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Cost impacts of a 'Beyond Kyoto' – Global Cap and Trade Scheme

– illustrated at the example of the GCCS – Global Climate Certificate System

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With a chapter IX: „Macroeconomic impact analysis of GCCS and GCCS PLUS" by
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Researchreport - Sheet

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– illustrated at the example of the GCCS –
Global Climate Certificate System

1. Short summary of the results of the research-work (more details in executive summary)

By way of a global cap and trade scheme – possibly implemented as the investigated GCCS and GCCS PLUS-schemes –, there still exists a realistic chance to reach EU's climate target of a maximum global warming of +2°C. According to Böhringer's results in this study and relevant DIW's macroeconomic impact analysis (mainly on benefits of climate policy) there will be an excellent benefit/cost ratio by way of implementing GCCS PLUS, because the avoided climate change damage exceeds the needed costs by four to ten times.
These costs for the climate friendly restructuring of the world economy would amount to a loss between 0.3% and 1.2% of the global gross domestic product in the time of GCCS PLUS-implementation during 2015 and 2100. The total global welfare loss over the whole 21st century amounts to 0.29% (change in lifetime consumption, intertemporal welfare measure). These burdens are significant, but they should be bearable – compared to the thus achievable effect of definitely preventing dangerous climate change as defined by the European Union. The same holds true (some reservations and remedies are clearly shown) for the GCCS-born price increases and the transfer sums between industrialized and developing countries.
Like all conceivable efficient improvements of the current Kyoto I – regime also the GCCS/GCCS PLUS–cap and trade 'structural evolution' of the Kyoto Protocol will be very difficult to be implemented, irrespective of the fact that world's economic leaders urgently are calling for such a system. Beside other reasons also those sketched cost impacts will make it hard to overcome the unanimity principle and therefore to get at the end of negotiations an unanimous vote for such a improved Beyond Kyoto I - system. Nevertheless: There exist several good reasons, why such a global cap and trade scheme has got – compared to other Beyond Kyoto I strategies – relatively good chances to be accepted at the end.

2. Progress for Science and Politics

The report improves the GCCS-system, already presented to the ministry for environment of Baden-Württemberg in 2003 significantly. It shows that such a cap and trade scheme would induce the technological change and the global breakthrough and implementation of climate friendly technologies such as renewable energies and the clean carbon capture und storage for fossil fuelled processes and would globally induce a climate friendly change of the way of life and production. These induced changes would imply a dramatic reduction of CO_2-emissions so that EU's climate target – contrary to the current completely adverse development – still would be reachable.
In case the GCCS PLUS – system would be implemented, the climate policy of Baden-Württemberg could act – contrary to the present situation – within an efficient international framework, thus making sure, that Baden-Württembergs climate achievements really can have a substantial climate impact.

3. Recommendations for the political practise

The report shows, that it would be highly worthwhile to implement the basic GCCS PLUS – cap and trade scheme into the international climate negotiation process in order to present one realistic chance to reach EU's climate target on the basis of a least cost solution.

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List of abbreviations and short terminological explanations

AA	Assigned amount (amount of emission allowances assigned to Annex-I states)
AAU	Assigned Amount Units (Quantity of emission allowances assigned)
Allocation	Allocation of CCs (climate certificates) free of charge, per auctioning or at a price to FRPs
AOSIS states:	Alliance of Small Island States
Annex-I states:	The (industrialized countries and 'economies in transition') that committed themselves in the Kyoto Protocol to reduce emissions between 1990 (if necessary, other years) and the 'first commitment period from 2008 to 2012'
BAU	'Business as usual' development
CC	Climate Certificate, in principle, 1 CC entitles the holder to emit 1 tonne of carbon dioxide (respectively CO_2 equivalents)
CC - trust account:	Accounts managed by the WCCB for funds resulting from the transfer of surplus CCs (earmarked for measures within the scope of the SDEP plans)
CCS	Carbon Dioxide Capture and Storage - Technology
CDM	Clean Development Mechanism (mechanism for projects of environmentally friendly development financed by Annex-I (industrialized) nations and carried out in developing countries (according to the Kyoto Protocol)
CER	Certified Emission Reductions within the scope of the CDM
Commitment Period	Period for which commitments are adopted and defined under the Procol. The first commitment period is 2008-2012.
COP	Conference of the Parties to the Kyoto Protocol
CCS	Carbon respectively CO_2-capture and storage – technology for CO_2-reduction (-elimination) for various big scale processes
DCs	Developing (and newly industrialized) countries
EIA	Energy Information Administration in the US
ERU	Emission Reduction Credits (within the scope of JI = Joint Implementation)
FAO	Food and Agriculture Organisation
FRP	(Fossil) Fuel and Resources Providers at the first national trading level
G 77	Group of developing countries within the COP plus China
GCCS	Global Climate Certificate System
GCCS PLUS	GCCS plus a more stringent global greenhouse gas emission caps, yearly cap-reductions between 2030 und 2100 (ref. to VIII.E.2.)
GHG	Greenhouse Gases, the basket of greenhouse gases controlled by KP (relevant for climate change): CO_2, Methane, HFCs (hydrofluorcarbons), Nitrous oxide N_2O, PFCs (Perfluorocarbon)
ICs	Industrialized Countries
IEA	International Energy Agency (scientifically recognised, even if more inclined towards industrialized nations), subsidiary authority of the OECD (organization for economic co-operation and development of many industrialized nations)
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation between Annex-I states
KP	Kyoto Protocol
LULUCF	Land use, land use change, and forestry (as a climate-relevant activity)
NCCB	National Climate Certificate Bank

Non-Annex-I states:	All developing, threshold- and other that did not that committed themselves in the Kyoto Protocol to reduce emissions between 1990 (if necessary, other years) and the 'first commitment period from 2008 to 2012'. Annex I-states: The industrialized countries and 'economies in transition' (successor states of USSR)
OECD	Organization for Economic Cooperation and Development
Price cap	Price cap for CCs where the WCCB intervenes by selling additional CCs in order to cap prices. In other words: The WCCB's intervention price.
RD&D	Research and Development & Demonstration
RMU	Removal Units within the scope of LULUCF measures/changes
Safety valve:	Intervention by the WCCB in order to stabilize CC prices with the price cap
SDEP plan	Sustainable Development and Elimination of Poverty Plan (global and national)
Transfer market:	Market for transfers of CCs between DCs and ICs (via WCCG as 'Clearing House')
Umbrella group:	Group of contracting states from Australia, Canada, Iceland, Japan, New Zealand, Norway, Russia, the Ukraine and the US (membership changes at times)
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Convention of Climate Change, in short: Climate Framework Convention)
WCCB	World Climate Certificate Bank

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I. Executive Summary

1. There can be no doubt: In order to achieve its basic targets to prevent dangerous climate change there must be a structural evolution of the commitment-based Kyoto Protocol. The quantitative and structural deficiencies are evident. Therefore world's economic leaders of the WEF (World Economic Forum) urgently called for G 8 –leaders to establish a cost-effective and efficient approach to the problem of climate change with the following specification: ●A global cap-and-trade system that ●strictly limits greenhouse gas emission concentration, that ●provides a long-term policy framework till 2030 (2050) ●thus defining emission rights for ●a long term value of clean investments. Above that: Such an efficient global climate policy must ●ensure a sustainable development of emerging countries. (chapt. II)
2. According to this urgent call the global climate certificate system (GCCS) has been developed by expanding the flexible Kyoto mechanisms to a Global Cap and Trade Scheme – thus ensuring EU's climate target (max. plus 2°C) and the demands of the WEF. The main elements are: (1) A still tolerable cap for the global GHG/CO_2-emissions. (2) Distribution of emission rights on an equal per capita basis as incentives for developing countries. (3) Emission trading between countries and between fuel and resources providers at the first trading level (upstream system) with market regulations for the acceptability by industrialized nations. (4) Ensuring climate friendly development of emerging countries. (5) The construction of the GCCS implies that the global CO_2/GHG- limits and the resultant global cap of climate certificates directly influences all household, public and commercial consumers and users of fossil fuels and resources by way of increased fossil fuel prices (chapt.III).
3. The basic reproaches against a cap and trade system, based on an immediate equal per capita distribution key ●'tropical hot air', ●excessive transfer payments to developing countries by overburdened industrialized countries and ●'skyrocketing climate certificate prices' are – based on a smart construction scheme – irrelevant for the GCCS. (chapt. V)
4. Although a low-cost allocation of climate certificates (CCs) and low cost burdens to the fossil fuel and resources providers (FRPs) are intended – there might be significant price increases of fossil fuels and GCCS-born windfall profits of FRPs. To compensate these harmful, politically and economically unintended effects, the allocation possibly should be according to the prices at the free market of CCs plus a nationally redistribution of the earned allocation revenue to all citizens irrespective of their fossil fuel consumption. (chapt. VI)
5. By way of the GCCS-Cap and Trade induced marginal CC price at the free CC-market of maximum 30$ per CC/ton of CO_2 (later of – in ten years increments – max. 60 and 90$) there will be a big impact on an induced climate friendly technological change. (chapt. VII)
6. These GCCS-born incentives by higher prices for all economic actors predominantly implies the world wide breakthrough of already applicable climate friendly technologies like renewable energies and (nearly applicable) carbon capture and storage technologies for power generation and other industrial processes as well as more efficient energetic appliances. Thus globally also a substantial increase of energy efficiency can be reached – especially because attitudes and consuming and production patterns will be changed towards 'climate efficiency'. Therefore: A decisive global reduction of CO_2/GHG- emissions is feasible, thus reaching EU's extremely ambitious max. 2°C-target with a certain probability equivalent to a max. 450 ppm CO_2-concentration in the atmosphere. (chapt. VIII)
7. A global cap and trade scheme is (if adequately implemented) equivalent to the cheapest way to definitely prevent dangerous climate change. Because this must result in a climate friendly restructuring of the global economic system, this can not be achieved without (substantial) costs. In this report a macro economic impact analysis of the GCCS by Prof. Böhringer, ZEW (Centre for European Economic Research) is presented. According to this, these costs for the climate friendly restructuring would amount to a between 0.3% and 1.2%-loss of the global gross domestic product in the time of GCCS-implementation during 2015 and 2100. The total global welfare loss over the whole 21st century amounts

to 0.29% (change in lifetime consumption as an accurate intertemporal welfare measure of the impacts of policy change). In other words: The loss of 0.29% life time consumption means that the world would need to be given 0.29 % of its business as usual income, to be materially and economically as well of as without the climate efficient GCCS or GCCS PLUS policy. These burdens should be bearable – compared to the thus achievable effect of definitely preventing dangerous climate change. Above that: The model used for this macro economic impact analysis is a member of the CGE-'family' of macro-economic impacts analysis models, which usually are 'located' at the upper end of different macro-economic models for estimating costs of different climate protection systems. Therefore the quoted global GDP-loss definitely should be the highest possible global economic loss by the implementation of the GCCS-Cap and Trade – System. (chapter IX, summary in XI.B.)

8. Such a macroeconomic impact analysis can not or only to a certain extent be 'broken down' to national levels. Therefore an additional, more detailed analysis of the cost impacts for certain national economies has been presented by calculating the transfer revenues of lower CO_2-emitting countries (mostly developing, economically emerging countries) and the transfer sums of higher emitting (mostly industrialized) countries. These calculations show, that most developing countries are significantly favoured by transfer sums (chapter X.B. till X.D.). For most industrialized countries the burdens can be born without extra compensation measures that seem to be conceivable for some countries.
9. Additional macroeconomic impact analyses (especially by DIW, German Institute for Economic Research) of both costs and benefits (in monetary values) clearly seem to indicate: The avoided costs by a definite avoidance of 'dangerous interference with the climate system' (as ultimate target of global climate policy, 'defined' by EU's climate target of max. plus 2°C) by the GCCS are much higher than the above quoted costs of the implementation by such an efficient global cap and trade scheme. (chapter XI.A.)
10. Integrating the 3 mainly discussed macro-economic, price-impacts and impacts regarding transfer sums of different countries by the GCCS the results of this report are the following:
    - The price effects (higher fossil fuel prices) are totally tolerable in DCs with price-regulated fossil fuels markets. In non-regulated markets in DCs as well as in industrialized countries the price effects will be tolerable too in case the revenue from a market oriented CC allocation to fossil fuel and resources providers would be distributed on a nearly equal per capita distribution to all citizens.
    - The transfer gains of most of developing countries are significant and would boost climate friendly and sustainable development and growth as well as the elimination of poverty. The CC-transfer burdens of some (higher emitting) developing and newly industrialized countries and some highly emitting industrialized countries (with a low per capita GDP) can be alleviated by some general relief clauses. The GCCS-burdened oil and coal producing countries normally have a high GDP and could bear the GCCS-transfer- and negative export price impacts for fossil fuels.
    - The GCCS implementation costs as welfare losses of an otherwise faster growing economy and losses of the GDP are globally (highly) worth while. This shows an excellent benefit/cost ratio of an efficient global cap and trade scheme: Such a mitigation policy 'produces' for every dollar/euro a benefit of reduced climate change costs in the range of 10 dollar or euro. Therefore the world and all nations can and should bear the cost burdens. Because of this high benefit by implementing the cap and trade scheme an economic compensation scheme for economically higher burdened and economically lesser strong economies should be reachable. To get the absolutely needed unanimous acceptance of the GCCS (PLUS) global cap and trade scheme, there can and should be a burden sharing between those economically burdened (economically lesser strong) and GCCS (PLUS) related benefited countries.
    - Irrespective of the economic effects in monetary value terms: Nearly all countries world wide will get great environmental benefits by very significantly reduced climate change and its otherwise more or less extremely negative physical impacts.
11. As far as the chances for an implementation of the GCCS is concerned, one has to consider: Irrespective of the quoted excellent benefit/cost ratio – whatever efficiency im-

provement of the ‘Beyond Kyoto 2012’-global climate protection system should be aspired to – it will be extremely difficult to implement: Mainly because of the ‘unanimity principle’ in international treaties and in climate policy as well. But: There exist several reasons for relatively good chances for the implementation of the GCCS and GCCS PLUS:

- The necessary review of the Kyoto Protocol will reveal its quantitative and structural deficiencies in reaching the basic target of international climate policy to prevent dangerous climate change.
- GCCS / GCCS PLUS in fact are ‘appropriate actions’ to overcome those deficiencies.
- Because of its important development components, this system is highly attractive for developing countries thus giving a chance to actively integrate those countries into the international climate protection scheme.
- Therefore in principle there exists a chance for an initiative of some developing countries for such a global cap and trade scheme thus implying an active integration of developing countries into the global climate policy system.
- This in fact could lead to a completely changed ‘battle order’ at international climate conferences: Suddenly there could be – at least – a two third majority of all states for a progressive international climate policy and for a global cap and trade scheme like GCCS/ GCCS PLUS.
- Because all official US-American reservations and objections towards the current Kyoto I system have been implemented into the GCCS and because additional US-American proposals against too high burdens for the economies have been integrated there even seem to be some chances, that the USA could accept such a global cap and trade scheme.
- Contrary to prolonging the Kyoto I system by individual national commitments and national caps (a method that is not at all successful in the first commitment period!), a system with a global cap and with flexible market mechanisms seems to be much more acceptable to most governments.
- The above mentioned excellent benefit/cost ratio of implementing GCCS PLUS is another very strong argument for international talks about its implementation.
- GCCS and GCCS is a nearly ‘1 to 1 – implementation’ of the main elements of world’s leaders urgent call for an efficient long term climate protection system into a conceivable global climate protection system as a structural evolution of the Kyoto Protocol. (Ref. to section XII.C.)

