



Project 21/05:

“Economic criteria for assessing alternative negotiation results of a post-2012 climate regime”

on behalf of the German Federal Ministry of Economics and Technology

### **Summary**

GWS mbH:  
Christian Lutz (project leader)  
Ariane Jungnitz  
Bernd Meyer

Prognos AG:  
Almut Kirchner  
Christian Michelsen

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Gesellschaft für Wirtschaftliche Strukturforchung mbH (GWS)  
Heinrichstraße 4  
D-49080 Osnabrück  
Dr. Christian Lutz  
Email: [lutz@gws-os.de](mailto:lutz@gws-os.de)  
Tel.: +49(541)40933-12  
Fax: +49(541)40933-11  
<http://www.gws-os.de>

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## **Project Contents**

The research project 21/05 “Economic criteria for assessing alternative negotiation results of a post-2012 climate regime” was accomplished between January 2006 and September 2007 on behalf of the Federal Ministry of Economics and Technology. Given the recent discussion on climate change, possible criteria for a distribution of targets for global action on mitigating climate change among the major economies have been highlighted and possible outcomes of the negotiation process substantiated in the course of this project. Using the extensive and disaggregated global GINFORS model, consequences of the different post-Kyoto regimes on the German and European economy and other major economies in the medium run until 2020 are depicted.

### **State of the discussion on climate change**

Global greenhouse gas (GHG) emissions substantially increased since 1990 in spite of various national and international mitigation activities. Natural scientists expect in case of continued emission growth a significant increase of global mean surface temperature, which might have diverse negative effects. Recent insights of the IPCC on climate change and warnings by the “Stern Review” on massive economic costs of this development newly enhanced the discussion.

The EU has therefore affirmed the strategic objective of limiting global temperature rise to not more than 2°C above pre-industrial levels at the Brussels summit in March 2007 under German presidency. The EU further committed to reducing GHG emissions by 20% compared to 1990 irrespective of the results of negotiations on a post-2012 agreement. If other industrialised countries commit to similar reduction targets and economically more advanced developing countries agree upon adequate contributions to climate protection, the EU is willing to reduce emissions by 30% until 2020. Furthermore, EU targets were set for a substantial expansion of the use of renewable energies as well as for an increase in energy productivity. These targets not only contribute to climate change mitigation but also to energy security in the EU due to a reduced dependency on energy imports. The EU explicitly emphasises three objectives of energy and climate change policy: security, competitiveness of EU industries and sustainability. The German government started with a corresponding integrated energy and climate programme in August 2007 to implement the EU decision on the national level.

After the G8 summit in Heiligendamm the likelihood of a post-2012 agreement including the U.S. increased. The U.S. have agreed on negotiations under the UN Framework Convention on Climate Change. The UN Climate Change Conference in Bali in December will indicate how seriously and how fast this process will proceed.

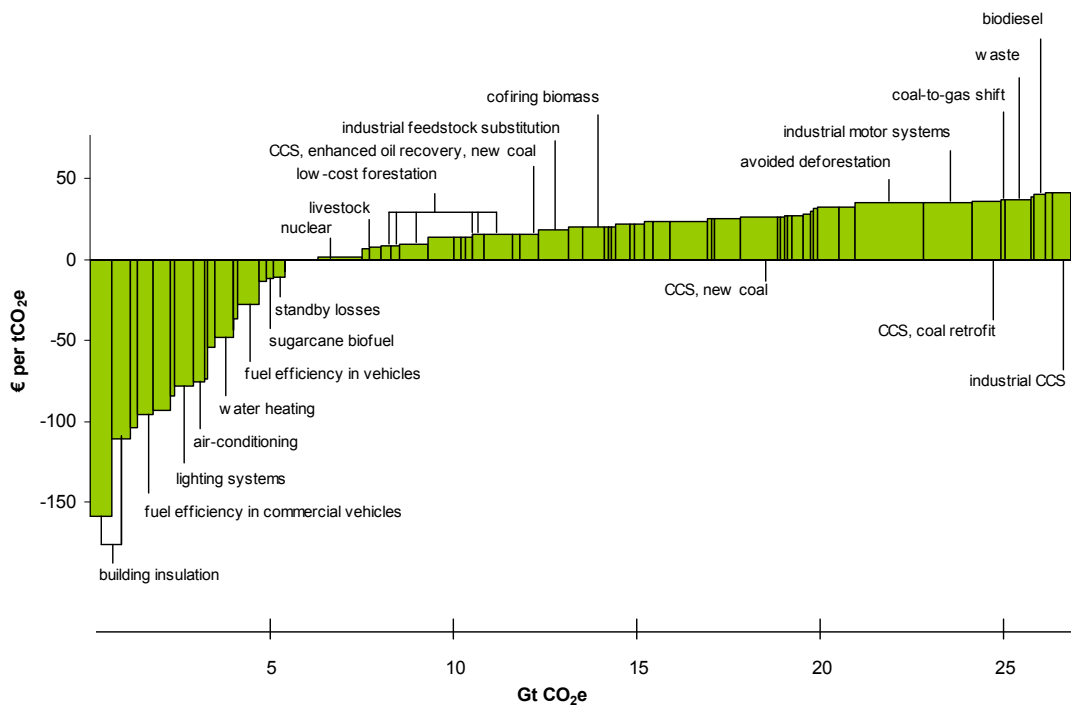
The discussions on the costs of climate protection often originate from marginal abatement cost curves which are deduced from technological analyses. Compared to the reference scenario 25Gt CO<sub>2</sub> equivalents (CO<sub>2</sub>e), i.e. approximately 25 times the amount of the current emissions of Germany, could be saved world wide in 2030 at costs of less than 40 Euro per ton of avoided CO<sub>2</sub>, according to a study of McKinsey (see Figure 1). A set of measures, e.g. in the building sector, has negative abatement costs, and would therefore even be profitable for investors without explicit mitigation commitments. Apparently, the exhaustion of this potential is rather difficult due to various constraints.

By now, a detailed analysis of abatement potentials and costs on sector level exists for Germany as well (McKinsey&Company 2007), but it does neither quantify nor

model secondary effects. It is therefore not possible to deduce macroeconomic costs of policy strategies, which are the main issue of the analysis at hand.

An overview of possible macroeconomic costs of extensive actions for mitigation of climate change is given in the recent report of the IPCC (2007), according to which different analyses show that the yearly reduction costs of alternative stabilisation paths of global emissions until 2030 will be below 3% of global GDP. These analyses generally assume an effective global post-Kyoto framework and optimal exploitation of existing economic potentials in energy efficiency. All countries have unlimited access to existing and new energy technologies. Less optimal conditions have to be assumed at least on the way to a global post-2012 framework though. There exist a full set of constraints including principal-agent problems. Cost-efficient change of capital stocks via new investment takes a long time. Various studies indicate that the use of flexible mechanisms can substantially reduce the costs of mitigation in the EU.

**Figure 1: global cost curve for GHG abatement measures, 2030**



Source: McKinsey (2007)

### Development of GHG emissions since 1990

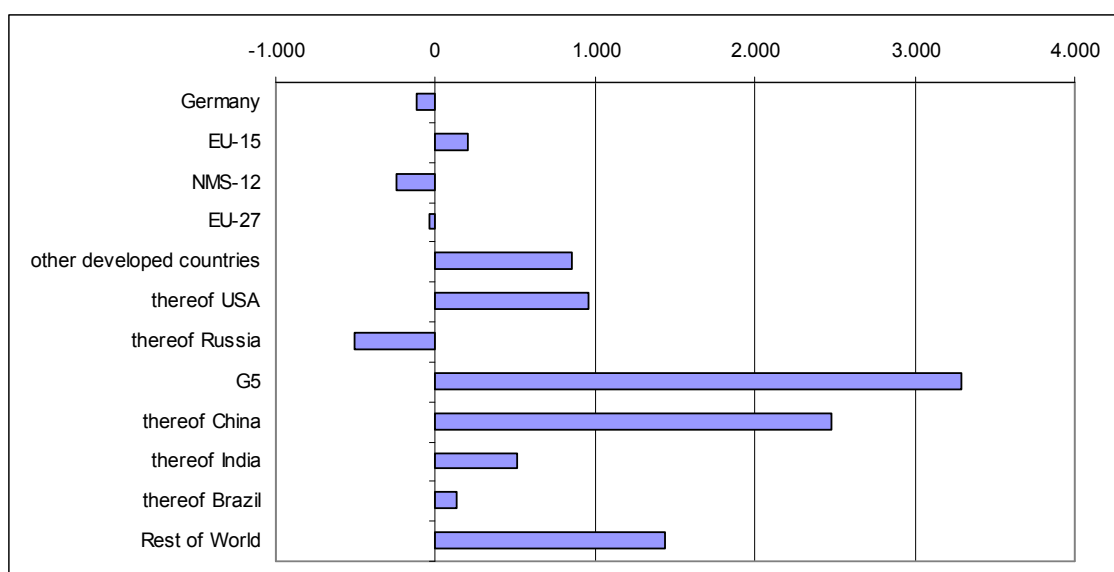
Energy-related CO<sub>2</sub> emissions, which constitute about 70% of total GHG emissions, increased between 1990 and 2004 by 27.9% world wide. While emissions decreased in countries of transition and some of the developed countries, they substantially increased in the remaining developed countries. They more than doubled in some of the major emerging countries. The absolute increase was largest in China and the U.S. The major part of the total increase in global emissions originates from the G5 countries (China, India, Brazil, South Africa and Mexico). Still, the developed countries were responsible for more than half of global emissions in 2004. The per-capita emissions in these countries are considerably higher than per-capita emissions in the developing countries.

