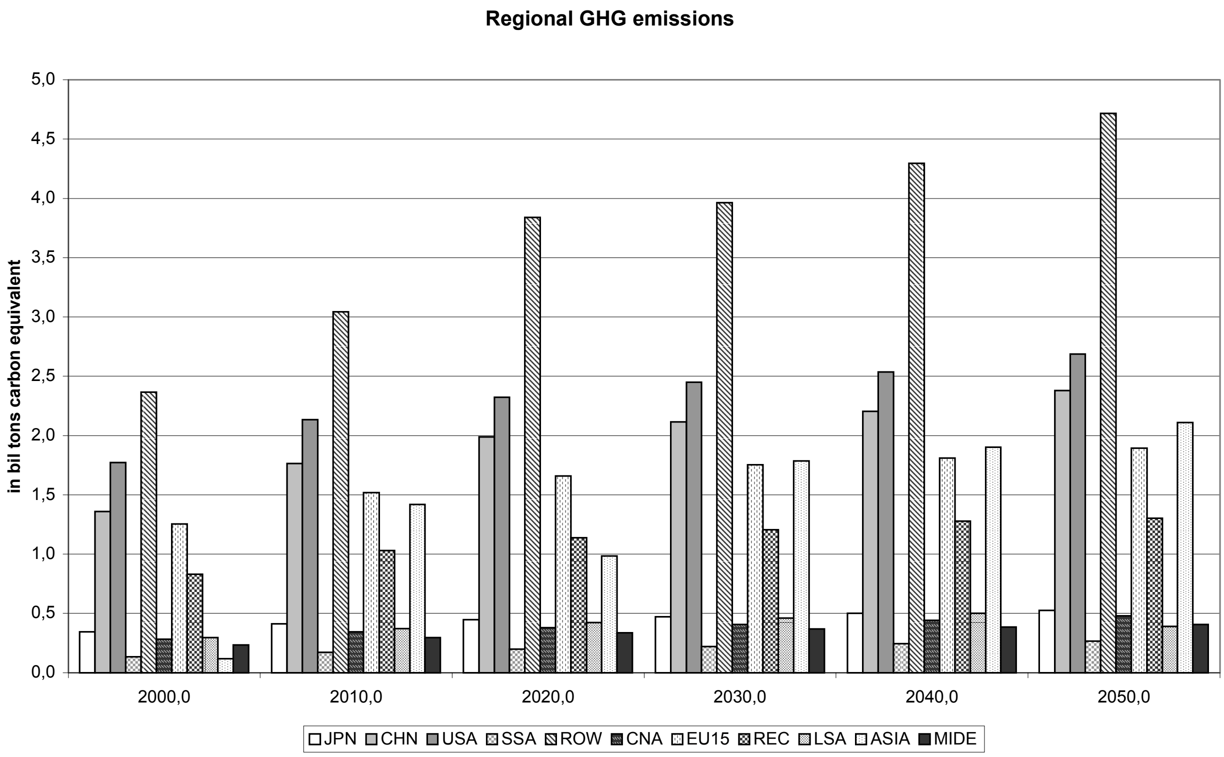

Figure 12: Regional GHG emissions reaching the Kyoto emissions reduction target

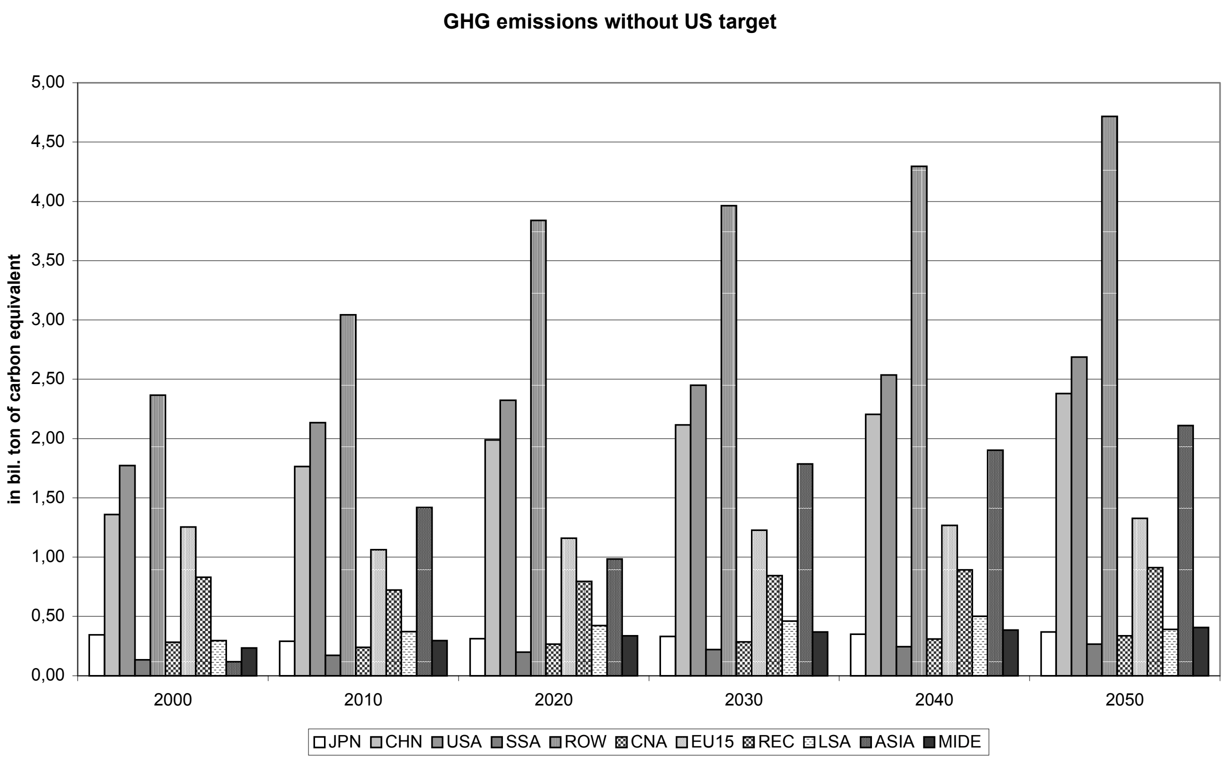

Figure 13: : GHG emissions with global Emissions reductions target of 5.2 without US reduction

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