12. Based on the above quoted findings and detailed considerations in this report the author is convinced: Should it be possible at all – with the author being both sceptical and hopeful at the same time in this respect – to reduce global climate gas emissions to such an extent that the prevention of dangerous climate change is still possible, then this can only be achieved with the help of a global incentive system in the form of a 'cap and trade' emissions trading system where allocation is – at least – substantially based on the 'one human – one climate emission right' principle.

II. The need for a structural evolution of the Kyoto Protocol – Quantitative and structural deficiencies of the KP 'Commitment Strategy'

II.A. Urgent Call of Worlds' Economic Leaders for a Structural Evolution of the Kyoto Protocol

Worlds' economic leaders, being members of the so-called G8 Climate Change Roundtable of the World Economic Forum and representing the top-level of 24 international concerns like ABB, Alcan, BP, British Airways, BT, Cinergy, Cisco Systems, Deloitte, Deutsche Bank, E.ON, EADS, EdF, Eskom, Ford, HP, HSCB, Petrobas, RAO UESR, Rio Tinto, Siemens, Swiss Re, Toyota, Vattenfall and Volkswagen 'in collaboration with her majesty's government' (UK) frankly characterize the current world climate protection system straight forward as follows and therefore urgently call for its consequent restructuring respectively for its structural evolution:

> "The current 'patchwork' scheme of regulatory, financial, and technology incentives that has evolved in various parts of the world is not conducive to a cost-effective and efficient approach to the problem of climate change. The difficulty is exacerbated by the short term nature of the Kyoto Protocol and related policy mechanisms whose targets and timetables do not extend beyond 2012. For an investor seeking to gain a fair return on low capital projects whose life cycle may often be in the 25-60 year range (e.g. power plants), the level of risk can become a significant disincentive. The same kind of uncertainty clouds the future value of tradable emission credits and the value of investment in low carbon infrastructure in emerging markets. …
>
> For these reasons, we urge the G8 governments to
>
> - establish a long term, market-based policy framework extending to 2030, that will give investors in climate change mitigation confidence in the long term value of their investments. Establishing indicative signals extending to 2050 would also be beneficial.
> - Ensure that the policy framework is global in scope – utilizing a coordinated and consistent set of national or regional regimes, with maximum fungibility between regimes, and opportunity for future consolidation into a single regime.
> - Define greenhouse gas emission rights through a cap-and-trade system or other market-based mechanisms that can be adjusted over time to reflect evolving scientific, technological and/or economic developments and that will help shape consumer choices.
> - Address climate change as part of an overall sustainable development agenda, putting in place mechanisms which address the challenges of poverty, energy, and economic growth in emerging markets while mitigating greenhouse gas emissions." (WEF 2005, p.3)
>
> *(Underlining by the author for highlighting a nearly identical evaluation of the climate protection system and the targets of the global cap and trade scheme (GCCS), both presented below.)*

This assessment of the current global climate protection system by worlds' economic leaders – focussing mainly on the low incentives of the current 'patchwork' climate protection system and the short term periods of the Kyoto Protocol (KP)' for the necessary long term climate friendly investments – has got to be followed by an 'official' review of the KP: In 2005: According to the Kyoto protocol (art. 3.2, 3.9 and 13.4.a. and b.), there must be the initiation of an official review by the Conference respectively the Meeting of the Parties (COP/MOP) of the UNFCCC and the KP, whether the current Kyoto commitments and their implementation (by industrialized Annex-I-states) have had or will have the necessary progressive impacts in order to achieve the ultimate objective of UN Framework Convention on Climate Change 'to prevent dangerous anthropogenic interference with the climate system' (UNFCCC, art. 2). After that review – in case the prospects for reaching that target would not be sufficient – the 'Meeting of the Parties to this Protocol (MOP) "shall take appropriate action". (KP Art.9.1.)

The author has already done such an unbiased review of the KP in order to assess the quantitative prospects of success of the Kyoto Protocol commitment system and its structural chances for a successful mitigation of the climate change (Wicke 2005, p29seq). This 'inofficial review' shall be actualized and summarized in the following three sections.

II.B. The regrettable quantitative failure of the Kyoto Commitment Strategy

Two figures among thousands in the latest World Energy Outlook 2004 clearly show the complete failure of the Kyoto Climate Protection Strategy by national climate commitments: Taking into account all energy and CO_2-relevant decisions world wide – also initiated by the Kyoto process – up to summer 2004 the prognosis of the IEA[1] reveals: Up to the year 2010 the industrialized countries (OECD) will increase their CO_2-emissions by 25.3% ('change since 1990', IEA, 2004, p437) instead of reducing them by (at least) 5.2% (missing the target by 30.5%(!)) as originally signed in the Kyoto Protocol. And the European Union, self-nominated 'world leader' in CO_2-reduction will fail in a similar range of magnitude: Instead of reducing their CO_2-emissions by 8% (as compared to the 1990 emission level) the increase will be 9.1% (IEA, 2004, p469) – thus missing the ratified and therefore internationally legally binding target by 17.1%![2]

These – applied to the climate change mitigation target – non-compliance figures clearly show: By not achieving the 'committed' very limited emission (growth) reduction by industrialized countries and the EU (as the main promoter of additional international efforts for combating climate change) the whole basic future Kyoto strategy, being pretty unrealistic from the very beginning, falls apart: Industrialized countries de facto are 'not taking the lead' in combating climate change but (on balance) fail to comply with their – applied to the climate change mitigation target – objectively very limited obligations as quoted above (PLUS 25,3% instead of a reduction of 5.2% over a time of 20 years respectively 0.25% per annum).

Describing (by quoting) this deplorable development doesn't mean all that the author does neglect or doesn't highly appreciate the great success of the Kyoto Protocol: For the first time the international community has agreed upon an internationally ratified and legally binding anti climate change treaty. And above that: With the ratified Kyoto Protocol there exists a basis for improvements by structural evolution of the international climate protection system, as urgently demanded by the above quote world's economic leaders.

Coming back to the quoted projections of IEA: Even if there might be an overestimation of the growing emissions in the IEA-prognosis: This magnitude of the foreseeable non-compliance of Annex I states evidently implies that there will be no chance whatsoever to include even one single newly industrialized or developing ('Non Annex I') country to commit to a reduction of their emissions growth or even of their absolute emissions. Because of the high reliability of the IEA prognosis[3], starting with the publication of the World Energy Outlook 2004, now there exists one decisive <u>additional</u> argument to the two 'traditional' and understandable refusal arguments by developing countries <u>against</u> any CO_2- or greenhouse gas commitments: (1) Much less per capita emissions and income and level of economic development <u>and</u> (2) the indubitable historic guilt of industrialized nations ('their' historic and actual anthropogenic CO_2-concentration share in the atmosphere). But (3): The de facto failure of 'taking the lead' in emission reduction by those nations is the last and decisive tomb stone of

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[1] International Energy Agency, the autonomous energy cooperation 'body' within the framework of the OECD

[2] The only conceivable 'formal' compliance of the EU (being objectively 'legal' under the flexible mechanisms of the KP) with its minus 8%-target, equivalent to around 700 million tons of CO_2-reduction (compared to the predicted around 4.1 billion tons in 2010, IEA, 2004, p469) with its target can be achieved by buying 'emission credits from non-EU-countries' (IEA, 2004, p254). Besides legally achieving emission credits by joint implementation in Annex I states or clean development mechanism measures in developing Non Annex I – states, EU legally can buy the so called 'hot air' of around 1.5 billion tons – presumably primarily from Russia or Ukraine. (Grubbs et al. Definition of 'Hot Air: <u>The excess emission allowances over the business as usual emissions</u> in the commitment period are called hot air. The existence of (too much) <u>hot air could undermine the trading regime or even the whole climate change regime</u> *(underlining by the author)*. Hot air is believed to exist mainly in the Former Soviet Union and some Central and east European states.' (Grubb et al, 1999, pxxviii). Grubbs 'belief' is confirmed by the European Union especially for the example of Russia: 'Negotiated' zero emission 'growth' up to 2012 compared to a predicted business as usual path of at least minus 30%, difference: nearly 1.5 bill. t of 'hot air' CO_2! (European Commission, 2002, p45). Note: Buying 'hot air' is not a means against climate change. <u>Not</u> conceivable are appropriate additional EU internal measures up to 2010 to meet its obligations.

[3] IEA itself describes the reliability of its projections: "Since 1993, IEA projections for global energy demand have been within 2.2% of the most recently reported data." And "The publication (of the World Energy Outlook, WEO) ist acknowledged world wide as the single most important source of energy statistics, projections and analysis. The WEO 2002 … received several awards for analytic excellence. (IEA 2004, p.519 and p.3)

the present 'conventional' Kyoto 'commitment' strategy: No active inclusion of so called Non-Annex I countries (newly industrialized and developing countries) in the Kyoto commitment system and no future or a prolongation of the completely inadequate and far too small commitments of industrialized and countries in transition[4]! Therefore there will be no chance at all, to start with appropriate commitments of all countries that originally signed the Protocol in Kyoto in 1997 for future 'commitment periods'.

And this consequently means: Trying to go on with the 'commitment strategy' seems to be equivalent to no prevention of dangerous climate change: In the contrary – if there will be no decisive change or structural evolution in the global climate protection regime the world is directly heading towards a CO_2-concentration of up to 750 ppm CO_2 or even more as shown in Figure 1 (in section II.D.), if the IEA-prognosis up to the year 2030 – plus 90% = 38.2 bn t of CO_2-emissions till 2030 compared to 1990 (IEA, 2004, p76 and 433) is going to materialize and not to be reversed in later decades of the 21st century be enormous decreases of emissions[5]. "…50 years of BAU (business as usual development) emissions followed by 50 years of a flat trajectory at 14GtC/year *(=51GtCO_2/year)* leads to more than tripling of preindustrial concentration *(= around 750ppm!)*(text in italics suppl. by the author)" (Pacala/Socolow 2004, p968) And this – there can be no doubt at all about that by any serious scientist – in fact would be equivalent to dangerous if not even catastrophic climate change! (For the maximum plus 2°C – target of the European Union (to prevent dangerous climate change) one must reduce world wide emissions till 2050 by 60% (as can be (indirectly) seen at the 450 ppm CO_2-stabilization curve of the IPCC (refer to Figure 1 in section II.D.) which is – after newest findings with a certain degree of probability – still not enough reduction for reaching the quoted 2°C-target. Only a concentration of 450 ppm $CO_{2equivilants}$ (including all other greenhouse gases) would be with a 100% likelihood be target-sufficient. (Hare and Meinshausen, 200 4 p. 26, p. 35)

II.C. Structural efficiency deficits of the Kyoto Protocol

There is unfortunately little to no hope at all that this foreseeable development can be changed within the current Kyoto Protocol system, based on a commitment strategy. This system is designed in such a manner that it bears from the very beginning the – very likely – risk of failure because of the following structural deficits:

1. There is ***no*** global, quantified climate sustainability target (and no intermediate target up to 2010). Contrary to the EU, the 'Kyoto negotiation community' as a whole was unable or unwilling to define the concentration level of greenhouse gases that may not be exceeded in order to prevent dangerous anthropogenic interference with the climate system. Therefore, this system lacks the ***one*** decisive basic precondition for evaluating the success or failure of the climate protection process.
2. Developing countries have refused and still refuse – and rightly so from their point of view – to restrict or reduce in any manner the increase in their CO_2 or climate gas emissions in light of
   - their economic development backlog and
   - their by far below-average per capita emissions and
   - the large share of blame borne by industrial countries for burdening the earth's atmosphere with accumulated CO_2 emissions (about 85%, 'historic greenhouse gas debt').

   This is true irrespective of the fact that overall emissions by developing countries and newly industrialized countries are on balance rising strongly and, according to forecasts

[4] Contrary to some announcements it seems not conceivable that even climate committed Annex I states – at the end of the first commitment period – will commit to adequate reductions (for a global climate stabilization) after their above predicted own non-compliance in the first period and the disaster of the non-compliance of the whole group of Annex I states by both sub-groups of the Kyoto non-ratifying and ratifying countries.

[5] Additionally one has to consider the dramatic increase of world wide CO_2-emissions since 1990: Emission growth 1990 to 2010 (projected) plus 38.9% or plus 7.8 billion tons per annum (IEA/OECD, 2004, p433). Nevertheless there exists at least one chance for compensating the dramatic "overshooting " of global emissions in the first three decades of the 21st century, by installing the CO_2-capture and storage (CCS) technology in all new CCS-inclined processes world wide (preferably starting in 2015), thus reducing global emissions significantly. (Refer to sections VII.B.2.c. and VIII.C.)

by the IEA, this will result in their emissions being higher than those of industrial countries in and around 2025. (IEA 2002a, p73) (Per-capita emissions of developing countries, however, will still be far below those of industrial countries. IEA 2002a, p73)

3. This is why, pursuant to the Kyoto protocol, industrial countries should and are to go ahead (initially) alone with effective reductions ('taking the lead'). More or less as a form of voluntary commitment ('voluntary agreement') within the international framework (Knebel/ Wicke/ Michael 1999 p.283seq.) (later, after ratification of the KP, those commitments turned to be legally binding under international law). The various Annex-I states (or the EU as a whole) offered in the aftermath of a lengthy round of 'poker' negotiations to restrict or reduce in as far as they deemed (at that time) to be possible their increases in emissions – based on (and proportional to) their globally far above-average per capita emissions (grandfathering). This in balance ultimately led to a *commitment* of an overall emission reduction of 5.2% by 2010/12 against 1990 by industrial Annex I countries. The quantities agreed to were then included in the Kyoto Protocol and thus have been made binding under international law as Assigned Amounts (AA equal to the emission permits allocated to the countries (average per year) in the period 2008 - 2012) for the individual countries or the EU as whole. [6]
4. This (voluntary commitment) principle of negotiation and agreement leads to a complete misguidance of the players involved ***against*** the global climate protection interest. The result of comprehensive investigations into 'voluntary commitments/agreements (even if they are integrated in a national or international legal binding system') for solving environmental problems is very clear. Voluntary commitments cannot solve really costly environmental problems (even if these commitments should become legally binding immediately or at a later point in time) (Knebel/ Wicke/ Michael 1999 p.520seq.).
   Recurring to the climate change problem this means: As soon as energy savings ***and*** the resultant cost reductions (or other positive economic effects) make climate protection no longer 'profitable' on a single-economy or on the national level, and therefore greenhouse gas reduction can only be reached by increasing costs and reducing consumption, the 'free rider effect' will prevail [7]: All the industrial countries affected try to reduce their climate gas emissions burdens to a level that is economically "painless" and possible without any (economic) sacrifice (thus doing no harm to national economy). The effect of every nation's single possible share (of slowing dangerous climate change) is small to rather limited (USA, Russia), every nation hopes – 'free rider idea' - that other countries will bear the necessary GHG reduction burden. This means for the climate efficiency of the negotiated 'voluntary commitment' system: Emission reductions cannot and will not be defined as what is necessary in terms of climate policy and climate protection, but as what can be expected from and implemented in the individual countries or groups of countries. This even leads to a 'negotiable' CO_2 (growth) potential compared to the business as usual development (example Russia: 'negotiated' zero emission 'growth' up to 2012 compared to a predicted business as usual path of at least minus 30%, difference: 1.5 bill. t of 'hot air' CO_2! (European Commission 2002, p45)).
5. One hence must note that the instrumental approach of the international Kyoto self-commitment system is in no way capable of solving the problem of climate change. The environmental instrument of 'self-commitment' is in fact the weakest instrument of all when it comes to overcoming environmental problems: This instrumental approach is normally adopted if
   - there is no chance that nations or supranational institutions are able to set clear standards in order to restrict emissions – here greenhouse gases – to the extent necessary, or
   - if no consensus can be reached in order to introduce effective emission charges or taxes on a global scale that 'automatically' steer the behaviour of all relevant businesses and private consumers in the right direction, i.e. towards reduction.