Data on GHG emission for gases other than energy-related CO<sub>2</sub> emissions is rather deficient. Emerging and developing countries are not obliged to report annual data. The developed countries could reduce part of these emissions by cost-efficient technical measures. These emissions most probably still increased on a global level. Considerable cost-efficient potentials for reducing non-CO<sub>2</sub> emissions still exist, especially in developing countries.

Energy efficiency improvements and changes in the energy mix could not compensate the increased emissions induced by population growth and higher income in most countries.

China, the country with the highest absolute increase in emissions, has a completely different sector structure of emissions than developed countries. Transportation and households only play there a minor role until now.

**Figure 2: energy-related CO<sub>2</sub> emissions, 1990 to 2004 in Mt**



## Technological development

Possible technological developments under a post-Kyoto framework cannot solely be econometrically estimated based on past developments due to lacking experience. Based on bottom-up-information procured by Prognos AG from recent energy projections for the German Ministry of Economics and Technology, the Energy Report IV and the corresponding oil price version, two possible evolution paths for technologies that form the basis for future development were estimated:

- “restrained” technological development for the reference scenario without tightened climate protection strategies. The basic assumption is moderate autonomous technological change.
- “accelerated” technological development, in which existing efficiency technologies faster diffuse into the market during the investment cycles assuming higher mitigation efforts.

Due to the medium-term time horizon, the project focuses on already existing technologies („best practice“), as for example highly efficient heat insulation, moderated electric motors as cross-sectional technologies, usage of waste heat, etc. Technologies currently under development or speculative technologies are not included

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here. For conventional power plants it is differentiated between fast or slow conversion of high efficiencies. It is assumed that CCS (Carbon Capture and Storage) technologies are not standard by 2020, but gradually reach market readiness. Key technologies like bio- and nanotechnologies are assumed to have especially high potential to generate more energy and material efficient products and methods of production after 2020.

To provide a corridor of possible technological developments for the calculations in GINFORS, a set of evolution paths was calculated for individual sectors using the cohort-based bottom-up models of Prognos AG. In particular evolution paths regarding average specific energy consumptions per unit of production or reference (e.g. heating surface, vehicle km) were determined. The specific targets for 2020 compared to 2005 in important sectors in the “accelerated” technological development scenario have the following lower bounds (or upper bounds in the case of bio fuels):

- specific energy consumption of industry (integrated) per unit of production: < -14%
- specific energy consumption of heating: -30%
- specific energy consumption of gasoline-driven passenger cars: -25%
- share of bio fuels in total fuel consumption: 25%

These findings are taken into account in the simulation runs with GINFORS. Thus, technologically meaningless developments from the point of view of the bottom-up analysis can be avoided. The approach therefore is superior to many purely economic models, which assume, for sufficient price changes, large substitution possibilities of production factors between sets of technologies, even though the possibilities of substitution remain restricted until 2020 or 2030 given the existing capital stocks.

### **Model based scenario analysis**

When using a modelling approach in economic analyses, one usually conducts different simulation runs to compare the different possible developments (scenarios) with a reference scenario. The scenarios distinguish themselves by one or more different input specifications (in this case: particular climate protection actions). Differences in model outcomes are then ascribed to the differences in input specifications. The outcomes of the scenarios should not be seen as forecasts; they rather describe different, possible alternatives for future development.

This research project requires the usage of a global, disaggregated (according to countries and product groups) model that dynamically reproduces interdependencies between economic development, energy consumption and GHG emissions. The GINFORS model, which was developed and used during the last decade, meets these requirements. It captures macroeconomic and sectoral feedbacks. The represented markets mainly react to price changes that are necessary for higher climate protection. Price increases due to investment in mitigation will appear even for measures that are cost-efficient in the long run, e.g. building insulation.

Special features of GINFORS compared to other existing models are: (1) econometrically estimated behavioural parameters, based on past experience, (2) GINFORS allows for market imperfections, thus cost-minimizing behaviour is not required and (3) a high level of disaggregation in the model by explicitly incorporating 50 countries and 2 regions as well as 41 economic sectors. More than 95% of global GDP, global trade and global GHG emissions originate in the explicitly modelled countries.

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The data set used in GINFORS and the corresponding estimations were updated to include data up to 2004 to capture effects of the increased energy prices. To capture possible relocation effects of unilateral commitments on climate change mitigation, bilateral price influences were analysed for 25 product groups and 50 countries as well as two aggregated regions. For example, the influence of prices on German iron and steel imports from China and the corresponding exports to China in the past was examined.

The model focuses on energy-related emissions, for which a good database exists. There exists a high potential for cost-efficient reduction for non-energy-related emissions especially in developing and emerging countries, mainly from land use. A broad inclusion of these emissions into a post-Kyoto regime could further reduce the identified macroeconomic costs and create additional reduction potentials.

The model was run on the following alternative scenarios, some in different variants:

- (1) a unilateral GHG emission reduction in the EU of 20% until 2020 compared 1990,
- (2) a unilateral GHG emission reduction in the EU of 30% until 2020 compared 1990 with use of flexible mechanisms,
- (3) inclusion of the remaining developed countries except the U.S. into (2),
- (4) an extension of (3) by including the U.S. and
- (5) an extension of (4) by additionally including the G5 countries China, India, Brazil, Mexico und South Africa, whereas less stringent guidelines are applicable to these emerging economies.

### **Reference scenario**

The reference scenario bases population development, economic growth, energy consumption and emission development on national and international projections, in particular on the reference scenario of the World Energy Outlook 2006 published by the IEA. According to this, the world population will increase to above 8 billion by 2030. The world economy will grow considerably driven by the economic development in the developing countries. The international energy prices continue to be on high level, but below the recently attained maxima. Mitigation efforts are not increased world wide.

Global energy-related CO<sub>2</sub> emissions increase by 50% until 2030 compared to now (2004) without additional mitigation measures. Compared to the base year of the Kyoto Protocol, 1990, they almost double. The EU-27 will still produce about 10% of global emissions (15% in 2004). The main increase of global emissions can be ascribed to developing countries – particularly to China, which will be the world's biggest CO<sub>2</sub> emitter – for which there are no emission reduction targets set in the Kyoto Protocol. The EU target of cutting global GHG by 50% until 2050 will be severely missed without additional climate protection measures in all important countries; thus the 2°C-target of the EU will most probably not be reached.

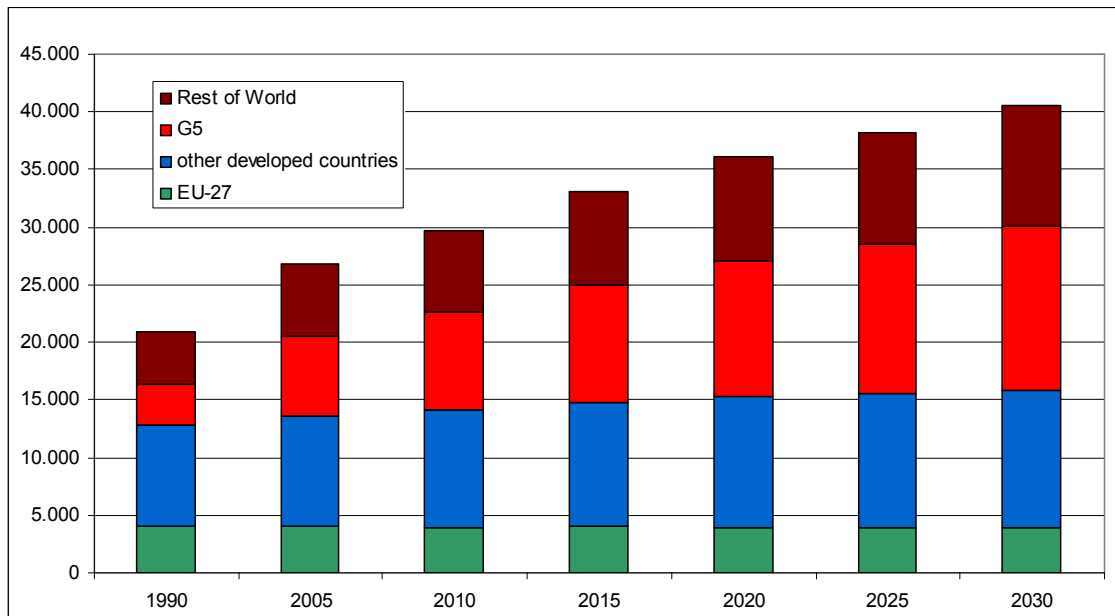
Germany will just succeed in meeting its EU burden sharing target to reduce GHG emissions by 21% until 2008-2012 compared to 1990/95. Afterwards emissions will continue to only slightly decrease. The recent policies (e.g. phasing out of nuclear energy, energy tax rates, support of renewable energies, etc.) will be maintained. The EU-15 will as well meet the targeted 8% reduction compared to the base year, but only under the inclusion of the reduction in other GHG emissions and the use of sinks (land use, land use change and forestry) and flexible mechanisms.

Basic assumptions and parameters of the reference scenario for Germany, the EU, the remaining developed countries and the G5 countries, China, India, Brazil, Mexico and South Africa, are displayed in Tab. 1.

**Tab. 1: main values of the reference scenario**

GDP: average annual growth rates		1990-2000	2000-2010	2010-2020	2020-2030
	in %				
Germany		2,1	1,4	1,5	1,3
EU-15		2,3	1,9	2,0	1,7
NMS-12		2,3	4,0	4,0	3,2
EU-27		2,3	2,1	2,2	1,9
other developed countries		3,5	2,6	2,3	2,0
<i>thereof USA</i>		3,3	2,7	2,6	1,9
G5		6,7	6,8	5,1	3,6
<b>World</b>		<b>3,6</b>	<b>3,9</b>	<b>3,4</b>	<b>2,7</b>
share in world-GDP					
	1990	2000	2010	2020	2030
in %					
Germany	5,7	4,9	3,9	3,2	2,8
EU-15	25,3	22,1	18,2	15,8	14,4
NMS-12	2,2	2,3	2,4	2,6	2,7
EU-27	27,5	24,4	20,7	18,4	17,1
other developed countries	37,9	37,4	33,2	29,7	27,8
<i>thereof USA</i>	23,6	22,9	20,4	18,8	17,4
G5	17,4	23,4	30,8	36,4	39,6
<b>World</b>	<b>100,0</b>	<b>100,0</b>	<b>100,0</b>	<b>100,0</b>	<b>100,0</b>
CO <sub>2</sub> emissions from fossil fuel combustion					
	1990	2005	2010	2020	2030
Mt CO <sub>2</sub>					
Germany	966	829	806	797	757
EU-15	3.118	3.281	3.229	3.169	3.130
NMS-12	954	725	739	779	733
EU-27	4.072	4.007	3.968	3.949	3.863
other developed countries	8.716	9.542	10.160	11.374	12.001
<i>thereof USA</i>	4.842	5.729	6.108	7.085	7.405
G5	3.585	7.009	8.495	11.789	14.215
<b>World</b>	<b>20.683</b>	<b>26.703</b>	<b>29.613</b>	<b>35.975</b>	<b>40.326</b>
CO <sub>2</sub> emissions: deviations compared to 1990					
	1990	2005	2010	2020	2030
in %					
Germany		-14,3	-16,6	-17,6	-21,7
EU-15		5,3	3,6	1,7	0,4
NMS-12		-24,0	-22,5	-18,3	-23,2
EU-27		-1,6	-2,5	-3,0	-5,1
other developed countries		9,5	16,6	30,5	37,7
<i>thereof USA</i>		18,3	26,2	46,3	52,9
G5		95,5	137,0	228,9	296,6
<b>World</b>		<b>29,1</b>	<b>43,2</b>	<b>73,9</b>	<b>95,0</b>
other figures					
	1990	2000	2010	2020	2030
world population in Mill.	5.264	6.086	6.843	7.578	8.199
population DE in Mill.	79,3	82,2	82,6	82,2	81,4
population EU-27 in Mill.	439,7	483,7	492,8	494,0	490,7
CO <sub>2</sub> allowance price in Euro2005/t			7,0	7,5	7,5
oil price in US\$2000/bbl.	17,9	28,0	50,0	47,0	60,0

**Figure 3: energy-related CO<sub>2</sub> emissions, reference scenario in Mt CO<sub>2</sub>**



### Alternative Scenarios

Using the GINFORS model, different scenarios regarding the participation of countries were analysed. Costs of additional mitigation measures are expressed in deviation from the Gross Domestic Product (GDP) in the reference scenario. In doing so, all macroeconomic and inter-industry interdependencies, nationally and internationally, are embodied in the results.

The alternative scenarios can be divided into two categories. At first, macroeconomic and sectoral effects on the European economies corresponding to a target of a 20% reduction in EU GHG emissions by 2020 compared to 1990 are analysed assuming that the rest of the world will not participate in a post-2012 framework. Such a unilateral commitment of the EU is not desired, but currently not entirely impossible. At the same time it is necessary to consider, that the exact design of the GHG emission reductions and the EU internal burden sharing is currently debated. Insofar quite a number of assumptions must be taken. The second type of scenarios will analyse possible participations of different country groups in a post-Kyoto regime.

### Unilateral 20%-reduction target of the EU by 2020 (Scenario EU-1)

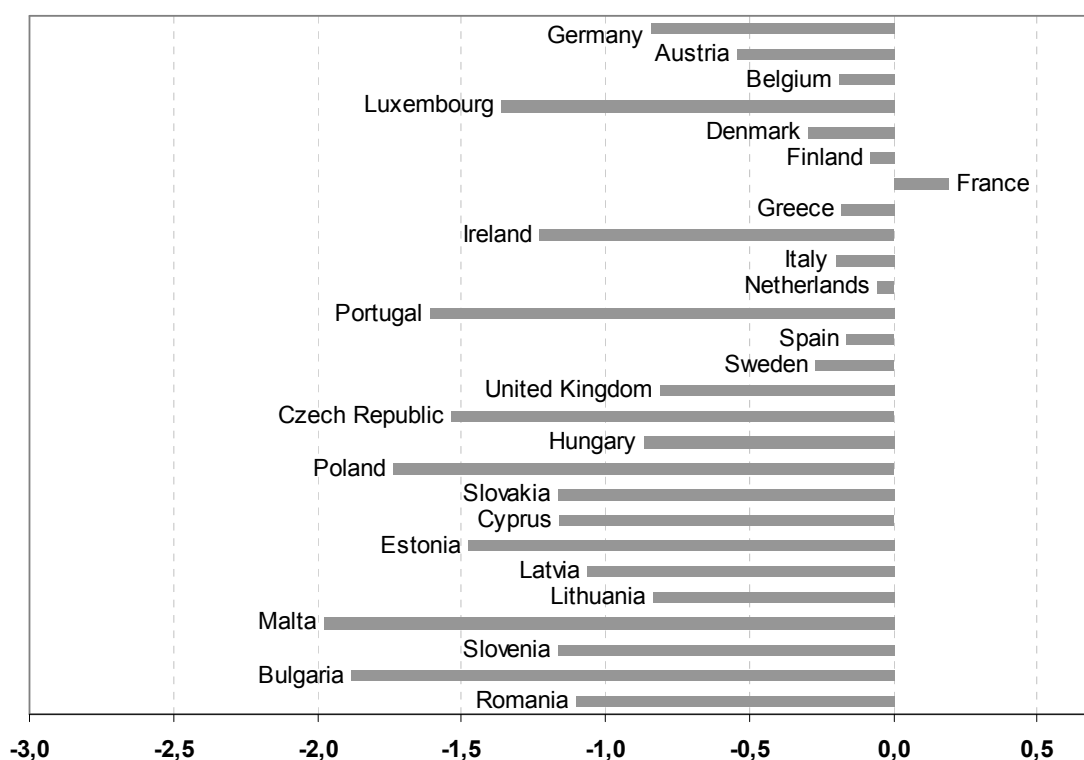
The design of future regimes is important for model results: In this study it is assumed, that the EU aims for a fair burden sharing by uniform percentage reduction for EU-15 countries with respect to the Kyoto-targets (EU-15) respectively to the (expected) actual emissions in the period 2008-2012 (NMS-12). Under the EU emission trading system (ETS) the allowances of the energy sector are allocated by auctions. Energy intensive industries are not directly burdened, as long as they meet a required benchmark. The ETS will be extended to also include air traffic (EU-internal and 50% of international flights). To cover the impacts of diverse climate change policies on non-ETS sectors (business, trade, services, households, transport), a CO<sub>2</sub> tax (which is not a political recommendation) is used as a proxy for a variety of mitigation measures in the

model. The tax revenues are recycled via tax reductions. The use of flexible mechanisms is not allowed in this scenario.

The price of allowances will rise to 30 Euro2005/t CO<sub>2</sub> to meet the reduction target. This is approximately equal to 10 Cent per litre fuel oil. To achieve about the same percentage reduction in the non-ETS sectors an increase of the CO<sub>2</sub> price to 100 Euro2005 per ton (or 32 Cent per litre of diesel fuel) is needed in the EU15. In the remaining EU-27 countries, an increase of 50 Euro2005 per ton is sufficient due to high energy efficiency potentials.

Compared to the reference scenario the increased CO<sub>2</sub> abatement costs have a negative impact on EU-27. Gross domestic product (GDP) of the EU-27 will be 0.6% or 73 billion Euros lower in 2020 compared to the reference scenario. Total GDP-loss between 2013 and 2020 will be about 560 billion Euros. The major reason for that is a decrease in international competitiveness resulting in declining exports and rising total imports, even though energy imports decrease. Additionally, the higher prices have a negative impact on domestic demand. Growth dynamics, i.e. the average annual GDP growth rate, can however almost be maintained.