[6] Due to the binding definition of percentage increases or reductions, which are based on the starting emissions of individual countries, these historically above-proportion per capita and/or absolute national emissions were implicitly recognised as being the basis for agreements governed by international law (the so-called 'grandfathering principle').

[7] Refer also to the following third (very long) footnote (starting with this footnote)

- In such a dilemma (the world community wants do something but is unable to take the right and adequate steps), the instrument of voluntary commitments is adopted merely in order 'to do something' and to 'go in the right direction', but with the implicit and clear aim not to harm national economies or businesses as a whole. Like in the Kyoto process, the outcome is that the world community continues on a course of self-commitments accompanied by disappointment over inadequate commitments where most nations fail to comply with their legally binding commitments or evade their commitments under the Kyoto Protocol. (ref. to the projections of the IEA (p433seq) till 2010.
- If the world community continues to focus on improving the commitments undertaken by the adopting states (with zero success up to now) and on increasing the number of self-committing nations, the attention will in the long run be distracted even more from the ecological objective, i.e. 'to stabilize greenhouse gas concentrations in the atmosphere in order to prevent dangerous anthropogenic interference with the atmosphere'.

The failure of the Kyoto system of self-commitments therefore is unfortunately preprogrammed: If ***self-commitment approaches don't work for (far less) costly environmental problems on a national level, there is no way that they are going to work for the most expensive environmental problem either***. Reaching climate stabilization does in fact represent the world's most expensive environmental problem: ***In order to solve this problem, consumption and production patterns of the world economy must be totally transformed in a climate-friendly and sustainable manner.*** The 'binding international self commitment approach' of the Kyoto Protocol in fact seems to be its basic structural deficiency from the very beginning!

6. Furthermore the UNFCCC/Kyoto process
   - neither offered or offers any incentives whatsoever for Annex-I states to enter into particularly far-reached obligations,
   - nor does the Kyoto Protocol offer any particular incentives to actually ratify the Kyoto Agreement (as is demonstrated by the departure of the USA and by Russia's hesitance)
   - nor are there sufficient incentives or sufficient 'draconian and feasible sanctions' to observe the commitments entered into (after ratification). (In light of the current failure on the part of many key states to observe their commitments, the performance checks and sanctions pursuant to Article 18 of the Kyoto Protocol, which are defined in great detail in the Marrakesh Accords, including prewarnings, reporting on the violation of the emission budget, the requirement to buy a corresponding quantity of certificates and the deduction of a higher emission share in the subsequent commitment period (UBA 2003b, p26) seem to be 'dud weapons'.)
7. The market-orientated incentives that were justly included in the Kyoto Protocol 'merely' serve to make implementation on the respective national (or collective – as in the case of the EU) commitments easier and more cost effective, which can without doubt be seen to serve a 'catalyst' function. However, these flexible instruments provide no incentive to reduce emissions further than the level that was ultimately agreed to. Since some states have been granted more (tradable) emission rights[8] than the emissions that would be generated with 'business-as-usual' development, the instrument of joint implementation at least ensures that more emissions than otherwise expected are actually permitted under international law.

Taking a somewhat closer look at the basic problems, the main shortcoming of the Kyoto climate protection system arises from the injustice of the currently free use of the atmosphere, which has not been changed by the Kyoto Protocol. On the contrary, the commitments by Annex-I countries to reduce or maintain or even allowing them to increase their

[8] According to Grubb et. al., such 'hot air' is primarily in the states of the former Soviet Union (Russia, Ukraine and the Baltic states as well as in central and in the eastern European states). (Ref. Grubb/ Vrolijk/ Brack (1999) p. xxviii)

emissions on the basis of emission levels in the 1990s clearly constitute 'recognition' or factual 'acceptance' of these high, absolute and per-capita, zero-cost emissions that pollute the atmosphere with (potentially) dangerous greenhouse gases. Around a fifth of the world's population emits approx. four fifths of all climate gases. This means that developing and threshold countries (and hence approx. 80% of the world's population) are of the opinion that industrial countries with very high per capita climate gas emissions must first of all perform drastic reductions before one can even think of including developing countries into a system of climate gas restrictions or even reductions.

This was the basis for developing and enforcing the inefficient Kyoto climate protection strategies according to the "grandfathering principle" (each industrial state reduces a certain 'negotiated' percentage on the basis of its former climate gas emission, developing countries being not included[9]). This results in the ***"Unfairness trap of climate policy"*** with the following fatal impact on climate policy:

a. Individual industrial countries and the entire group of states have – among other things, due to the 'multiplied global commons problem' with climate protection[10] – no self-interest, or at least very little self-interest, in suitable climate gas reductions (of a total of 5.2% between 1990 and 2010 or even of up to 80% by the end of the 21st century). This means that the targeted reduction in emissions in industrial countries will ***in no way*** be so 'impressive' that it substantially reduces the difference in per capita emissions between industrial and developing countries.

b. Therefore – according to the basic idea on which the system is based and which is the source of a sense of justice, i.e. that 'industrial countries with high emissions must first reduce their emissions significantly ('should take the lead')' - developing and threshold

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[9] 'Grandfathering' allocates emission budgets cost-free according to emissions in a specified base year. ... grandfathering advantages countries with high emission in the reference year ... which basically are industrialized countries.' (Michaelowa/ Butzengeiger/ Jung/ Dutschke 2003, p. 35.)

[10] Wicke 2002, p. 37seq. Here, the section "The exponentiated global commons problem with environmental protection" deals with the capacity to solve national and the general incapacity to solve global environmental problems (which is summed up briefly here): Each individual climate (protection) contributes only to a small, at best to a restricted (USA, approx. 20%), degree to climate destruction. The contribution towards global climate protection is just as low and extremely restricted. This familiar collective asset problem with climate protection is aggravated further (with the trend towards 'free riders') by the following aspects:
A climate-influencing reduction can only be achieved, if at all, by all the players affecting climate. This joint action, this ***global*** will to take on responsibility and to implement is not yet recognisable and can hardly be expected.
As long as climate protection is not possible at no extra cost or even with added revenue (e.g. through energy savings), but continues to be linked with higher costs and sacrifice of whatever kind, citizens living today (and voters in the majority of countries) must be become convinced that they must bear costs and sacrifices (above all) in the interest of future generations.
In view of the haziness of forecasts on the impact of climate development/climate change (even the IPCC doesn't dare to define quantitatively at what level 'dangerous interference with the climate' starts!), it is very difficult to forecast with certainty
whether future generations in one's own country (one's 'own' children and grandchildren) will have 'climate disadvantages' or even advantages (e.g. more favourable climate) and
when (in 10, 50 or 100 years?) the impact of the – minimum, usually not 'measurable' – effect of reduction of one's own actions will be felt.
These are hence additional – completely uncertain – preconditions for the vast majority of voters to accept the disadvantages of climate policy for themselves. This implies with (almost) certainty that voters and politicians alike – just as with the "usual" political problems – will decide in favour of current welfare and – unfortunately – against the welfare of future generations. This is particularly true when it comes to serious restrictions and disadvantages which are to be expected (on the basis of current findings) in conjunction with the very high climate gas reductions rates required in particular in industrial countries and/or the serious emission-related 'growth curb' in developing and threshold countries. This is why each climate protection policy is doomed to failure, no matter how committed it is. This can already been seen, for example, with the initial, still very low reduction commitments according to the Kyoto mechanism (and the related, relatively slight increase in prices and disadvantages), for instance, in the blockade behaviour exercised by the USA. Nobody in the EU should "hide" behind the bad example set by the USA and should not be deceived: If really serious sacrifices are expected, the majority of European voters and European politicians will behave just like the political class in the US!
At first glance, it appears that this fatal logic of the "exponentiated global commons problem of climate protection" can only be overcome by an incentive-based climate protection system that makes it possible to mobilize the economic interest of all the players in climate protection and hence to boost eco-efficiency enormously. The GCCS, described and designed in chapter V and following, attempts to trigger precisely this situation.

countries will continue to have no inclination and cannot be enticed to restrict emissions in any way.

c. Global climate policy thus remains caught in its own 'unfairness trap' with the resultant consequence: In general, first modest climate gas reductions by some states or groups of states (for example, Germany and Great Britain) will be compensated for or even over-compensated for by higher emissions by other countries. This is the only way to explain the previously stated forecast – fatal from the point of view of climate policy – issued by the International Energy Agency of a large increase in global emissions between 1990 and 2010 (plus 38.9% (IEA 2004, p433)(!)) and beyond.

Summarizing the structural deficits of the Kyoto Protocol:

- Without a clear and quantified climate protection objective and
- with the (wrong) instrumental approach of binding self-commitments,
- which therefore includes far too small self-commitments by industrialized countries only (which they are – on average – even unable to achieve),
- therefore without the least chance of including developing and newly industrialized countries in the climate protection system with substantial emission growth limits and
- with no (economic) incentives for climate-friendly behaviour for all nations and all fossil fuel consumers worldwide,

there is no chance whatsoever that climate sustainability will be reached, thus preventing dangerous interference with the climate system.

Even worse: By not achieving the 'commited' very limited emission (growth) reduction by industrialized countries ***the whole basic future Kyote strategy falls apart***: Because industrialized countries de facto are 'not taking the lead' in combating climate change but – on balance fail to comply with their obligations – there will be no chance at all, to go on with appropriate commitments of Annex I states in future 'commitment periods' ***and*** to include even one single newly industrialized or developing country.

II.D. A Comprehensive Quantitative Assessment of the Structural (In-)Adequacy of the Kyoto Commitment Strategy to Combat Dangerous Climate Change

The above quoted figures and the resulting consequences for international negotiations are 'nothing but' a foreseeable political forecast about the non-willingness or the incapacity of the main international players at the world wide climate 'conferences of the parties' to any or approximately adequate commitments to a climate stabilization at least on the 'original (1996)' far too high level or minimum level of the European Union of 550 ppm CO_2[11] (which is not (or no longer) according to climate science (Berk and den Elzen, 2001, p6, Hare and Meinshausen, (2004), p38) consistent with the second and now dominant EU-aim of stabilizing the world wide temperature rise at 2°C by 2100 and thereon.

In the following section there will be discussed – as objectively as possible – that indeed the commitment system of the Kyoto Protocol seems to be structurally unable to meet its main objective (Art. 2 UNFCCC) 'to prevent dangerous anthropogenic interference with the climate system'. This can be shown based on very careful studies of the most relevant literature with regard to the evaluation of the prospect of success of different climate protection systems (mainly: IEA/OECD (2002), IEA/OECD's authors Philibert and Pershing (2001) and ECOFYS (2002) The assessment criteria of Bodansky et. al. (2004 p5seq.) and earlier publications have been integrated in the criteria of the above quoted authors and therefore integrated in the assessment (ref Wicke 2005, p11seq.)

By taking into account the experiences and the evaluation criteria of those authors the author of this report has developed the so-called 'comprehensive standard system for evaluating the prospect of success of different climate protection systems' (Wicke, 2005, p11seq.).

[11] This target was proclaimed first in 1996 by the EU (before the Kyoto conference) – later revised down to very desirable but politically completely illusionary 400ppm (refer to the above quoted prognosis and Figure 1) with a nearly 100% probability of reaching the 2°C-target. For "achievability"-reasons the EU now pledges for around 450 ppm CO_2 (with a lower probability of reaching its 2°C-target) as follows: "…limiting the temperature rise to 2°C will very probably require greenhouse gas concentrations to be stabilized at a level even lower that 550 ppm $CO_{2eq.}$." (CEC 2005b, p.5) This consequently would imply to reach at least the 450 ppm CO_2-stabilization curve of the IPCC.

All the criteria and sub-criteria of the above mentioned literature have been integrated – and weighted in partly slight deviation to other authors. Especially the possibility to achieve 'climate sustainability' with a certain climate protection system – contrary to others, (with only 33%) – has been given a weight of 50% thus being called the 'paramount criterion':

> *"Environmental effectiveness – measured in terms of the ability of a policy to stabilize atmospheric concentrations of greenhouse gases – is in this sense the overriding priority of international climate policy. Political considerations of equity, efficiency and so on must take second place to this priority;* ***there would be little point in implementing a politically feasible approach that isn't up to the environmental job in hand.*** (prominent rendering by the author)" (Evans/ Simms 2002, p. 5)

Therefore – as mentioned before – the climate sustainability criterion accounts for 50%, economic efficiency for 18%, technical applicability for 8% and political acceptance for 24% of the maximum score. On that **clearly defined basis** (with a total of 19 sub-criteria, which have a single weight according to the information within Table 1 to Table 4) which – of course – is **open to scientific debate and criticsm**, Wicke could do a comprehensive evaluation of the Kyoto Protocol. (Note: The evaluation of the GCCS, shown in Table 1 to Table 4 too, has been carefully done and documented in the basic book. (Wicke 2005, p119 to 148))

To start with the **'paramount' criterion** of '**climate sustainability or effectiveness**' the important question here is whether the climate protection targets laid down in the system in question are also implemented and the climate goals be reached.

As far as the weighting of its nine sub-criteria shown in Table 1 is concerned, one has got to note: Because most of the sub-criteria were taken directly from the above quoted most important literature they sometimes evaluate similar effects. This is why some very important sub-criteria (for instance the opportunity to fully include developing countries in the global climate protection system) are weighted in at least three sub-criteria. Therefore those 'weights' have to be summed up. And: The incentives / compulsion for all countries and greenhouse gas emitters for climate-friendly behaviour are so important that they have got a scoring at different sub-criteria. Especially at this paramount criterion it can be shown that the Kyoto Protocol 'commitment system' based on negotiated commitments of only Annex I – industrialized countries and countries in transition and with no greenhouse gas relevant commitments at all of developing or newly industrialized countries, the Kyoto Protocol is structurally unable to 'do its environmental job in hand' that is to say 'to produce climate stability':

The first four criteria, taken directly from demands by the IEA/OECD (2002, p40) and IEA's 'Standing Group on Long-Term-Cooperation' nearly are not fulfilled at all (only 4 points out of a maximum of 22 points):

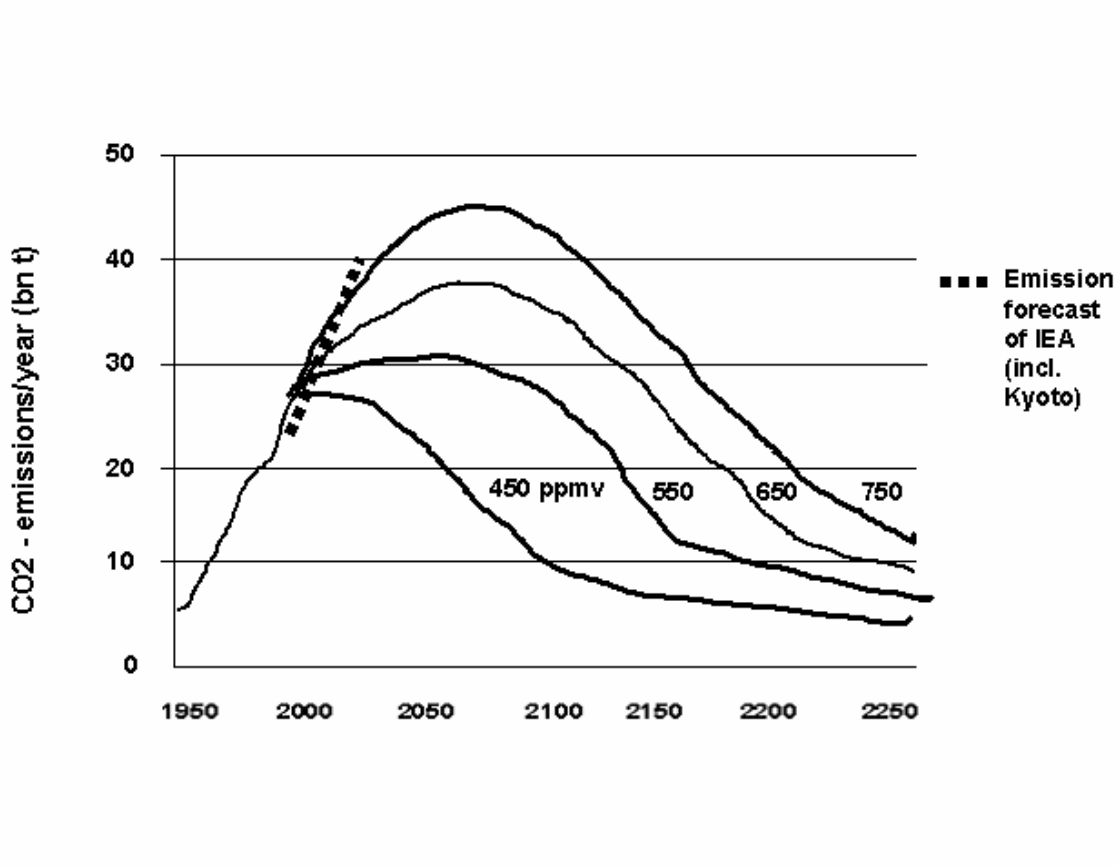
1. There exists virtually no general incentive (based on the regulations of the Kyoto Protocol) for developing countries to reduce the increase of their CO_2-emissions[12] (Zero points out of 4, (CDM see 4th criterion)).
2. Deplorably also the second criterion of the IEA/OECD for a successful climate protection system "additional action" for a stop of "developed countries' aggregate emissions" (IEA/OECD, 2002, p40) preferably by 'permanent incentive / compulsion for substantial reduction measures in developed industrialized countries whose aggregate emissions continue to rise' is fulfilled by the Kyoto Protocol only to a very limited extent: Only the Annex I states that have ratified the protocol have a legally binding commitment of an 5.2% reduction on balance. As shown above in section I.A. those industrialized countries will not meet that objective. Even the EU will not meet its commitments (IEA 2004, p469) or – if at all – partly with the help of some JI- or CDM-projects and mainly by buying 'hot air' – as shown above (sec. II.B.). The Marrakech compliance and sanctions' modalities according to Art. 18 Kyoto Protocol for non-complying countries (UBA, 2003, p26) seem to be a pretty dud weapon. One has to consider that the above quoted IEA-prognosis of

[12] The very small incentives by financing some CDM-projects are evaluated under criterion 4.

non-complying of nearly all industrialized countries seems to be pretty much realistic[13]. Therefore the evaluation of 3 out of 10 points is rather optimistic for that sub-criterion.

[13] IEA's basic knowledge: implementation of all relevant actions world wide up to summer 2004 for a prognosis of the changes between 1990 up to the year 2010!

Figure 1: Global CO_2 emissions from 1990 until 2030 and emission scenarios of the IPCC – presented by WRI – for stabilizing at concentration levels between 450 and 750 ppm CO_2 and emission forecast of IEA till 2030



Sources:

a) Stabilization paths at various levels: PowerPoint presentation by the World Resources Institute (http://powerpoints.wri.org/climate.ppt) according to IPCC 1995 a, p.10, and 1995 b[14]

b) Energy-related CO_2 emissions: IEA (2004) p76 and p433[15] [16].

3. From the very beginning developing countries categorically refused to take part in the Kyoto Protocol commitment system – mainly because of much smaller per capita emission and income and because of the 'historic emission guilt' of industrialized states. The current failure of those countries to meet their 'taking the lead' commitments makes it even more unlikely that they will be willing to be integrated in that commitment system. (Zero points out of four for this third sub-criterion)

[14] IPCC (1995 a), p. 10 Fig. 1 (b) and IPCC (1995 b) p. 85 (Fig. 2.6). These findings are based on the publication of Wigley, T. M. L and Richels, R and Edmonds, J. A. (1995). (*Note for particularly interested readers*:According to Fig. 6-1 and Table 6-1 IPCC TAR (2001/S), p. 99 and following, the 550ppm stabilization curve shown in the TAR (already) reaches its peak between 2020 and 2030 and drops to a level below the 1990 value between 2030 and 2100. But:This TAR IPCC presentation represents the 550ppm carbon dioxide equivalents of all greenhouse gases and sources (ibidem, footnote6, p. 98).According to the IPCC (TAR S, ibidem, p. 100) the 650ppm CO_{2eq} stabilization curve which comes closer to the EU's 550ppm CO_2 stabilization target, which is solely based on CO_2 emissions, reaches its peak between 2030 and 2045 and falls to below 1990 emission levels between 2055 and 2145. This is also reflected by the above-mentioned WRI stabilization curve on the basis of the IPCC's Second Assessment Report (SAR).The WRI/IPCC(SAR) 550ppm curve hence (largely) corresponds to the 650ppm IPCC (TAR2001/S) stabilization curve.)

[15] Since other CO_2 emissions from sources other than energy production and use (especially from other industrial processes and changes in land ad forest use) must be additionally considered, carbon dioxide emissions of around 30 billion tonnes must be expected in 2012-2014.

[16] Note: Since in Germany, for example, another 1% to 2% of emissions from sources other than energy production and use (especially from solvent and process emissions) must be added, this IEA curve represents a trend slightly below the actual CO_2 emissions during the period from 1970 to 2030.

4. IEA/OECD (2002, p40) rightly demands, that "solutions must be found to finance emission reduction costs, particularly in the developing world" because "GDP levels projected for developing countries imply that capital resources to reduce emissions will be extremely scarce". The financial assistance mechanisms (Art. 11 UNFCCC and Kyoto Protocol) are inadequate or only a 'drop in the sea' for that huge capital need for the reduction of CO_2 emission growth of developing and newly industrialized countries. Above that some additional emission reduction measures can be financed by foreign investors within the scope of the extremely complicated 'clean development mechanism' (Art. 12 KP) to meet their obligations resulting from the commitments of their countries within the Kyoto Protocol. But this mechanism again can bring only a very small contribution to the huge costs for 'financing emission reductions in developing countries'. (Therefore the evaluation of one point out of four for that sub-criterion again is very optimistic.)

The following 5th to 9th criterion, taken directly from literature especially from ECOFYS ((2002), p33 and following) are not fulfilled:

5. Early actions in developing and industrialized countries are not favoured by the Kyoto Protocol: As long as emission reduction is equivalent to higher costs the Kyoto mechanisms are favouring 'late actions' both in industrialized. This holds true even more in non-committed developing and newly industrialized countries.
6. There is no 'avoidance of emission shifting (leakage) effects' by the Kyoto Protocol. On the contrary: 'Industrialized countries' and their domestic enterprises in principle can comply with their commitments (of reduction or limiting their CO_2-emissions) by shifting their highly emitting industry to not committed developing countries. There even exist incentives for such a behaviour for those industrialized countries (or their enterprises like in the European emission trading system) that are taking their Kyoto commitments 'seriously' by really proving their compliance!
7. There exists up to a zero mobilization of the permanent interest on the part of all states and economic players world-wide in contributing to climate–friendly behaviour and minimizing carbon dioxide emissions by the Kyoto Protocol: CO_2-emission remains cost-free world wide. As long as emitting is cheaper and more comfortable (for industry and consumers) than saving energy and reducing emissions there virtually is no incentive whatsoever to a more climate friendly behaviour. There may be some tiny incentives by way of the flexible mechanism of the protocol and of the EU Emissions trading system – but as long no state (or group of states like the EU) really cares for the compliance with their commitments, these mechanisms have no really relevant effect at the global CO_2-emission scale. (It must be admitted, that some spectators that have a high confidence in the willingness to comply of Annex I states may evaluate this very important sub-criterion[17] higher than zero out of ten maximum points as done by the at this point pessimistic author in Table 1.)
8. Evidently there exists no clear link between the climate protection system in place and a targeted, quantified climate sustainability / carbon dioxide stabilization goal (ECOFYS, (2002), p33): Besides the – on balance – 5.2% reduction of Annex I states there exists no overall global emission and no green house gas concentration target whatsoever.[18]
9. As quoted above, Grubb at al. (1999, pxxviii) suspect and the European Commission (2002, p15) proofs that there exists at least 1.5 billion tons of 'hot air' mainly in the states of the former Soviet Union. And: Each conceivable new 'commitment period' negotiation would produce new hot air: The interest of each self committing party would be to get a commitment that can be easily fulfilled or that even – as 'Russia-case' shows – lays below the 'business as usual' path in order to be able to sell unused 'assigned amounts' preferably by no efforts at all that is to say by zero-costing 'hot air'. (And you can't stop that bargaining result, as long the unanimous-rule is in place!)

[17] Only a climate protection system that gives very intensive incentives to all CO_2-emitting stake-holders in the quoted manner can have a chance to be adequately successful in climate stabilization.

[18] The UNFCCC Art. 2 objective of preventing dangerous interference with the climate system was never officially quantified by the conference of the parties – contrary to the EU's (minimum) target of 550 ppm CO_2.

Table 1: The evaluation of the 'Climate sustainability or effectiveness' of the existing UNFCCC/Kyoto system and of the Global Climate Certificate System

Climate sustainability: Main criteria (50 points): Ensuring that with the help of the international climate protection system examined the concentration of CO_2 in the atmosphere does not exceed the EU's minimum level of 550ppm on a permanent basis. (Are the rules agreed to in the contract and adhered to?)	Maximum score	Actual score Kyoto-Protocol		GCCS
Sub-criteria for securing the main criterion:				
General incentive to reduce the increase in CO_2 in developing countries	4	0		4
Incentive / compulsion for fast, substantial reductions in industrialized nations	10	3		7
Fastest possible involvement of developing countries	4	0		4
Financing emission reductions in developing countries	4	1		4
Favouring "early actions" world-wide	4	0		4
Avoidance of emission shifting (leakage) effects	4	0		4
Permanent interest in climate-friendly behaviour world-wide	10	0		10
Quantified climate protection aim of the climate system	6	0		6
Avoidance of "hot air" world-wide	4	0		2
Total:	50 max.	4		45

Source: Wicke, 2005, p38

The very sobering result of that evaluation of the 'climate sustainibility' or the climate effectiveness of the Kyoto Protocol is four points out of fifty – far below a 'poor' result – and therefore completely insufficient![19]

As far as the **economic efficiency** is concerned the evaluation is a slightly better one as can be shown at Table 2.

Out of an overall evaluation of 100 points the economic criterion is given a weight of 18 points (18%) (also in light of the necessary consideration of the fact that the economic assessment also plays an important role for the criterion of political acceptance (weighting factor of 24%) thus being evaluated there too.) The various and differing economic criteria and sub-criteria of Philibert and Pershing (2001, p213), ECOFYS (2002, p.34) and Boehringer and Welsch (1999, p17) have been subsumed under four sub-criteria:

1. 'Cost efficiency: Minimizing global costs'and
2. 'Flexibility during national implementation (minimizing national costs) and financial assistance for development countries'
   The JI, ET and CDM flexible elements, supplemented by the EU-emission trading system contribute – with (climate-based) overall low requirements and a pretty low share of the overall costs for climate change mitigation – towards cost efficiency and financing. Therefore these two sub-criteria are evaluated with 2 points out of maximum 6 respectively 5 points.
3. 'Considering structural differences in climate-related requirements': Because developing countries and threshold countries are not subject to any (reduction or limiting) requirements and because there exist (climate-based) very low and differentiated commitments for industrialized countries the structural differences of various countries are considered to a high degree within the Kyoto Protocol – therefore three of a maximum of 4 points.
4. Because the commitments of the industrialized countries are pretty low, 'the potential positive (growth) impetus' for a energy and cost saving restructuring of the various national economies of industrialized states (as well as for developing countries by CDM measures) remain pretty low. Therefore one out of 3 points.

On that basis the economic efficiency of the Kyoto Protocol is evaluated on balance with 8 points out of 18 points. (Ref. Table 2)

[19] Even a somewhat better evaluation of one or two sub-criteria would not change that depressing result.

Table 2: The economic efficiency of the Kyoto Protocol and the GCCS

Economic efficiency: Main criteria (18 points): Minimizing adverse economic effects and promoting positive economic impetus whilst implementing the climate-related goals of the climate-policy instrument examined	Maximum score	Actual score Kyoto-Protocol		GCCS
Sub-criteria for securing the main criterion:				
Cost efficiency: Minimizing global costs	6	2		6
Flexibility during national implementation (minimizing national costs) and financial assistance for development countries	5	2		4
Considering structural differences in climate-related requirements	4	3		3
Positive economic (growth) impetus	3	1		2
Total:	18 max.	8		15

Source: Wicke, 2005, p38

Technical and political applicability criteria also have an important role to play for the implementation capability and acceptance of a system. These criteria are given a total weight of 8%, i.e. a maximum of 8 points in the overall evaluation of the system in question.

Only ECOFYS (2002, pxiv,34) provides data and references on this criterion. The following issues are mentioned there.

- Compatibility with the Framework Convention on Climate Change and the Kyoto Protocol
- Moderate political and technical requirements in the negotiating process (simple approach, low number of decisions, data and calculation methods available)

These aspects are certainly important for the negotiation process. They are, however, certainly not the exclusive "technical applicability criteria".

The following aspects must be added.

- Easy applicability of elements
- Capacity to implement and checking adherence to the rules in order to achieve climate sustainability
- Avoiding fraud and corruption

Based on these aspects which supplement and occasionally overlap each other, this criterion and its sub-criteria are evaluated as follows (refer to **Table 3**):

The first sub-criterion is fulfilled completely. If one looks into the extremely high and complicated prescription of the Marrakech Accords about the functioning of the Kyoto Protocol and its supervision one sees that this is not an easy applicability nevertheless it has been set in function – therefore three out of four maximum points and 7 out of 8 points of the criterion 'technical applicability'.

The fourth and second most important criterion of all 4 main criteria (with a weight of 24 out of 100 points) is the '**political acceptance**' of the Kyoto Protocol or alternative climate protection systems. Contrary to the 'climate sustainability criterion' (can in fact the climate target be reached (after ratification and adherence to the rules by all parties)?) the decisive question for political acceptance criterion is just how likely is it that the climate protection system studied will be accepted in (perhaps lengthy) international climate protection negotiations, so that this could end with the signing of an agreement.