**Figure 4: GDP in 1995 prices in selected countries: percentage deviations of scenario EU-1 against reference scenario in 2020**



The effects within the EU-27 differ between countries due to differences in carbon intensity, especially in electricity generation. Effects on economies having an export surplus are above-average. Impacts on the new member states (NMS-12) are especially unfavourable due to their high carbon intensity. Emission reductions in these countries are above-average as well. France slightly benefits from a unilateral action of the EU because of low CO<sub>2</sub> emissions in electricity generation, which is mainly based on nuclear power, and its rather low dependence on exports. Economic performance of most non-EU countries increases due to a rise in international competitiveness against

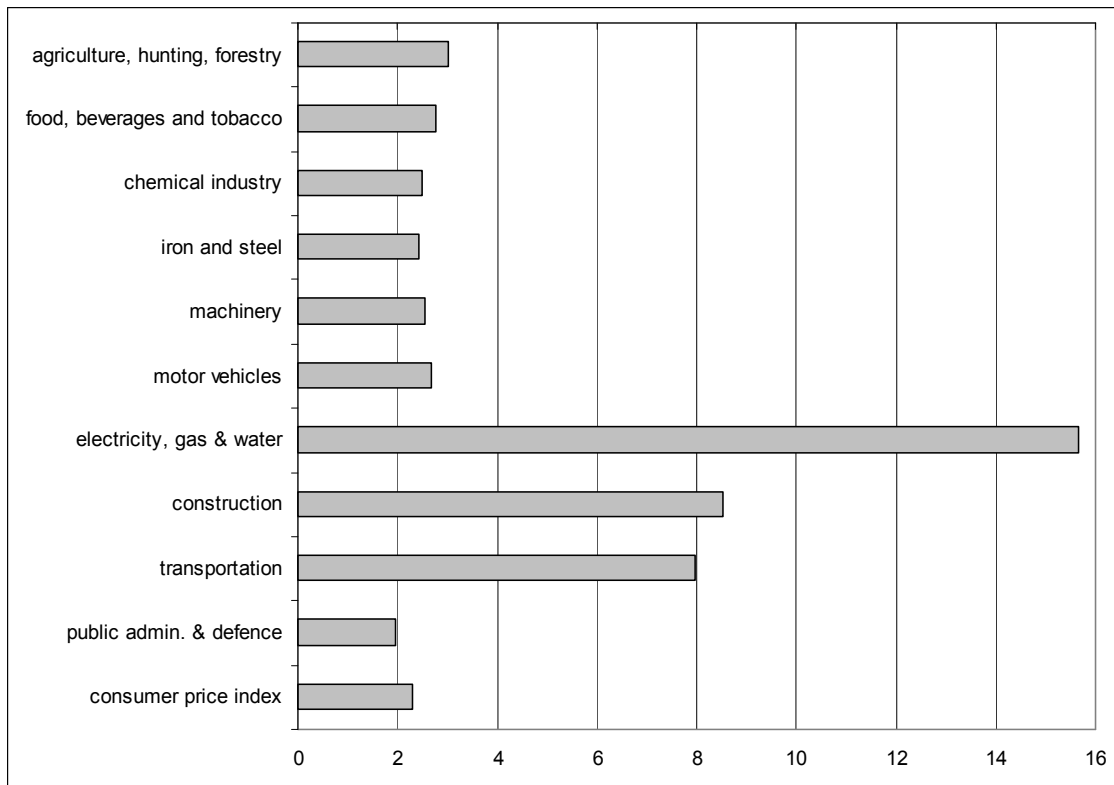
EU compared to the reference scenario. Only those countries that are major energy suppliers for the EU are negatively affected.

Despite of the modelled favourable design of the ETS for energy-intensive industries, those that are especially exposed to international competition might still relocate some of their production. Indirect effects of higher electricity prices, e.g. in aluminium production, are hard to avoid.

Global CO<sub>2</sub> emissions are reduced by 1.4% (504 Mt CO<sub>2</sub>) only compared to the reference scenario. Emissions outside the EU-27 rise by 14% (85 Mt CO<sub>2</sub>) of the avoided emissions within the EU (589 Mt CO<sub>2</sub>), due to relocation effects (carbon leakage) mainly to the U.S. and G5 countries. Given these facts, a unilateral action of the EU is appropriate only, if it leads to a participation of additional countries in the international post-Kyoto regime.

The negative impact on GDP in Germany (-0.8% or -22 billion Euro) is slightly above EU average in 2020. Per-capita income reduces by about 275 Euro compared to the reference scenario in 2020. Total GDP-loss between 2013 and 2020 will be about 123 billion Euros. Reasons for this are a rather high export dependency and the above-average CO<sub>2</sub> intensity of electricity generation, which results from the nearly completed phasing out of nuclear energy in 2020. In the case of a unilateral commitment of the EU there is no rise in demand for mitigation technologies outside the EU, which could compensate the decline in exports. Price increases are highest for electricity, gas and water and in the construction and transport sectors.

**Figure 5: price effects in Germany: percentage changes of scenario EU-1 against reference scenario in 2020**



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### **Impacts of the design of unilateral EU action:**

The European commission will present a proposal for a burden sharing agreement within the EU-27 in January 2008. The effects of different distribution rules, based on a uniform percentage reduction of emissions of some base year in all EU countries, have been quantified in the course of this project. The choice of the base year is rather unimportant for a small group of countries including Germany and the Benelux countries. It does make a large difference for other countries though. In Spain and Poland annual deviations of the identified reduction effort multiplied with the price of the allowances can be up to 2 billion Euros per year.

The method of the allocation of allowances (scenario EU-6) significantly influences the results. Strong negative macroeconomic results arise when auctioning off allowances in energy intensive industries like iron or steel. The industries have to pass on the higher costs and therefore face diminishing international competitiveness, which, additionally to decreases in production and employment, has further indirect effects in the economies. The CO<sub>2</sub> allowances should rather be allocated to these industries free of charge. By using appropriate benchmarks these industries as a whole should not face any burden. Only companies with above-industry-average emissions due to obsolete production facilities would have to purchase allowances. The problem of high electricity prices remains though. A free allocation of allowances in the energy sector has also negative impacts on the economy because the incurred windfall profits are withdrawn from the economic cycle.

The utilisation of auction revenues, which amounts to about 9 billion Euros in the German energy industry in 2020 alone (about 40 billion Euro in EU-27), for a quicker introduction of CO<sub>2</sub> reduction technologies (scenario EU-8) could halve mitigation costs, if the measures are indeed as efficient as expected by the German government for e.g. the programme to reduce CO<sub>2</sub> emissions from buildings.

Using flexible mechanisms (scenario EU-11) such as CDM, which allows for partly achieving emission targets in developing countries, could reduce mitigation costs considerably. E.g. if the use of credits from CDM projects is limited to 50% the EU-27 could reduce emission by 30%, for the same costs that it would face for a 20%-reduction in the case of not using these flexible mechanisms.

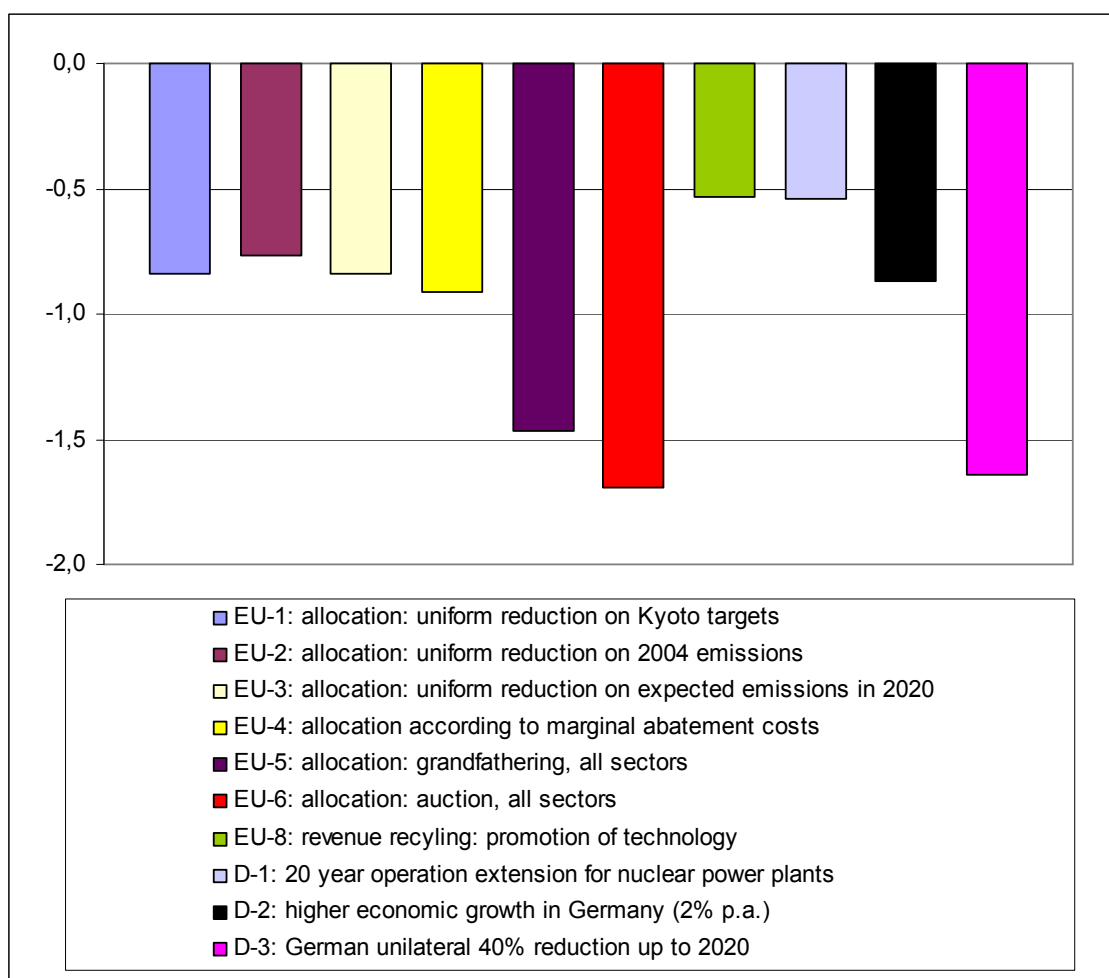
The scenarios point out that the costs of action for the EU-27 can be twice or only half as high for a given reduction target, depending on the allocation method of allowances, recycling of auction revenues and the use of flexible mechanisms. Crucial decisions on these issues will have to be taken during the coming months, especially on the EU level. The combination of alternative approaches can reduce or increase mitigation costs to levels outside the range presented above.