Table 3: The technical applicability of the Kyoto Protocol and the GCCS

Technical applicability: Main criterion (8 points): Do the structure and individual elements of the system meet the requirements of easy technical applicability	Maximum score	Actual score Kyoto-Protocol		GCCS
Sub-criteria for securing the main criterion:				
Ability to fit into the international climate protection system and the negotiation process	4	4		3
Easy applicability and control capability in order to ensure practical functioning	4	3		3
Total:	8 max.	7		6

ECOFYS (2002, pvii) states the following – largely acceptable – political criteria:

- Equity (fairness) principles[20]: Are the three equity principles need, capability and responsibility covered?
- Agreement with fundamental positions of all major constituencies: Could the approach be acceptable for all constituencies given their current positions?

Only the latter aim seems to be somehow problematic: Only if a climate protection systems is not demanding serious climate effective efforts by all parties the approach can be acceptable for all major constituencies from the very beginning – and this would extremely contra-productive in ecological terms.

The author is well aware of the principle of unanimity in international climate protection treaties and negotiations. Nevertheless, one should not rule out from the very beginning that conceivable (large) majorities in favour of certain further-developed or new climate protection systems could in fact lead to unanimous acceptance. This holds true not least because the negotiating process and compromise (as well as international pressure on initial 'refuser states') could make many initially 'inconceivable proposals' acceptable for the totality of all states.

With a view to the lengthy negotiating process which will be necessary anyway during the first commitment period of the ratified Kyoto Protocol the further developed Kyoto Protocol (second commitment period) or an alternative climate protection concept comes into effect not before the year 2013, the second political ECOFYS criterion is hence broken down into the aspects of

- Acceptance by all key players (groups of players)
- Acceptance by the largest possible percentage of all contracting states.

These sub-criteria together with two sub-criteria to include the fairness or 'equity' principles that are described by ECOFYS (2002, p33) and others in more detail are shown in Table 4.

Table 4: The political acceptance of the Kyoto Protocol and the GCCS

Political acceptance: Main criterion (24 points): Do the climate protection systems examined comply with the principles of fairness and how likely is it that they will be accepted by all or a majority of the contract states? (Could it lead to a signing of a contract?)	Maximum score	Actual score Kyoto-Protocol		GCCS
Sub-criteria for securing the main criterion:				
Fulfilment of the fairness principles				
- Promotion / non-prevention of sustainable development	5	3		4
- Stronger burden on industrialized nations bearing main responsibility and capable of bearing more burdens	5	3		5
Political acceptability				
- Acceptance by all key players (groups of players)	5	4		3
- Acceptance by the largest possible percentage of all contracting states	9	8		6
Total:	24 max.	18		18

[20] For an in depth discussion of those fairness criteria – GCCS-related – refer to Wicke 2005, p.238seq.

The Kyoto Protocol fulfils the two fairness sub-criteria only to around 60%: On the one hand the incentives for a sustainable development both in industrialized and in developing countries are in total pretty low and on the other hand the requirements and commitments (climate-related) of industrialized states are in total very low too.

Political acceptability of the protocol: In Kyoto originally the protocol has been signed – contrary to a very early 1997 unanimous vote of the US-senate against the Kyoto Protocol (Byrd and Hagel, 1997) and a later official rejection on that basis and the non-ratification by the US (and the Australian) administration

On balance: The ‘political acceptance’ of the KP is pretty high, therefore 18 points out of a maximum of 24.

Taking the evaluation of all 4 main criteria and its 19 sub-criteria into account a very depressing result must be stated: The existing **Kyoto system was awarded only 37 out of 100 points** which, pursuant to the English scoring system means **a score of "poor"**. The main reason for that: Due to its structural deficits, the current UNFCCC/Kyoto system is not capable to do ‘its environmental job in hand’, that is to say to adequately reaching at least the European Union's minimum stabilization goal of 550 ppm CO_2, thus **not contributing to a minimum climate sustainability**.

III. A conceivable structural evolution of the Kyoto Commitment System by a Global Cap and Trade Scheme: Description of the GCCS System

In chapter II the author described the quantitative and qualitative respectively structural deficits of a (self) commitment system of different states (commitments getting legally binding by international treaty later on). But regarding the time for and the improbability of a completely new negotiated treaty, of course the Kyoto Protocol can be the only basis for a more efficient international climate protection system.

III.A. Expanding the flexible Kyoto mechanisms to a global cap and trade scheme in the form of the 'Global Climate Certificate System, GCCS'

By presenting the actual projections of the IEA/OECD about further increases of CO_2-emissions by industrialized countries and for global emissions up to the year 2010 respectively 2030 as well as by presenting the evaluation of the Kyoto Protocol on an unbiased and clearly defined assessment basis (open of course to scientific and political debate!), the author Lutz Wicke has done a 'review of the Kyoto Protocol' in advance of the 'official review', to be initiated in 2005 according to its articles 3.9. and 13.4.a.. Because of these and future 'official' review findings with inevitably 'poor' results the 'conference' respectively the 'meeting of the parties' (COP or MOP)' according to art. 9.1. of the Kyoto Protocol must take 'appropriate action'. All major proposals for an 'incremental evolution' (Berk and den Elzen, 2001, p2) are awarded – because of the same or similar structural deficits – with a similar 'poor' scoring too (Wicke, 2005, p72 and following). Therefore – in order to in fact 'prevent dangerous interference with the climate system' – there must be a substantial 'reformation' respectively (as Berk and den Elzen (2001,p2) call it) a 'structural change' by a 'Beyond Kyoto' system.

By the evaluation of all major proposals 'Beyond Kyoto 2012' Wicke (2005, p28 to p115) demonstrates, that an effective climate protection system can not be achieved only by the continuation of the present commitment system. (For the summary of that evaluation refer to Table 5). As urgently demanded by world's economic leaders (ref. II.A.) this quoted broad evaluation has shown too, that an expanding of the already existing flexible Kyoto mechanisms to a long term global cap and trade scheme is urgently needed. These mechanisms are 'emission trading between ratifying Annex I countries' (Art. 17 Kyoto Protocol), 'joint implementation' (Art. 4 KP), 'clean development mechanism' (Art. 12 KP) and the additionally developed and introduced EU emission trading system (started in 2005).

Up to now three such global cap and trade schemes have been presented: The C&C approach by GCI (1999) und Meyer (2000), strongly backed by WBGU (2003, p78)[21] and secondly the here discussed GCCS. The third one "Common but differentiated convergence, CDC" has been put on the table of scientific discussion in 2005 in a study for and partly by the German Federal Environmental Agency (UBA)[22]. The second approach, which has been elaborated in much more detail to a stage 'in general application maturity' has been presented early in 2005 in the form of the Global Climate Certificate System by Wicke (2005).

Especially the first both 'structural change'[23]– 'cap and trade' schemes have in principle an indubitable advantage contrary to all "commitment" incremental evolution approaches of the Kyoto Protocol: With cap and trade schemes – if properly implemented – the paramount climate sustainibility criterion of 'preventing dangerous interference with the atmosphere' can be reached because there exists an 'emission cap' that has been defined to prevent dangerous climate change. This is one important reason why the scoring of those two climate protection schemes is much higher than all 'incremental evolution' approaches (Wicke, 2005, p110 and following) and therefore they should be the preferential approaches. This holds true mainly because both those approaches trigger incentives world wide for climate friendly behaviour and development and incentives especially for developing countries too to be actively integrated into the global climate protection system.

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[21] The C&C (contraction and convergence) system, put forward already in the nineties, can and should be transformed to an applicable system (refer beside others to Wicke, 2005, p85 and following).

[22] Höhne, N./den Elzen, M./Weiss, M. (2005), p101seq.

[23] The GCCS – more correctly should be called 'structural evolution' of the Kyoto Protocol, see below.

Table 5: Evaluation of all climate protection systems studied in Wicke (2005)

		Actual score										
Overall evaluation of climate protection systems according to *main criteria A to D* and their sub-criteria for ensuring fulfilment of the main criteria:	**Maximum score**	**Kyoto Pr.**	**Cont.Kyoto**	**MSA**	**NMSA**	**GTA**	**ETA**	**MSCA**	**CAN's FrW**	**(C&)C**	**GCCS****	**GECT**
Part A: Climate sustainability (actual score ***(xx)):***	***50***	***(4)***	***(12)***	***(17)***	***(23)***	***(11)***	***(11)***	***(11)***	***(12)***	***(42)***	***(45)***	***(27)***
General incentive to reduce the increase in CO_2 in developing countries	**4**	**0**	**1**	**1**	**2**	**0**	**0**	**0**	**1°**	**4**	**4**	**3**
Incentive / compulsion for fast, substantial reductions in industrialized nations	**10**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3***	**5**	**7**	**5**
Fastest possible involvement of developing countries	**4**	**0**	**1**	**2**	**3**	**1**	**1**	**1**	**1**	**4**	**4**	**3**
Financing emission reductions in developing countries	**4**	**1**	**1**	**1**	**2**	**1**	**1**	**0**	**1****	**3**	**4**	**4**
Favouring "early actions" world-wide	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**4**	**0**
Avoidance of emission shifting effects	**4**	**0**	**1**	**2**	**3**	**1**	**1**	**1**	**1*****	**4**	**4**	**2**
Permanent interest in climate-friendly behaviour world-wide	**10**	**0**	**0**	**3**	**4**	**0**	**0**	**0**	**0+**	**10**	**10**	**6**
Quantified climate protection aim of the climate system	**6**	**0**	**3**	**3**	**3**	**3**	**3**	**4**	**3°°**	**6**	**6**	**2**
Avoidance of "hot air" world-wide	**4**	**0**	**1**	**2**	**3**	**2**	**2**	**2**	**1*****	**2**	**2**	**2**
Part B: Economic efficiency (actual score ***(xx))t***	***18***	***(8)***	***(9)***	***(8)***	***(11)***	***(8)***	***(8)***	***(4)***	***(8)***	***(13)***	***(15)***	***(15)***
Cost efficiency: Minimizing global costs	**6**	**2**	**3**	**3**	**3**	**3**	**3**	**2**	**3***	**4**	**6**	**4**
Flexibility during national implementation (minimizing national costs) and financial assistance for development countries	**5**	**2**	**3**	**2**	**3**	**2**	**2**	**1**	**2***	**4**	**4**	**4**
Considering structural differences in climate-related requirements	**4**	**3**	**2**	**2**	**3**	**2**	**2**	**1**	**2****	**3**	**3**	**4**
Positive economic (growth) impetus	**3**	**1**	**1**	**1**	**2**	**1**	**1**	**0**	**1*****	**2**	**2**	**3**
Part C: Technical applicability (actual score ***(xx))***	***8***	***(7)***	***(6)***	***(7)***	***(7)***	***(2)***	***(2)***	***(0)***	***(6)***	***(5)***	***(6)***	***(1)***
Ability to fit into the international climate protection system and the negotiation process	**4**	**4**	**4**	**4**	**4**	**2**	**2**	**0**	**4°**	**3**	**3**	**0**
Easy applicability and control capability in order to ensure practical functioning	**4**	**3**	**2**	**3**	**3**	**0**	**0**	**0**	**2***	**2**	**3**	**1**
Part D: Political acceptance ***(actual score (xx))***	***24***	***(18)***	***(7)***	***(8)***	***(10)***	***(7)***	***(7)***	***(7)***	***(7)***	***(14)***	***(18)***	***(9)***
Fulfilment of the fairness principles												
- Promotion / non-prevention of sustainable development	**5**	**3**	**2**	**3**	**3**	**1**	**1**	**1**	**2***	**3**	**4**	**3**
- Stronger burden on industrialized nations bearing main responsibility and capable of bearing more burdens	**5**	**3**	**2**	**2**	**2**	**3**	**3**	**2**	**2***	**5**	**5**	**4**
Political acceptability												
- Acceptance by all key players (groups of players)	**5**	**4**	**1**	**1**	**2**	**1**	**1**	**1**	**1****	**2**	**3**	**0**
- Acceptance by the largest possible percentage of all contracting states	**9**	**8**	**2**	**2**	**3**	**2**	**2**	**3**	**2****	**4**	**6**	**2**
***Total score*:**	***100 max.***	***37***	***33***	***40***	***51***	***28***	***28***	***22***	***33***	***74***	***84***	***52***

Abbreviations: Kyoto-Pr.=Kyoto Protocol; Cont.Kyoto=Continuing Kyoto (Ecofys), MSA=MultiStage Approach, NMSA: New MultiStage Approach; GTA=Global Triptych Approach; ETA=Extended Triptych Approach; MSCA=MultiSector Convergence Approach; CAN'sFrW= CAN's Viable Framework for the preventing of dangerous climate change (C&)C=Contraction and Convergence Model; GCCS=Global Climate Certificate System; GECT=Global Earmarked Climate Tax

Source: Wicke 2005, p. 110/111

Note: For the evaluation of GCCS and GCCS PLUS refer to Table 19 in section XII.A.

III.B. Briefest description of the GCCS

In this article the authors can give only an overview of the global cap and trade system, developed in great detail by the Wicke, and an evaluation of this GCCS, quantitatively done in Table 1 to Table 4[24].The main features of the GCCS can be characterised as follows:

In June 1996, the European Council has translated the ultimate objective of UNFCCC-Article 2 into a measurable and verifiable target as follows:

"… the Council believes that global average temperatures should not exceed 2 degrees above pre-industrial level and that therefore concentration levels lower than 550 ppm CO_2 should guide global limitation and reduction efforts …" (European community 1996)

According to this 'political definition' dangerous interference will occur,

- if there will be no stabilisation of the global temperature increase till 2100 at a level below plus 2°C above the pre-industrialized level and
- if the concentration of carbon dioxide exceeds a level of 'lower than' 550 parts per million (ppm).

This (second) concentration target is no longer in line with main and dominant first 2° C temperature target: According to the Commission of the European Community, which refers to a compilation of more recent studies estimating climate sensitivity (Hare/Meinshausen 2004), "…limiting the temperature rise to 2°C will very probably require greenhouse gas concentrations to be stabilized at a level even lower that 550 ppm $CO_{2eq.}$." (CEC 2005b, p.5) This consequently would imply to reach the 450 ppm CO_2-stabilization curve of the IPCC shown in Figure 1 and in Figure 6.

Up to the most recent publications of IEA (refer to sect. VIII.A. till VIII.C.) it seemed, that even EU's 'outdated' concentration target of 550 ppm CO_2 would be very hard – de facto nearly impossible – to be achieved as demonstrated as follows:

In its World Energy Outlook 2004 IEA has compared CO_2 emissions of IEA's most probable "reference scenario projection" till 2030 which will lead to 38.2 bn tons annually (plus 90% since 1990!) with the best achievable "alternative CO_2 emission scenario". This scenario could be achieved, <u>if</u> all major CO_2-emitting countries and country regions (<u>including</u> developing and emerging countries) would do their <u>very</u> best by completely <u>implemented</u> policies and measures for CO_2 reduction (<u>or</u> at least the deceleration of its growth)[25]. This nearly most climate progressive development would lead to around 31.5 bn tons by 2030. If all new OECD fossil power plants from 2015 onwards would be equipped with carbon capture and subsequent safe storage (costs around 50$ per t of CO_2), the CO_2 emissions can be reduced further to around 30 billion tons[26]. And exactly this is the maximum amount of CO_2 in order to achieve the EU's 'maximum concentration target', which is equivalent to be in line with a 550ppm CO_2 stabilization up to the year 2070, computed by the IPCC (Refer to Figure 1 and Figure 2).

<u>Important note:</u> In sections VIII.A. to VIII.C. it will be shown, that it is – according to newest IEA-findings – <u>technologically</u> feasible also to reach the 450 ppm CO_2 stabilization line of the IPCC. With an expansion of the following GCCS rules (to GCCS PLUS targets, ref. to sub-section VIII.E.2.) even the 2°C-temperature target of the EU could be (nearly) reached. In the following "only" the 'original' GCCS (targeting EU's concentration aim) will be explained. (GCCS-PLUS is explained in sub-section VIII.E.2.)

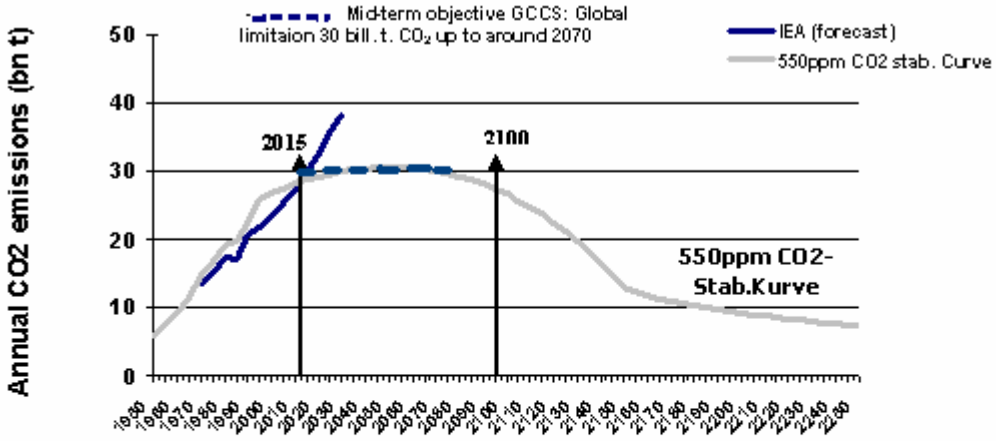
A global 'cap and trade' system is the only way to ensure that – under a strict 'emission cap' <u>and</u> world wide incentives for a climate friendly development – the various countries would implement adequate policies and measures, so that the EU's maximum concentration level is not exceeded <u>and</u> the most cost-effective solution is achieved. The stabilizing line for

[24] A summary on five pages – of course – can not be an adequate resuming of nearly 200 pages with a lot of complicated questions and answers. That is why the interested reader has no choice but to look in the relevant sections of the book (Wicke, 2005, p115 to p312).

[25] These – for reaching IEA's 'alternative scenario' - necessary enormous efforts of all major groups of countries are listed in WEO 04 p. 387 till 396.

[26] Refer to WEO 04, p413.

Figure 2: Emissions from 2000 until 2250 aimed at in order to stabilize CO_2 levels in the atmosphere so as to achieve the European Union's 550ppm CO_2 objective (according to IPCC/WRI) and the 'actual' rise of energy-related CO_2 emissions from 2000 until 2030 according to the International Energy Agency



Sources for Figure 2 (see also the footnotes to Figure 1):

a)550ppm CO_2 path as a target: PowerPoint presentation by the World Resources Institute (http://powerpoints.wri.org/climate.ppt) according to IPCC 1995 a, p.10, and 1995 b

b)Energy-related CO_2 emissions: IEA 2002 a– International Energy Agency: World Energy Outlook 2002, p. 73 and p. 413.

550 ppm in Figure 2 shows how much CO_2 per annum can be emitted globally (as area below the 550 ppm curve). On the basis of this second ('concentration') EU objective, the 'cap and trade' scheme – Global Climate Certificate System (GCCS) can be outlined in eight main elements as follows[27]:

1. Global CO_2 emissions and therefore the 'cap' maximum are fixed as of 2013/5 at around 30 billions tonnes for at least 50 years. Since this amount is almost equal to future emissions as of the year 2015 (according to the International Energy Agency), there will be no global shortage in the beginning. The annual allowances of 30 billion tonnes of CO_2 are represented by 30 billion Climate Certificates (CCs) (refer to Figure 2).
2. The pretty limited number of providers directly importing or domestically producing fossil Fuels and Resources Providers (FRPs) require a sufficient amount of CCs in order to cover CO_2 emissions resulting from their trading of fossil fuel products. Unlike the European Emission Trading System, the GCCS starts at the first level of trading, i.e. at the level of domestic fossil fuel and resources providers (FRPs), importing or producing, thus being the 'source' of subsequent CO_2 emissions. This basic level constitutes a significant simplification of the emission trading system, because all 'upstream' sources of CO_2-emissions (industry, traffic, commercial, trade and services as well as the household sector) are included. (The costs for the CCs will be passed on to the prices of the fossil fuels

[27] Note: The figures are nothing but an **illustration** for a conceivable compromise between industrialized and developing countries (ICs and DCs) after long 'bargaining' negotiations about the GCCS (Note: The interaction of the elements is shown in

of all selling stages.[28]) This is a so called 'upstream regime' described and discussed at length in literature and being one of the basics within the underlying two studies (Wicke/Knebel 2003c, 2004) and the underlying book (Wicke 2005).

3. The CCs, valid only for the year of their distribution, first are distributed yearly free of charge to all national states (and their National CC Banks (NCCBs)) on the basis of a – in the eyes of the author and probably of the vast majority of mankind – generally fair distribution key of 'one man/one woman – one climate emission right' or 'one human – one emission right'. This distribution would be built on the population figure of a certain fixed reference year.[29] Taking the global population of 6.1 billion in 2000 as the basic population figure, these CCs would represent 4.9 tonnes of CO_2 per capita – for example, 400 million tonnes for Germany (for GB and F: 290 mill. tonnes), for the USA 1.39 and for India 4.9 billion tonnes. Developing countries would be able to sell their surplus CCs. Industrialized countries would have to buy CCs in order to continue producing and/or consuming as before. But: CO_2-emitting for the first time would be globally no longer free of charge. [30]
4. On a global scale, this would create an enormous incentive for climate friendly and (in this respect) sustainable development. By implementing the GCCS, developing countries would be able to sell large quantities of CCs over several years whilst industrialized nations would have to buy (expensive) CCs. But this 'text book'-type of 'cap and trade' would lead to enormous annual multi-billion dollar or euro transfers from industrialized to developing countries. This, in turn, would lead to unbearable and unacceptable disturbance of the world economy. This enormous 'prima facie' problem was the reason why this 'immediate equal per capita distribution' proposal from India and Pakistan – without thinking about an acceptable instrumentation of that basic idea – widely was denounced from the very beginning by western authors with sayings like "not suggested by any serious proposal" (Michaelowa et al., 2003, p35).

   Not withstanding that position: To have a good chance to be accepted by all or at least the overwhelming number of all states the GCCS must guarantee at least three conditions:
   - the transfer sum between industrialized and developing countries must be limited to an acceptable level – but still giving enough incentives for DCs to be part of GCCS,
   - there must be a guarantee that FRPs get a basic CC supply with moderate prices – but still having enough incentives for CO_2-limiting and reduction and
   - there must be a guarantee against 'skyrocketing prices' on the free CC-market.
   - This is why the GCCS requires a clear cut 'division of markets' as follows:
5. On the transfer market between states (via a World Climate Certificate Bank, WCCB), developing countries would (have to) sell their surplus CCs[31] for – as an illustrative example – US$2 per CC to industrialized nations. On the basis of the total amount of CCs (based on the countries' population of 2000) allocated free of charge to the National Climate Certificate Banks (NCCBs) plus the CCs re-transfer by developing countries, the NCCBs (of ICs) allocate to their FRPs on the basis of their demand proven for the previ-

[28] Note: In case new techniques like a CO_2-free fossil fuels fired power station (Vattenfall 2005) would be installed, the equivalent amount of fossil fuels would be CC- and CC-cost-free, therefore significantly cheaper.

[29] This equal per capita distribution key is based on proposals both from India and Pakistan (Agrarwal and Narain, 1998, Aslam, 2002. *Note: Since august 2004 Mr. Malik Aslam is the minister for environment of Pakistan*) the former Indian Prime Minister Vajpajee advocated this distribution key in his closing address at the Conference of the Parties (COP 9) in New Delhi at the end of 2002. Vajpajee certainly also spoke for the vast majority of developing countries when he commented on the prospects for achieving climate sustainability: "We don't believe that the ethical principles of democracy could support any norm other than that all citizens in the world should have equal rights to use ecological resources!"

[30] In principle NGOs both on the environmental and on the development aid side in principle are backing a certificate or 'cap and trade' solution for the fight against dangerous climate change. Refer to BUND/Misereor (Editors) (1996), p. 403 and following.

[31] Surplus CCs: CCs not needed for the development of the specific country: Maximum CC-allocation to DC's FRPs: FRPs proven last years' demand plus – at maximum – the predicted (by a independent supranational bank) DC's CO_2 growth rate. If the maximum CC-amount will be not allocated (because of a better climate friendly development) these CCs can be sold as 'Climate Bonus' by the NCCB at the free CC-market. (see below)

ous year. (The FRPs hence receive a reasonable basic supply for a minimum price of US$2). If the US$2-price of the CCs is passed on to consumers, this would add around US$ 0.005 to the price of a litre or 0,02 of a gallon of petrol.
The NCCBs of DCs are obligatorily bound to a 'CC-surplus' re-transfer for US$2 on the basis of the difference between the sum of the per capita distribution and the CO_2 emissions of a pre-defined business as usual development[32]. Note: Of course there must and can be an efficient system of supervision of all the allocated and marketed Climate Certificates, described for instance in detail by Grubb, Michaelowa and other authors by 'defining the principles, modalities, rules and guidelines for verification, reporting & accountability for emission trading' (UNCTAD 1999). National Climate Certificate Banks fo developing countries (NCCBs of DCs) strictly

- must allocate CCs to their national FRPs only a well defined amount of CCs (last years demand of the FRP for fossil fuels sales plus a national (CO_2)- growth margin[33] and
- NCCBs of DCs – after the above quoted obligatory 'CC-surplus-retransfer' – are allowed to sell CCs on the free market to a strict limit: They can sell CCs only to the extent of the difference between the above (in a footnote) defined business as usual situation in a certain year and the actual emissions of the same year, documented by the not allocated CCs to the FRPs of DCs. Therefore the incentive for DCs increases: On top of the retransfer revenues (for a low fixed 'transfer price') they can get the 'Climate Bonus' as 'reward revenues' for their sales at the free market for a development that is more climate friendly than the business as usual path.[34]

6. On the free CC market between FRPs, FRPs have to buy additional CCs if they wish to sell more fossil fuels and resources[35] as in the previous year (for example, due to expanding business) and if this demand is not covered by their basic supply of CCs as shown in 5. Note: Since developing countries have per capita emissions far below the global average, their (hopefully climate friendly) development cannot and should not be restricted. Therefore developing countries need and will get more CCs (according to their economic growth) and the obligatory low-cost re-transfer of surplus CCs on the transfer market to industrialized nations will decline anyway over the course of time – according to the in element 5 defined business as usual development.
In order to prevent any 'skyrocketing' CC prices on the free market, the WCCB sells – by an 'official market intervention' - a sufficient quantity of CCs at an initial free market price of US$30 per CC. Therefore it would exist a maximum price or a 'price cap' on the free market (proposed by Aldy, Orzag and Stiglitz (2000, p26)) that will prevent any overburdening of economies and consumers world wide by a so-called 'safety valve'. (This price cap and the transfer price will be raised every 10 years in order to boost incentives for climate-friendly 'action' on a global scale.)
Such a 'hybrid system', based on tradable CCs with free CC prices and on a price cap (price of 30$ per CC) is "combining the best features of an emission tax and a pure permit system". (Aldy, Orzag, Stiglitz 2001, p25. ref. also to sect. VII.A.1.) The economic problem of possibly 'skyrocketing' CC prices is solved by this hybrid system with a price cap. There remains the ecological problem, that the WCCB over the course of time might

[32] This predefined business as usual development could be calculated – for instance – on the basis of the periodically actualized WEC/IIASA long-term energy scenarios for 11 world regions (e.g. scenario 'A1', equivalent to a specific 'high growth' scenario, ref. Jefferson (2000) p279). This high growth scenario could be – in the context of this provision of the GCCS – at least realistic and fair for low developed and advanced developing countries. The business as usual scenario referring to specific countries' CO_2-emissions in the course of specific years could be calculated on WEC/IIASA's specific world's region's coefficient of CO_2/GNP-growth multiplied by the yearly predicted growth rate of the specific country. Other definitions of reference scenarios could be even more fair and reliable – this will be open to scientific and political debate and decions.
[33] Refer to these – important – details Wicke (2005), sections VI.E. to VI.H..
[34] This – limited – selling of CCs at the free market by NCCBs of developing countries is an intentional change (as an addition premium income for a climate friendly development "Climate Bonus") within the GCCS – compared to its original version. (Ref. Wicke 2005, p179seq.) (For visualisation: see element 13 in Figure 3 in sect. III.D.)
[35] Note: In case new techniques like a CO_2-free fossil fuels fired power station (Vattenfall 2005) would be installed, the equivalent amount of fossil fuels would be CC- and CC-cost-free, therefore significantly cheaper.

sell more CCs compatible with the CC cap of 30 billion being equivalent to a cap of 30 billion tons of CO_2 yearly. (This ecological problem could be – to a certain extent - compensated by sales of CCs by the WCCB if the prices sinks below 30$ per CC.) But without such a price cap you will never reach acceptability of GCCS by industrialized countries and their businesses. (Ref. to VII.A.3.)

7. Developing countries can only use the revenue from their sales of surplus CCs to finance measures in line with climate-friendly 'sustainable development and elimination of poverty' rooted in 'SDEP' plans (including climate change adaptation measures) which are developed on a national level and approved on a supra-national scale – thus avoiding fraud and corruption to the highest possible degree. (Ref. Wicke 2005, p.187seq. and p. 197seq.)
   This so described condition for using the principally 'free money' of surplus CCs only for distinct development purposes is essential for the acceptability of the GCCS by the 'transfer financing' fossil fuel and resources consumers of industrialized nations including their governments and parliaments. Beside of important humanitarian aspects: Only if they and their governments can be sure that the 'surplus CC' money mainly is taken to support a climate friendly development — this transfer money is used also in their (ICs) interest: The share of the remaining CCs for industrialized countries (under the strict global 30 billion cap) will be slower diminished as in the case of a climate unfriendly and not sustainable development of developing countries.
8. Efficient measures[36] to supervise and control the amounts of fossil fuels and resources sold according to a 'simplified IPCC reference system' and to protect against fraud and corruption in implementing SDEP measures and programmes will warrant correct implementation of the GCCS both in industrialized and in developing countries.
9. In case the GCCS would be discussed on international level, of the question of the inclusion of changes in climate sinks and other non-CO_2-greenhouse gases must be put on the negotiation table. This inclusion is of high relevance for the efficiency of a cap and trade system. "Rational climate policy should minimize the net economic costs of limiting temperature change." By including the so called 'what flexibility' (Böhringer, Löschel, Rutherford 2005, p.1seq.) in an expanded GCCS, the international community could decide which mixture of greenhouse gas reduction measures should be implemented: Some preliminary proposals for this inclusion of non-CO_2-greenhouse gases and other effects have been made in the basic 'Beyond Kyoto' book. (Wicke 2005, p.201seq.)

Figure 3 shows how the elements interact. (As already noted, in chapter VI of the quoted book Wicke (2005, p115 and following) all the key elements are there described in such a detail that the author considers the 'GCCS to be in a condition generally ready for application'.)