Additionally conducted simulation runs for Germany included a 20 year extension of the operation of nuclear power plants (scenario D-1), which could cut the mitigation costs in Germany in half and reduce emissions even further. In the case that Germany reduces its emissions unilaterally by 40% while other countries do not commit to any further action beyond 2012 (scenario D-3), mitigation costs in Germany could double. Assumed higher economic growth in Germany (scenario D-2) leads to a small increase of the relative mitigation costs.

Tab. 2: main numerical results in 2020, different scenarios

	scenario	design	changes compared to reference scenario [%]			vs.1990
				BIP	CO <sub>2</sub>	CO <sub>2</sub>
participation: EU-27 unilateral	EU-1	participation: EU-27 unilateral CO <sub>2</sub> price of ETS: 30 Euro/t equivalent CO <sub>2</sub> price, non-ETS: 100 Euro/t in EU-15, 50 Euro/t in NMS-12 usage of flexible mechanisms: no EU-burden-sharing based on Kyoto targets allocation: auctioning energy sector	DE: EU-15: NMS-12: EU-27: USA: G5: world:	-0,84 -0,41 -1,41 -0,55 0,13 0,41 0,13	-15,8 -13,2 -22,0 -14,9 0,1 0,2 -1,4	-30,6 -11,7 -36,3 -17,5 46,5 229,6 71,5
	EU-6	as scenario EU-1 except for <b>allocation: auctioning, all sectors</b>	DE: EU-15: NMS-12: EU-27: USA: G5: world:	-1,69 -1,17 -2,66 -1,38 0,13 0,38 -0,05	-16,2 -13,5 -22,3 -15,3 0,1 0,2 -1,5	-30,9 -12,1 -36,5 -17,8 46,5 229,6 71,4
	EU-8	as scenario EU-1 except for <b>recycling of auction revenues to technology promotion</b>	DE: EU-15: NMS-12: EU-27: USA: G5: world:	-0,53 -0,18 -0,90 -0,28 0,02 -0,02 -0,11	-17,3 -13,4 -21,9 -15,1 0,0 0,0 -1,6	-31,9 -12,0 -36,2 -17,7 46,4 228,8 71,1
	EU-11	as scenario EU-1 except for <b>EU unilateral, 30% reduction usage of flexible mechanisms: 50% CO<sub>2</sub> price of ETS: 23 Euro/t</b>	DE: EU-15: NMS-12: EU-27: USA: G5: world:	-0,95 -0,58 -1,26 -0,68 0,09 0,72 0,20	-10,7 -8,8 -15,2 -10,0 0,1 -4,3 -2,4	-26,4 -7,2 -30,7 -12,7 46,5 214,9 69,8
	D-1	as scenario EU-1 except for <b>20-year life extension for nuclear power plants in Germany</b>	DE: EU-15: NMS-12: EU-27: USA: G5: world:	-0,55 -0,34 -1,37 -0,48 0,13 0,42 0,15	-23,9 -15,2 -22,0 -16,5 0,1 0,2 -1,6	-37,3 -13,8 -36,2 -19,1 46,5 229,6 71,2
	D-3	as scenario EU-1 except for <b>Germany unilateral: 40% reduction up to 2020</b>	DE: EU-15: NMS-12: EU-27: USA: G5: world:	-1,64 -0,56 -1,51 -0,70 0,15 0,45 0,13	-25,8 -15,8 -22,2 -17,0 0,2 0,3 -1,6	-38,8 -14,4 -36,4 -19,5 46,6 229,7 71,1
participation: multilateral	USA	as scenario EU-11 except for <b>participation: all developed countries CO<sub>2</sub> price of ETS: 23 Euro/t uniform CO<sub>2</sub> price in developed countries</b> commitments of other developed countries as model outcome usage of flexible mechanisms: 50%	DE: EU-15: NMS-12: EU-27: USA: G5: world:	-0,51 -0,45 -1,24 -0,56 -1,03 0,47 -0,62	-10,4 -8,6 -15,0 -9,9 -22,6 -7,9 -10,7	-26,2 -7,1 -30,6 -12,6 13,3 203,0 55,3
	G5-1	as scenario USA except for <b>participation: all developed countries and G5 CO<sub>2</sub> price of ETS: 23 Euro/t CO<sub>2</sub> tax in G5 (all sectors): 23 Euro/t</b> usage of flexible mechanisms: 50% application of flexible mechanisms in G5 is not allowed	DE: EU-15: NMS-12: EU-27: USA: G5: world:	-0,71 -0,61 -1,61 -0,75 -1,02 -1,92 -1,69	-10,6 -8,8 -15,1 -10,0 -22,6 -20,3 -16,4	-26,3 -7,2 -30,7 -12,7 13,3 162,2 45,4
	G5-2	as scenario G5 except for <b>CO<sub>2</sub> tax in G5 (all sectors): 5,75 Euro/t</b>	DE: EU-15: NMS-12: EU-27: USA: G5: world:	-0,59 -0,51 -1,36 -0,63 -1,04 -0,54 -1,05	-10,5 -8,7 -15,1 -9,9 -22,6 -8,9 -12,6	-26,2 -7,2 -30,6 -12,7 13,3 199,6 52,1

**Figure 6: GDP in 1995 prices in Germany: percentage deviations of different scenarios against reference scenario in 2020**



### 30%-reduction target of the EU until 2020 with international participation:

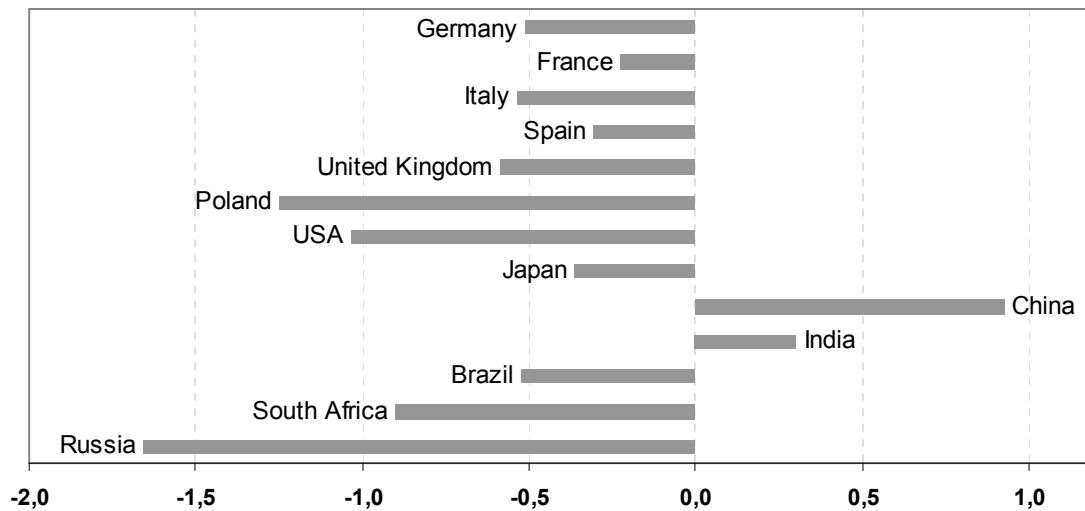
EU-27 has set a target of 30% reduction in GHG emissions by 2020 (compared to 1990 levels). However, this 30% target only applies if the developed world as well as large emerging countries commit to a similar target. If the use of flexible mechanisms is limited to a maximum of 50%, the EU will meet this 30% target at an allowance price of 23 Euro2005/t CO<sub>2</sub> (and costs of 100 Euro/t in the EU-15 respectively 50 Euro/t CO<sub>2</sub> in the NMS-12 in the non-ETS sectors). Emission trading between industrialised countries is allowed in this scenario. Since the concrete participation of non-EU countries is still unclear, effects on these countries are analysed assuming that they face similar price incentives as EU-27 countries.

A participation of the remaining developed countries (scenario USA, GDP deviation in 2020 -0.56%) has, in spite of the higher global reduction burden, a slightly positive effect on the European economy in comparison to the scenarios where only the European countries participated (EU-11, GDP difference -0.68%). The EU has competitive advantages in the areas of energy efficiency and mitigation. Despite a globally lower economic performance (-0.6%) and lower international trade compared to unilateral commitment of the EU, the relative position of EU-27 countries improve compared to the other participating countries. However; the global demand for

“traditional” export goods decreases in comparison to the reference scenario. Given a uniform price for CO<sub>2</sub> in the EU and the U.S., emission reductions and macroeconomic costs will be substantially higher in the U.S.