GCCS largely embodies almost all important wishes, apprehensions and constructive proposals lain down in the literature from both industrialized and developing countries as far as flexible mechanisms within the Kyoto Protocols and proposed 'cap and trade' schemes are concerned. The GCC system will, of course, be modified in many respects during the course of potential international negotiations up to the years 2010-2012.

III.C. GCCS – a "structural evolution" of the Kyoto Protocol

The GCCS can and must be characterized as a 'structural evolution' of the Kyoto Protocol because it is based on the expansion of the already existing flexible Kyoto mechanisms. Those are expanded and modified to a global cap and trade scheme. This holds true especially with the view of the 'emission trading between (ratifying) Annex I countries' (Art. 17 Kyoto Protocol) and the additionally developed and introduced EU emission trading system (started in 2005) – developed on the basis of the Art. 17 emission trading, the 'joint implementation' (Art. 4 KP) and on the basis of the 'clean development mechanism' (Art. 12 KP). But there are some very important expansions and modifications.

[36] Described in great detail in section VI.H. in Wicke 2005, p. 189seq.

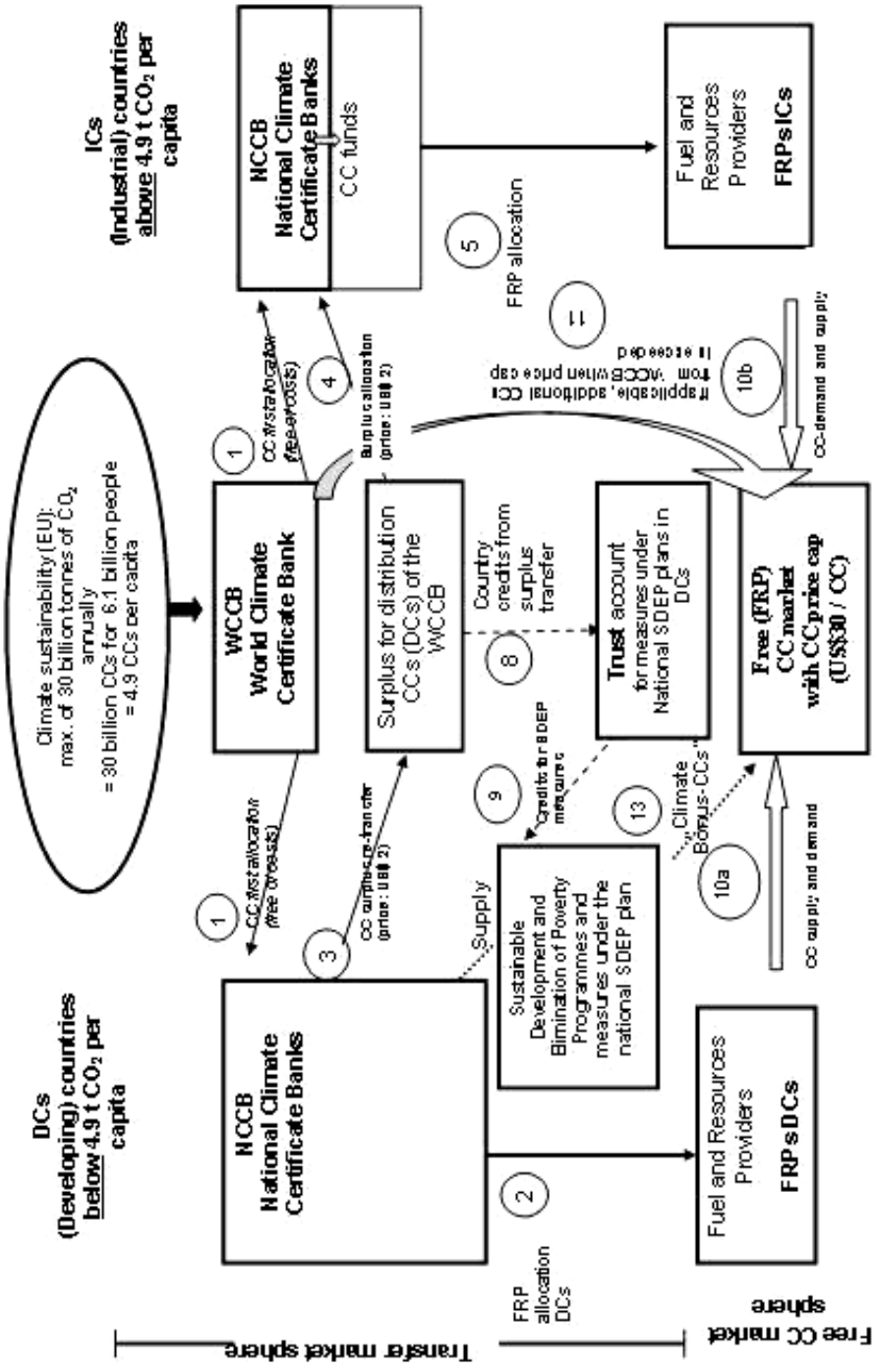
- In GCCS a still tolerable global emission cap is introduced, whereas in the KP the cap for international emission trading between Annex I parties has no direct climate change targets and is “merely” defined by the commitments and therefore ‘assigned amounts of emission allowances’ of the trading partners. (Their might be conceivable but not very likely future commitment periods with much higher commitments of Annex I states and hopefully other non-Annex I countries under a fixed global emission or concentration target. But: The probability of such a development is pretty low – because of the structural deficiencies of the current Kyoto I – commitment system (ref. to sect. II.C.).

- In the European emission trading system the emissions of a certain sector of industry are monitored and those emissions of the firms must be in line with the equivalent numbers of emission allowances (‘downstream system’). In the GCCS as a so called ‘upstream system’ the factual or potential emissions are supervised by monitoring the sales of certain amounts of fossil fuels and resources by the FRPs , thus integrating all future emissions on all following ‘upstream’ emissions of all economic sectors.

The GCCS is a certain form of a so called ‘hybrid system’ (ref. to sect. VII.B. to VII.D.) as proposed by Aldy, Orzag und Stiglitz (2001, p. 25seq.): Tradable emission permit with a cap on the permit price. “Such a hybrid permit approach would combine the features of an emission tay and a pure permit system”. These important authors – as the author of this paper – are convinced, “that this “basid approach … could be implemented without jettisoning the entire Kyoto Protocol, which substantially bolsters the real-world viability of the proposal”. (Aldy,Orzag, Stiglitz 2001, p.28)

These authors rightly conclude: ”The invested substantial resources in consensus building of the Kyoto approach … is a compelling argument for approaches that can be viewed as *modifications* (or as called in this report as a *structural evolution*) … of the Kyoto regime rather than as a new regime.” (ibd.)

Figure 3: Operation of the GCCS as a climate-stabilizing and at the same time economically compatible 'cap and trade' emissions trading system (key functions) (Wicke, 2005, p211seq)



IV. Key Dimensions of the Economic Costs (and Benefits) of an International Climate Agreement and of the GCCS

As will be shown in the last chapter of this report, there seem to some reasons for relatively good chances for the implementation of the GCCS – as this has been explained elsewhere (Wicke 2005, p.301seq.). But these reasons must be questioned in more detail before the background of the cost impacts of its implementation and provide a more systematic and objective cost impact assessment. This main task of the report will be undertaken in the following chapters.

IV.A. Aggregate cost and transfer sums within the GCCS

The main dimension and the dominant question of this study is: What are the aggregate costs of the GCCS? In other words, what is the impact of the introduction of a new or structural changed international climate agreement compared to a reference scenario? Aldy et al. describe the "aggregate cost dimension" as follows:

"The overall cost of GHG mitigation hinges largely on the stringency of the goal – which … is a function of both the magnitude and the timing – and its cost-effectiveness of the measures chosen to meet it. At the global and country level, the projected cost is most often analyzed and expressed as a reduction in GDP, or the economy's ability to generate value added through various activities. For example, the IPCC estimates that a goal of stabilizing atmospheric GHG concentrations at 450 parts per million would reduce global GDP 1-4 percent from the forecast business-as-usual level in 2050. … The change of GDP … does not fully reflect the welfare effect of a climate change mitigation policy. Other measures of the reduction of welfare, such as household consumption or employment, by illustrating potential losses more concretely, can strongly influence perceptions of cost and, in turn, the political viability of alternative approaches. … The cost of mitigation arises when companies and individuals undertake actions they would not have otherwise taken had they not been subject to a constraint on their emissions." (Aldy et. al. 2003, p91)

In this study we compare the development of the world's economy and the economies of certain world regions in case GCCS or GCCS PLUS (ref. to section VIII.E.) (and two other non-business as usual CO_2 developments, ref. to chapter IX) should be implemented in 2015 with the situation of the A1 baseline scenario of WEC/IIASA – 1998 up to the year 2100 compatible with the International Energy Agency's Reference Scenario used within the World Energy Outlook (WEO 04) till 2030. Because there would be a stringent global cap by the introduction of GCCS and because GCCS-induced CO_2 reductions – probably mainly in industrialized countries – can not be done simply by 'no regret' measures, the GCCS will and must have substantial consequences for the rate of growth, investment and costs in the energy sector and so on. It seems evident, that you can't solve the or one of the most important environmental problems of the world by a completely climate friendly restructuring of the world economy without substantial economic changes and some welfare losses, although in the beginning of that process there are a lot of win – win-situations by the rise of energy efficiency, which implies less emissions but also less expenditure for fossil and other fuel and resources.

As far as the GCCS is concerned, one of its basic elements is the equal per capita distribution and the reallocation of surplus climate certificates of low emitting countries to industrialized countries for a fixed price thus giving those low emitting developing countries substantial transfer sums which they can use according to their national SDEP Plans for climate friendly **S**ustainable **D**evelopment and growth, climate change adaptation and **E**limination of **P**overty. Therefore this positive economic benefit has to be taken into account as well as the transfer costs – financed by the consumers of fossil fuels and resources in highly emitting, mainly industrialized countries.

IV.B. Relative Cost and Cost Certainty

The aggregate cost impacts and the transfer sums are only two important dimensions for governments and parliaments to accept or to reject a 'global cap and trade' based international climate change agreement. "In assessing the political acceptability of climate agreements, aggregate cost may ultimately be less critical for some parties than relative cost – the distribution of costs among and within countries." … Even if the aggregate cost and therefore "the impact on national competitiveness overall is minimal, the concentration of cost in discrete sectors concerned about competitive disadvantage can be a powerful domestic obstacle to an international climate commitment." (Aldy/Baron/Tubiana 2003, p92).

According to Aldy et. al (2003, p92seq) those differences in relative cost impacts of different international climate commitments – described at a Kyoto Protocol type commitment system – can (and will) arise from following different conditions:

(1) Economic and energy structures of different countries can lead to a) different price increases and b) relative cost of compliance,
(2) Different GHG mitigation commitments
    (a) KP Annex I- or Non-Annex I- country, or
    (b) like the USA as "Annex I–Non-(ratifying) Party" and ratifying and therefore committed Annex I parties,
(3) Relative cost differences because of a lack of environmental effectiveness like in the current Kyoto I system by
    (a) a leakage effect (potential costly reduction in Annex I states can be offset by the so called 'leakage effect' – rising CO_2 by transferring climate intensive production to non-Annex I countries) and
    (b) by the mechanism that GHG reductions in industrialized countries may lower internal fuel prices thus triggering higher fossil fuel use in other countries.
(4) Finally unequal distribution of costs within a country:
    (a) "Fossil fuel energy producers, energy-intensive industries, consumers, and workers in those industries are likely to bear a larger share of the burden of an emission mitigation policy.
    (b) In contrast, suppliers of energy-efficient and renewable energy technology or forestry and agricultural firms that engage in carbon sequestration may benefit from such a policy." (Aldy et al.2003, p93)

"Another critical cost dimension influencing a country's willingness to accept and meet a climate commitment is the predictability – or certainty – of the costs it entails. A regime that provides greater certainty may promote stronger participation and compliance." (Aldy et al.2003, p93.)

As far as the benefits of an efficient international climate protection agreement are concerned: The author is not going to exercise a cost benefit analyses. He 'merely' is going to assess – in various 'dimensions' – the costs of the GCCS. The benefit of the GCCS definitely will be: The implementation of the GCCS respectively the GCCS PLUS (ref. sec. VIII.E.2) would 'guarantee' the world community that the globally agreed main target of 'non-dangerous interference with the climate system' would be realized. This realization would be done within the scope of EU's minimum '550 ppm CO_2-concentration' definition by way of the 'original' GCCS or even – by way of 'GCCS PLUS' – within EU's much more ambitious 2°C temperature target (ref. to VIII.E.2.).

V. The economic impacts of 'Earmarked' Transfer-Revenues as Rewards and Incentives for Low Emitting Countries and Transfer Costs for Industrialized Countries)

V.A. Three Serious Cost-Reproaches against a GCCS type 'Immediate Equal per Capita Distribution' Cap and Trade Approach

Three serious (cost) reproaches have been and are put forward against Global Cap and Trade Schemes based on an 'immediate equal per capita distribution' key for climate certificates.

- The alleged existence of 'tropical hot air',
- 'tremendous and unbearable high transfers from industrialized to developing countries' and
- 'skyrocketing' unbearable CC-prices'[37].

The author and 'designer' of the GCCS, of course knew those three reproaches (mostly made by western scientist) which are laid down in literature. They were put forward against any equal per capita proposals, having their origin mainly in developing countries and put on the political and scientific table by developing countries' scientists and activists starting early in the nineties of the last century (Agrawal/Narain 1991). Therefore those reproaches could be integrated into the shaping of the GCCS from the very beginning and therefore made more or less irrelevant within that scheme as shown in the following and in section VII.A. .

V.B. NO 'Tropical Hot air' in the GCCS

"The excess emission allowances over business as usual projection of emissions in the commitment period are called hot air." (Grubb/Michaelowa et al. 1999, pxxx)

Within a global cap of energy related CO_2 emissions there exists no 'hot air' at all, that can jeopardize the targeted climate change mitigation strategy: All CO_2 emissions world wide would be within that global cap as long as long there exists a full compliance of all states with that certificate system. Therefore no additional CO_2-emissions beyond the internationally agreed global cap can be introduced in this system. This is in contrast to possible and probable sales of 'hot air' within the Kyoto Protocol System as 'assigned amounts' as surplus emissions above the 'business as usual' path (equivalent to around 1.5 billion t of CO_2 in case of former USSR-states). (Grubb/Michaelowa et al. 1999, pxxx and European Commission 2002, p45). Those states therefore can sell negotiated emission allowances ('assigned amounts') which they can't use during their business as usual performance to third states, for instance to the EU. This could imply possibly higher emissions than without the KP situation. The existence of (too much) hot air in the Kyoto Protocol System can – according to Grubb/Michaelowa et al. (1999, pxxx) – "undermine the trading regime or even the whole climate change regime".

In the GCCS the situation would be different:

- The surplus climate certificates (above a business as usual path) of those (tropical) states within in the GCCS, emitting below the still acceptable world average of 4.9 tons of CO_2 per head ('acceptable' for the above mentioned 550ppm target of the EU) can – as far as the climate implications are concerned – not be denounced as 'tropical hot air'.
- On the contrary:
    - Those surplus certificates have to be sold to (above acceptable world average) highly emitting countries for a – modest – fixed price and
    - – non-emissions above the business as usual-line – can be sold at the free market as "climate bonus"-certificates.
    - The income of those sales are an 'earmarked' reward and a future incentive for the contribution of those (tropical) countries to decelerate global climate change. ('Earmarked' for programmes and measures for climate friendly development and climate change adaptation and fight against poverty.)