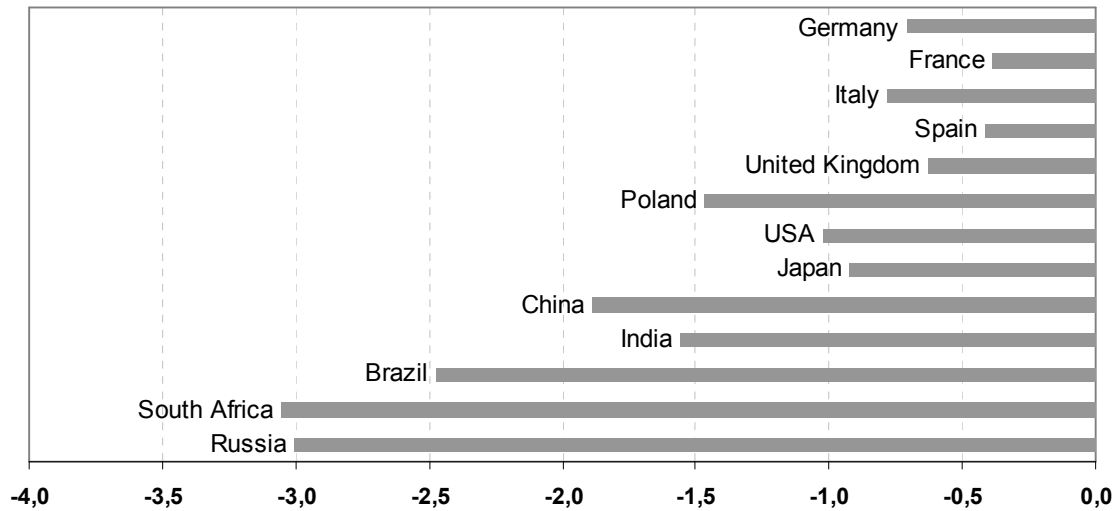
The G5 countries, especially China and India, can even increase their GDP compared to the reference scenario by the relocation of emission intensive industries into their countries. Germany benefits from a participation of all developed countries above the EU-average. Compared to the scenario of the unilateral action of the EU (scenario EU-11), the loss of GDP is slightly less than EU average in the scenario USA.

**Figure 7: GDP in 1995 prices in selected countries: percentage deviations of scenario USA against reference scenario in 2020**

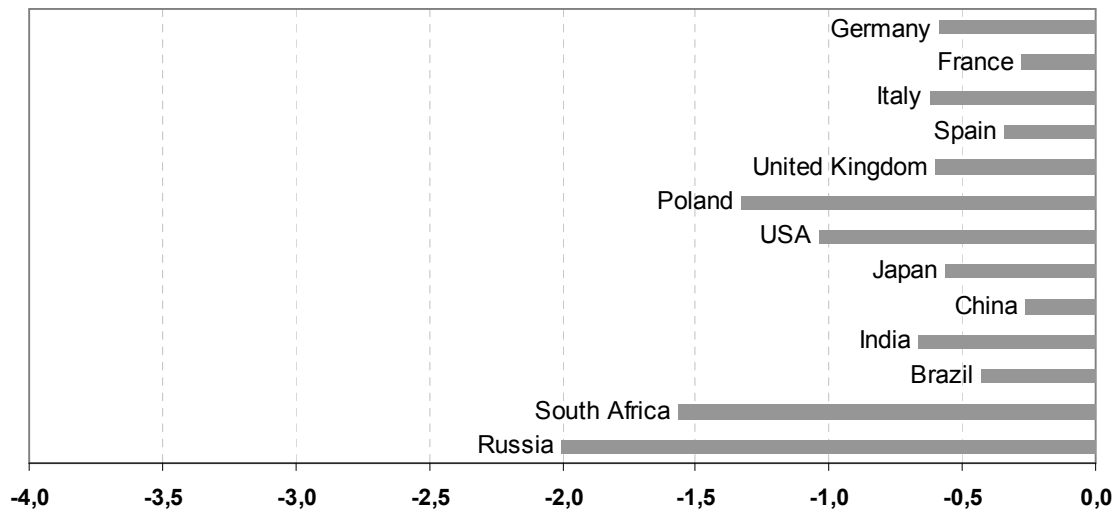


The complete (scenario G5-1) or the restricted (scenario G5-2) participation of the G5 countries China, India, Brazil, Mexico and South Africa in a post-2012 framework as described in scenario USA, allocate parts of the mitigation costs to these countries. This is reflected in GDP losses compared to the reference scenario. The percentage decrease of GDP in these countries is higher than in the developed countries in scenario G5-1. This might serve as a reason for these countries to not fully participate in the post-Kyoto framework right from the start. The EU-27 on the other hand economically gains from a globally applicable post-Kyoto framework. The relatively higher reduction of GDP in the rest of the world compared to the reference scenario points out that a far-reaching future climate regime that allows for meeting the 2°C-target of the EU is not easy to achieve. Energy exporting countries are most affected by a global post-2012 framework because the demand for their export goods decreases substantially.

**Figure 8: GDP in 1995 prices in selected countries: percentage deviations of scenario G5-1 against reference scenario in 2020**



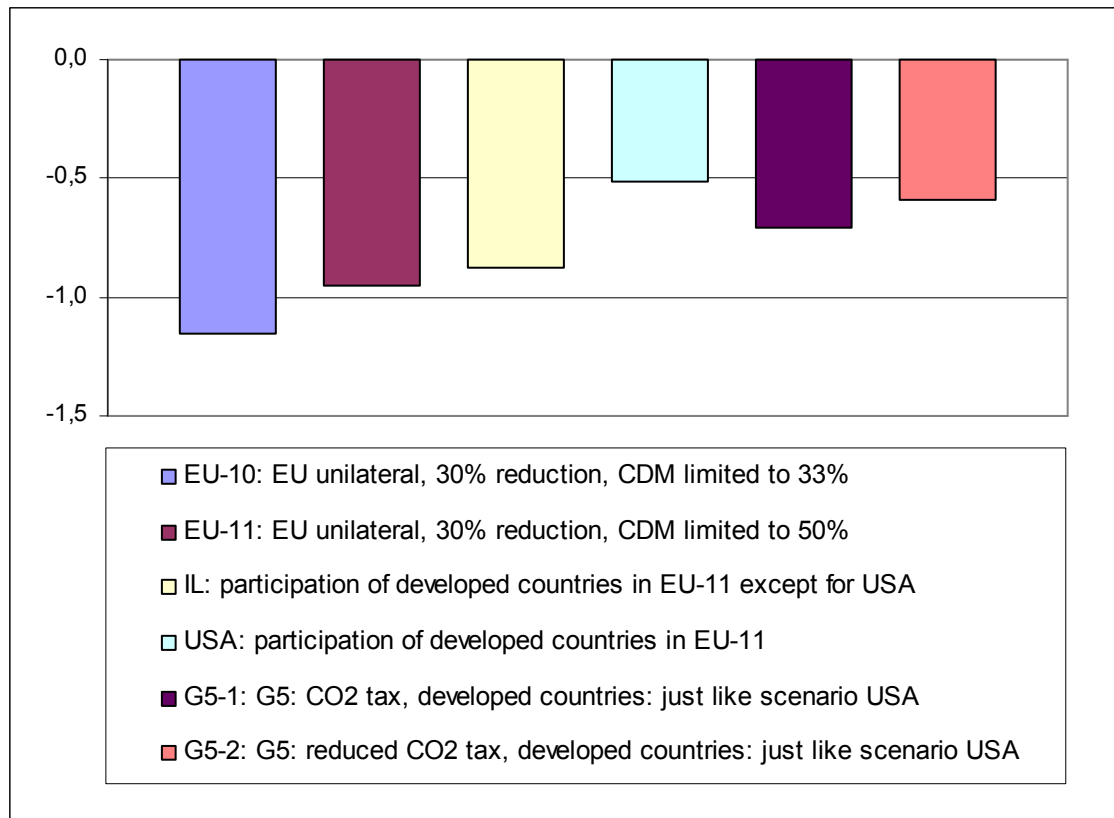
**Figure 9: GDP in 1995 prices in selected countries: percentage deviations of scenario G5-2 against reference scenario in 2020**



Germany can reduce its mitigation costs if other developed countries (especially the U.S.) participate. Germany has competitive advantages in low emission technologies, but thereof resulting effects are limited by the reduction in global trade volumes. CDM activities in developing countries generally lower mitigation costs.

The impacts on global GDP in the simulation runs are in accordance with recent analyses of the IPCC. Depending on the point of view one can bring forward the argument that the (level of) GDP in the participating countries is substantially lower for a given year than in the reference scenario, or that the annual economic growth (growth rate) is affected only marginally. The GDP-losses increase with the level of CO<sub>2</sub> prices and the level of GHG reduction.

**Figure 10: GDP in 1995 prices in Germany: percentage deviations of different scenarios against reference scenario in 2020**



### Climate change impacts of the scenarios:

Global emissions will double until 2030 compared to 1990 levels without the existence of a far-reaching post-2012 climate regime. A unilateral commitment of the EU would only be a “drop in the bucket”, which solely strengthens the credibility of the EU in international negotiations to convince other countries of concerted action. A stabilisation of global emissions in 2020 compared to 2010 can only be achieved, if all developed and at least the large newly industrialised (G5) countries participate and if all possible existing market-ready reduction technologies are used. Global emissions will still be 45% higher compared to 1990. Participation would still yield increased CO<sub>2</sub> emissions in the U.S. as well as in the G5 countries compared to 1990.

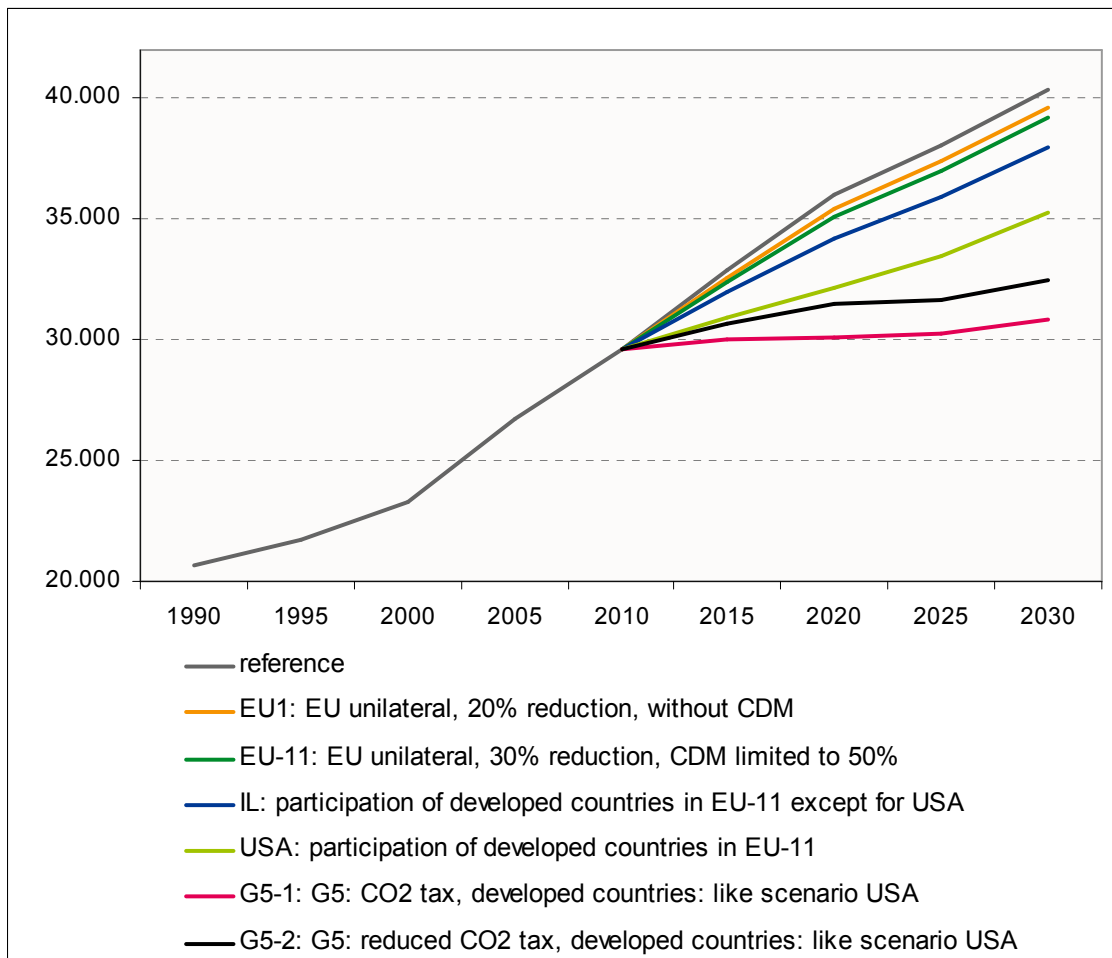
Assuming additionally a participation of countries not considered in the above analysis and the utilisation of sinks and further low-cost option of reducing non-CO<sub>2</sub> emissions could add up to a reversal of the current trend of global emissions without harming global economic growth to a large extent.

The energy-related CO<sub>2</sub> emissions in Germany are about 26% lower (30% for total GHG emissions) than 1990 in the scenarios with international participation. Additional GHG reductions are financed through emission trading and CDM measures abroad (creditable and actually domestic reductions can differ substantially).

In the period beyond 2020 when new abatement technologies are available, which might also be used in developing countries, the 2°C-target of the EU, which may require a bisection of global emissions by 2050, might become feasible. Aside from the establishment of a global carbon market, extensive technological developments until

2020 are necessary therefore. Actions to promote the deployment and diffusion of (new) technologies should be co-ordinated internationally.

**Figure 11: global energy-related CO<sub>2</sub> emissions in alternative scenarios, in Mt CO<sub>2</sub>**



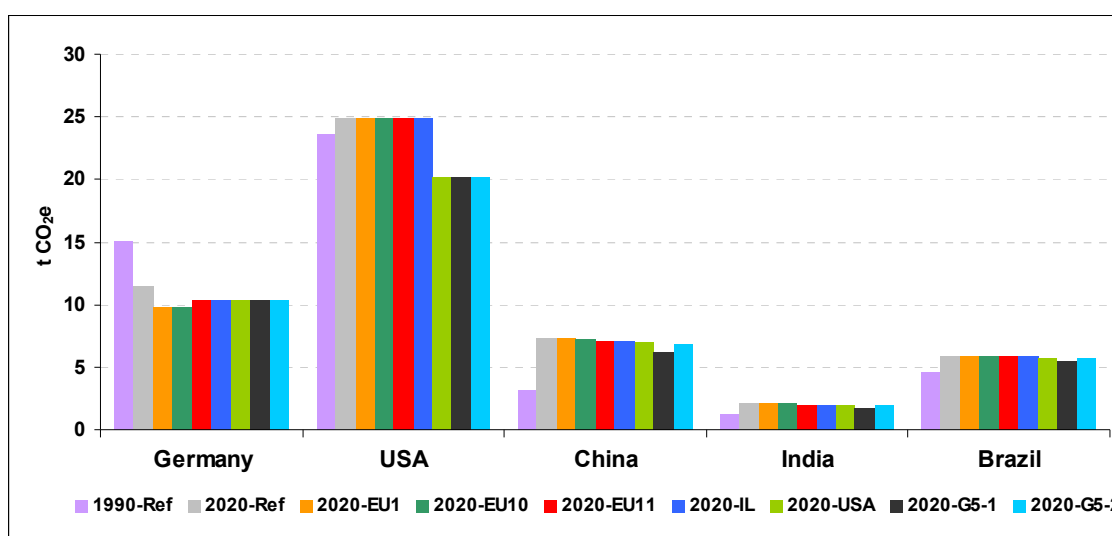
## Criteria

In the course of this project economic, environmental, equity and political criteria were analysed with regard to burden sharing in alternative post-Kyoto regimes. Important economic criteria are the minimisation of macroeconomic costs as well as the ability of sustained economic development respectively catch-up for developing countries. Besides the environmental criterion of the actual global GHG emission reduction, the less quantifiable equity and political criteria are of vital importance to the success of future negotiations. In the course of this project the basic economic and ecological criteria, i.e. emissions and absolute and per-capita GDP, were quantified for different scenarios.

The evaluation of the simulation runs indicates that developed as well as developing countries are able to reach their economic targets even in the case of an ambitious post-Kyoto framework. A significant reduction in CO<sub>2</sub> emission per capita only marginally reduces GDP per capita in both groups of countries in comparison to the reference scenario. Dynamic economic growth in the developed countries and the catching-up process of the developing countries are maintained for the most part. The still high

absolute GDP-losses should be minimized globally and shared in a fair way. GHG intensities of developed countries and emerging economies will converge in the future.

**Figure 12: GHG emissions in t per capita in selected countries and scenarios**



The developed countries will have higher CO<sub>2</sub> (and total GHG) emissions than developing countries in all scenarios. Only India (out of all explicitly analysed countries) will succeed in having emissions of 1-2 ton CO<sub>2</sub> per capita. On a global scale this level of 2050's per capita emissions is regarded to be necessary for attaining the 2°C target.

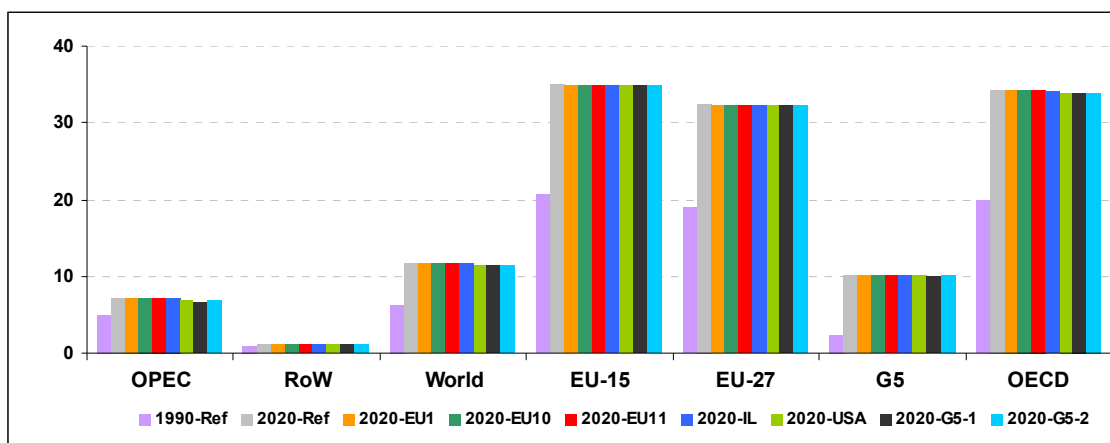
The consideration of per-capita emissions clearly shows that the developed countries face above-average commitments. This can also be seen from per-capita income levels which will still be on a considerable higher level in developed countries than in developing countries in 2020. The basic patterns of per-capita-emissions and per-capita income observed in the reference scenario remained unchanged throughout the examined future scenarios.

**Tab. 3: GHG emissions in t per capita in selected countries and scenarios and regions**

	Germany	USA	China	India	Brazil	OPEC	RoW	World	EU-15	EU-27	G5	OECD
1990-Ref	15,0	23,6	3,1	1,3	4,7	4,5	3,3	5,6	11,0	12,0	2,7	13,4
2020-Ref	11,4	24,9	7,3	2,1	5,9	7,0	3,4	6,4	9,9	10,0	5,1	14,5
2020-EU1	9,9	24,9	7,4	2,1	5,9	7,0	3,4	6,4	8,9	8,8	5,1	14,1
2020-EU10	9,8	24,9	7,3	2,1	5,8	7,0	3,4	6,3	8,9	8,8	5,0	14,1
2020-EU11	10,4	24,9	7,1	2,0	5,8	7,0	3,4	6,3	9,2	9,2	4,9	14,2
2020-IL	10,4	24,9	7,1	2,0	5,8	7,0	3,4	6,2	9,2	9,2	4,9	13,8
2020-USA	10,4	20,1	6,9	2,0	5,8	6,8	3,4	5,9	9,2	9,2	4,8	12,5
2020-G5-1	10,4	20,1	6,2	1,8	5,5	6,4	3,2	5,7	9,2	9,2	4,3	12,4
2020-G5-2	10,4	20,1	6,9	2,0	5,7	6,4	3,2	5,9	9,2	9,2	4,7	12,5

It is therefore obvious that the relation of GHG intensities of the different economies will not be changed considerably between the alternative future regimes. As can be seen from the reference as well as from all other scenarios, the large newly industrialised countries will achieve a drastic increase in GHG-efficiency (GHG/GDP) compared to 1990. Volumes changes will be comparable for OECD and G5 countries in terms of purchasing power parities. Most developing countries and OPEC countries will still comprise high efficiency potentials.

**Figure 13: GDP per capita in selected groups of countries and scenarios in 1000 US\$ 2000 (purchasing power parities)**



One can deduce the following statement from the simulation runs: If the developed countries agree upon a reduction path, which results into a 30% reduction of domestic emissions compared to 1990 (including a corresponding agreement on burden sharing), then the large developing countries should admit to a diminished growth factor of 1.2 from 2005 to 2020 for GHG emission, whereupon national differences are allowed.<sup>1</sup>

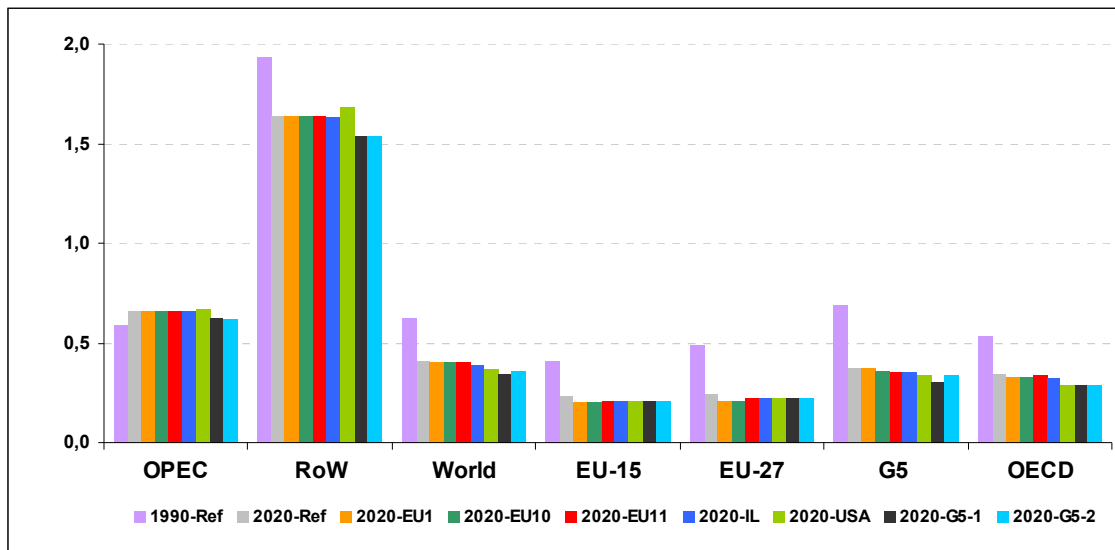
**Tab. 4: GDP per capita in selected countries/groups of countries and scenarios in 1000 US\$ 2000 (purchasing power parities)**

	Germany	USA	China	India	Brazil	OPEC	RoW	World	EU-15	EU-27	G5	OECD
1990-Ref	21,5	28,2	1,6	1,7	6,7	5,1	1,0	6,3	20,7	19,1	2,4	20,0
2005-Ref	26,7	37,3	5,9	3,0	7,5	4,6	0,8	7,9	26,5	23,3	5,0	25,8
2020-Ref	34,1	48,8	13,4	6,1	10,8	7,2	1,1	11,6	35,1	32,5	10,1	34,2
2020-EU1	33,8	48,9	13,5	6,1	10,9	7,2	1,1	11,6	34,9	32,3	10,2	34,2
2020-EU10	33,7	48,9	13,5	6,2	10,9	7,2	1,1	11,6	34,8	32,2	10,2	34,2
2020-EU11	33,8	48,9	13,5	6,1	10,9	7,2	1,1	11,6	34,9	32,3	10,2	34,2
2020-IL	33,8	48,9	13,5	6,2	10,9	7,2	1,1	11,6	34,9	32,3	10,2	34,1
2020-USA	33,9	48,3	13,5	6,1	10,8	6,8	1,1	11,5	34,9	32,3	10,2	33,9
2020-G5-1	33,9	48,3	13,1	6,0	10,5	6,7	1,1	11,4	34,8	32,3	9,9	33,8
2020-G5-2	33,9	48,3	13,4	6,1	10,8	6,7	1,1	11,5	34,9	32,3	10,1	33,9

The analysis of the main criteria clearly shows that developed as well as developing countries can meet their key objectives even in case of extensive international emission reduction targets as in scenarios G5-1 and G5-2. The countries and groups of countries will only agree upon a convention, if it is perceived as fair and political criteria, as for example reliability and transparency of the international agreement on climate protection, are ensured.

<sup>1</sup> Always assuming that the reference scenario correctly describes the expectations on economic growth and the corresponding development of GHG emissions in the G5 countries. The IEA will discuss the effects of possibly higher growth paths in China and India in detail in the new edition of the World Energy Outlook, which will be released in November 2007.

**Figure 14: CO<sub>2</sub>/GDP in selected groups of countries and scenarios in t CO<sub>2</sub>/1000 US\$2000 (purchasing power parities)**



### Design of a post-2012 framework

Given the necessity of a drastic global emission reduction until 2050 for meeting the 2°C-target on the one hand and the principles of the Framework Convention on Climate Change (Art. 3) on the other hand, a multi-stage approach seems to be required. A future climate regime should be based on a multi-stage approach concerning country participation and commitments. It should be constructed for multiple commitment periods to regularly check the consistency of mitigation commitments with the 2°-target.

Binding commitments for developed countries on a significant reduction of GHG emissions until 2020 are the crux of a future climate regime. A fair rule will lead to similar reduction burden on the individual countries. The establishment of a global carbon market, including exemptions for specific energy-intensive industries, therefore is a central policy instrument, which (1) leads to emission reductions taking place where reduction costs are minimal, (2) distributes the burden on all developed countries and (3) avoids far-reaching competitive disadvantages for some countries and industries.

Based on the principles of the United Nations Framework Convention on Climate change and their below average per-capita emissions developing countries will probably not be willingly to fully participate at early stages (until 2020) of a post-Kyoto regime. The simulation runs (scenario G5-1) show that the G5 countries would bear a higher relative share of macroeconomic costs than the group of developed countries given equal CO<sub>2</sub> prices in both groups of countries. On the other hand developing countries benefit from the GHG emission reduction and the simultaneous use of CDM of the developed countries (scenario USA), as developing countries experience competitive advantages in carbon-intensive products and due to the fact that investments are mainly financed by developed countries.

Given this background an agreement between developed and developing countries must be based on a fair burden sharing agreement between the two groups of countries, which – additionally to the climate protection effects – offers other advantages and imposes binding commitments on both groups.

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The further-reaching and the earlier developing countries are included in the global carbon market, the higher are the accumulated emission reductions (scenario G5-1) and the lower are global costs for meeting a specific reduction target, which can be shown by a comparison of scenarios EU-1 and EU-11. The flexible mechanisms should be extended and more broadly used than allowed by EU regulations today. Germany is currently not making enough use of flexible mechanisms. Additionally, new forms of cooperation between developing and developed countries will have to be found, especially regarding the U.S. orientation towards enhanced technology promotion. An advantage for the developed countries can be found in lower CO<sub>2</sub> prices because of lower abatement costs. Moreover, those enterprises in developed countries, which deliver goods for climate protection, will benefit from projects in the context of flexible mechanisms or new forms of cooperation. Mitigation costs will decrease in the long run due to a higher production volume of climate protection goods. Developing countries benefit from investments from developed countries via flexible mechanisms and the corresponding technology transfer. The minimum contribution of developing countries at the start of the post-2012 framework should in return compensate at least the macroeconomic benefits (i.e. GDP gains compared to the reference scenario) that originate from the proceeding of developed countries (scenario USA). When attaining specific binding thresholds of per-capita income or per-capita emissions, the minimum contribution of these countries should increase successively according to predefined rules.

An important task of international negotiations will be to decide upon a burden sharing between developed and developing countries that is perceived as fair. This eventually implies that developed countries reduce national emissions above average in a multi-stage approach for multiple compliance periods. Developing countries will have to increase their reduction efforts over time. Conditions for the future integration of all countries in a post-2012 agreement should be set early and be binding. Reductions targets of developed countries average should be linked to binding long-term commitments of developing countries. Based upon this and various internationally discussed approaches, a global post-Kyoto agreement, that is set up according to the principles of the UN Framework Convention on Climate Change of “their (the countries) common but differentiated responsibilities and respective capabilities”, should be feasible.