[37] For the discussion of this (third) reproach, see section VII.A.1 to VII.A.3

- Therefore these surplus CCs of low emitting countries are not a 'tropical hot air' gift or foreign aid by developed countries, but an independent reward for the contribution of those countries for a less dramatic climate change and a reward and a permanent incentive for an active involvement in the battle against climate change by a climate friendly development of those countries.

The additional CO_2-emissions within the GCCS by selling of additional CCs by the World Climate Certificate Bank in case the price-cap of 30, 60 or 90$ shall be surpassed, can not be called 'hot air' either. (Ref. to VII.A.)

V.C. Modest and bearable transfer payments to developing countries

Because of that modest 'transfer price' of surplus climate certificates (not needed for domestic economic activities and development) the total amount of transfer between industrialized and developing countries) remains moderate. (Refer for more details to X.C.) This is illustrated for some states by the amounts of CC-transfer on the basis of – as a conceivable and illustrative example – 2 US$ per certificate (refer to Table 6):

Table 6 then leads to the following picture:
Irrespective of whether the GCCS will ever be introduced at all, and irrespective of the economic implications for individual states discussed in later (X.C. and X.D.), this overview very clearly shows: Assuming

- that the use of – respectively the "dumping" of greenhouses gases (especially CO_2) – into this planet's atmosphere is no longer possible at no cost or free of charge, and
- that pollution of the atmosphere is only permissible to the extent which can just be classified as 'sustainable' in terms of the EU's climate (GHG concentration) target, and
- that above-average emissions cost just US$2 per tonne of CO_2, Table 6 shows exactly how high the "current and actual climate debt" of every single country to the totality of mankind is.

In other words: The overview of transfer payments and transfer revenues illustrates the different "CO_2 debts respectively CO_2 credits" of different countries in the case of the very low costs of just US$2 per tonne of CO_2.
Or, the figures in the last column show the harm which industrialized nations – apart from their 'historical debt due to the accumulated atmospheric pollution' – (permanently) do to the world by polluting the atmosphere to a (far) above-proportional extent with waste CO_2 resulting from their production and consumption thereby using the atmosphere as a still extremely cheap climate gas "dump", which use is actually even free!
On the other hand: The "CO_2-credit" show how much – at the quoted emission price – developing countries are contributing to the mitigation of the climate change by emitting less than the (according to EU's concentration target) still tolerable world average of 4.9 tonnes per head.

V.D. Price cap at the CC market: No 'skyrocketing prices'

An important part of the GCCS is a 'price cap' at the free CC-market which has been introduced in order to avoid possibly 'skyrocketing prices' for fossil fuels which indeed could endanger the performance of world's economy. About the importance and the consequences of the price cap see section VII.A.1 to VII.A.3.

Table 6: Important economic and climate data as well as transfer values forecast (revenues and payments) for the application of the GCCS

Country / country group	Population in 2000	CO_2 growth forecast in % p.a.		CO_2 emissions in 2015	Tonnes of CO_2 emissions in 2015	$2/CC transfer- payments *(-) and revenues
	Million	2000/30	2001-25	Million t	Per capita	Million US$
EU member states and new member countries			Ca. 0.7			
UK	59.5	(0.8)	0.7	630.6	10.6	- 678
France	59.4	(0.8)	0.9	414.3	6.9	-119
Germany[a]	82.2	(0.8)	0.6	854.4	10.4	-904
Italy	57.7	(0.8)	0.8	491.3	8.5	-415
Netherlands	15.9	(0.8)	0.5	264.0	16.6	-372
Lithuania[b]	3.6	(1.3)	1.3	16.5	4.6	+2
Poland[b]	38.6	(1.3)	1.3	347.1	9.0	-317
Czech Republic[b]	10.3	(1.3)	1.3	145.4	14.1	-190
North America			1.7			
USA	282.3	(1.0)	1.5	7127.0	25.3	-11,518
Canada	31.3	(1.0)	1.2	711.3	22.7	-1,114
Mexico	99.9	2.5	4.0	638.0	6.4	-150
OECD Asia-Pacific						
Japan	126.7	(0.4)	0.8	1.294.1	10.2	-1,343
Australia + New Zeal.	23.0	(0.4)	1.9	520.5	22.6	-814
Korea (South)	47.3	(0.4)	2.2	652.3	13.8	-421
Former Soviet Union			1.8			
Russia	146.0	1.4	1.8	1.949	13.3	-1,226
Ukraine[†]	49.2	(1.4)	(1.8)	474.3	9.6	-462
Kazakhstan[†]	16.7	(1.4)	(1.8)	189.8	10.8	-197
Political climate 'giants' in Asia						
China	1262.5	2.7	3.4	4.835.5	3.8	+ 2,778
India	1002.7	3.0	3.0	1.374.8	1.4	+ 7,019
South Asian countries°/Turkey						
Pakistan	141.55	(3.2)	(2.0)	169.6	1.2	+1,047
Bangladesh	130.40	(3.2)	(2.0)	52.98	0.4	+1,174
Indonesia	224.1	3.4	3.7	478.0	2.1	+1,255
Thailand	62.35	(3.2)	(2.0)	291.1	4.7	+13
Malaysia	21.79	(3.2)	(2.0)	195.3	8.96	-177
Philippines	79.74	(3.2)	(2.0)	109.7	1.38	+561
Turkey	65.7		3.1	381.3	5.8	-118
Middle East°°			2.2			
Kuwait	1.97	(2.2)	(2.2)	70.1	35.6	-121
Saudi Arabia	22.02	(2.2)	(2.2)	399.5	18.14	-292
United Arab Emirates	2.37	(2.2)	(2.2)	136.1	57.4	-249
Iran	66.0	(2.2)	(2.2)	416.3	6.3	-185
African states°°°		(1.9)				
Egypt	70.49	(3.5)	(1.9)	202.5	2.87	+286
Algeria	31.19	(3.5)	(1.9)	119.4	3.8	+69
South Africa	42.35	(3.5)	(1.9)	633.1	14.7	-415
South America**			2.9			
Brazil	146.0		3.4	557.2	3.8	+321
Argentina	37.5	(3.0)	(2.6)	172.8	4.6	+23
Chile	15.15	(3.0)	(2.6)	77.4	5.1	-6
Ecuador	12.92	(3.0)	(2.6)	23.3	1.8	+84
Peru	27.01	(3.0)	(2.6)	32.7	1.2	+200
Venezuela	23.54	(3.0)	(2.6)	163.7	6.9	+94

Source: Wicke 2005, p278seq.

Transfer payments* which industrialized nations and newly industrialized countries with above-average emissions have to effect (financed by the CC costs passed on to consumers of fossil fuels and resources) are marked with a **minus ("-")** sign. **Transfer revenues** are marked with a plus ("+") sign.

These values were calculated on the basis of the free initial allocation of 4.9 CCs (corresponding to a free emission right of 4.9 t per capita for each country) **minus** per capita emissions forecast for the country in question, **multiplied** by the respective country's population and the initial transfer price of US$2 per CC.

(**Note**: The totality of consumers of fossil fuels in (industrialized) nations has to bear – via rising prices – the burden of all the CCs allocated or purchased by FRPs on the free market: The national climate certificate banks (of these nations and, possibly, some higher emitting newly industrialized and developing countries) "bill" the FRPs for all CCs, i.e. both for the free climate certificates allocated by the World Climate Certificate Bank as well as CCs purchased at transfer prices as a result of the allocation of surplus certificates. Consumers – either private households or (producing) firms – hence have to bear the burden of these costs. In the long term, FRPs will pass these costs on to their customers.)

Appendix to Table 6 can serve as the basis for drawing a relatively telling, economic and climate-related "initial picture".
However, before discussing the economic effects which can be derived from this table, the most important basic data, sources and bases of calculation for this table should be laid open as follows within the following explanatory list.

Population figures were taken from IDB (International Development Bank): Countries Ranked by Population 2000. (updated data 7/2003) http://www.census.gev/cgi-bin/ipc/idbrank.pl .

The ***CO_2 growth forecasts*** are primarily based on: Energy Information Administration (EIA, US Department of Energy): International Energy Outlook 2003. Washington D.C. May 2003, p. 191 (data from 2001 to 2025). IEA 2002 a– International Energy Agency: World Energy Outlook 2002. Paris 2002, p. 413 and following (in the case of the IEA data for 2015: average **approximate** data from Emissions 2010 and 2020). (The underlined growth forecast indicates which of the two forecasts was used to extrapolate CO_2 emissions in 2015 – chiefly on the basis of EIA forecasts for 2000-2015.) *Values in parentheses* indicate that only forecasts or extrapolations are available from the respective source for the *region in question*.

The expected ***CO_2 emissions in 2015 by important industrialized nations as well as developing and newly industrialized countries*** were, in part, taken directly from EIA data and/or determined by interpolation from the 2010 and 2020 forecasts of these 2015 values from IEA statistics. The following must be noted with regard to Germany in this context.

•a The *growth rate* which the EIA assumes for Germany (from 854.3 in 2000 to 854.4 million tonnes in 2015) is not in line with the plans and commitments of the German government. Given a realistic view of German 'business as usual' development with the (complete) abandoning of nuclear power, this growth seems likely to be more at the lower margin of the trend. (However: If Germany achieves its self-set targets, it will have to buy fewer CCs and hence make less transfer payments for CCs! The GCCS would have a very 'climate-motivating' effect, especially for Germany!) In the event that Germany achieves its binding climate targets pursuant to the Kyoto Protocol by the year 2012[38], energy-related CO_2 emissions would then total around 711 million tonnes[39] . Given a population of 82.2 million in 2000, this would mean around 8.65 tonnes per capita.

The ***CO_2 emissions in 2015*** by many other countries were extrapolated from the above-mentioned EIA and IEA sources, as well as Germanwatch/Ludwig-Bölkow-Systemtechnik (2003): Analysis of BP Statistical Review of World Energy with respect to CO_2 emissions. 4thEdition. (Prep. by Zittel, W./Treber, M. Bonn/Ottobrunn 14 July 2003. www.germanwatch.org/rio/abst03.pdf, p. 7 and: Emission data for the year 2000, especially for important developing and newly industrialized countries, could be extrapolated for the year 2015 from EIA data and/or IEA statistics on the basis of the growth rates for the respective world regions. The following assumptions were made in this context.

•^{b}For the EU accession/new member countries listed, the CO_2 growth rate for eastern Europe was assumed on the basis of the EIA emission growth forecasts of 1.127 (13% emission growth) for the period from 2000 to 2015. Initial emissions in 2000 were estimated in analogy to the reduction from 2002 to 2001.

•^{f}A growth rate of 1.395 was assumed for the two USSR successor states, Kazakhstan and Ukraine. This is the rate also quoted by the EIA.

•°In the case of the south Asian countries, a CO_2 growth factor of 1.65 (i.e. 65% growth) was assumed between 2000 and 2015 on the basis of IEA forecasts.

•°°The growth factor of 1.38 as forecast by the EIA was assumed for the Middle East between 2000 and 2015.

•°°°In the case of the three African states (Egypt, Algeria and South Africa) for which CO_2 emissions ***only*** were known for the year 2000, a CO2 growth factor of 1.66 (i.e. 66% growth) was assumed for the period from 2000 to 2015 on the basis of IEA forecasts (for all of Africa!).

•**In the case of the South American states, the EIA emission growth forecast of 1.314 (31% emission growth) is assumed for the period from 2000 to 2015.

[38] Reduction of its climate gas emissions of all 6 climate gases by 28% against 1990, and assuming equiproportional reductions of the CO_2 share too.
[39] Calculation on the basis of data from DIW 2002b, loc. cit., p. 560, for energy-related carbon dioxide emissions in 1990.

VI. The relative fuel cost impacts of the GCCS by changing CC costs

In section IV.B. – according to Aldy et al. (2003) – the relative cost impacts of the Kyoto I – typed commitment scheme have been described systematically[40]. It is evident, that the author can't describe in the following those various impacts in the same systematic manner for all countries or countries' groups for the global cap and trade scheme GCCS. But these effects have to be kept in mind when it comes to discussing and reasoning about the economic interest related burden and acceptance of the GCCS by various countries (ref. to chapter X and XI.).

VI.A. The different cost burden of various fossil fuel and resources by the CC transfer price allocation and the surplus purchases at the free market at the start of the GCCS

Within the GCCS which is a global cap and trade scheme (without individual countries' commitments) those described relative cost impacts have to be analyzed differentiated. On one hand there will be additional costs for the fossil fuel and resources providers for the needed climate certificates, on the other hand those costs – and other market constraints, such as the global cap of CO_2-emissions – will lead to certain and differentiated price effects for the domestic sales of coal, oil (products) and gas.

As explained above in section II.B. the GCCS is an 'upstream' system. That means that the fossil fuels and resources selling 'Fuel and Resources Providers' of the first trading level has got to hold a sufficient number of climate certificates according to the (potential) resulting CO_2-emission if the fuel and resources are (finally) burnt.

Due to known

- relationships between kg of CO_2 per calorific content (gigajoule) and
- calorific content in gigajoules per kg of coal, brown coal (lignite), heavy oil or petrol fuels or diesel or standard cubic metre of gas ***plus*** the
- knowledge of density (weight) of one litre of heavy oil, diesel, or petrol fuels,
- the following "rough values" can be stated for the following fuels and resources.(Table 7)

On the basis of those 'rough values' of the CO_2-potential of various fossil fuels one has a clear indication for the additional CC-cost for FRPs in industrialized countries. (These FRPs get the CCs mainly allocated for the transfer price)

During the first GCCS phase (2015-2024), the **CC transfer price** (and hence the 'initial' supply of CCs to FRPs) **totals US$2** per CC or tonne of CO_2 and the **maximum CC price possible** on the free market (**'price-cap'** intervention price of the WCCB[41]) totals **US$30 per CC**. Thereafter (in ten years steps), the transfer price changes will rise to US$5 or US$10, respectively, and the maximum CC price possible on the free market to US$60 or 90, respectively.

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[40] According to Aldy et. al (2003, p92seq) those differences in relative cost impacts of different international climate commitments – described at a Kyoto Protocol type commitment system – can (and will) arise from following different conditions:

(1) Economic and energy structures of different countries can lead to a) different price increases and b) relative cost of compliance,
(2) Different GHG mitigation commitments
    (a) KP Annex I- or Non-Annex I- country, or
    (b) like the USA as "Annex I–Non-(ratifying) Party" and ratifying and therefore committed Annex I parties,
(3) Relative cost differences because of a lack of environmental effectiveness like in the current Kyoto I system by
    (a) a leakage effect (potential costly reduction in Annex I states can be offset by the so called 'leakage effect' – rising CO_2 by transferring climate intensive production to non-Annex I countries) and
    (b) by the mechanism that GHG reductions in industrialized countries may lower internal fuel prices thus triggering higher fossil fuel use in other countries.
(4) Finally unequal distribution of costs within a country:
    (a) "Fossil fuel energy producers, energy-intensive industries, consumers, and workers in those industries are likely to bear a larger share of the burden of an emission mitigation policy.
    (b) In contrast, suppliers of energy-efficient and renewable energy technology or forestry and agricultural firms that engage in carbon sequestration may benefit from such a policy." (Aldy et al.2003, p93)

[41] Refer to III.B. and VII.A.3.

Table 7: Magnitude of carbon dioxide intensity per quantity unit of different fossil fuels and resources (Deviations due to other substance compositions are possible)

Hard coal:	2.75 kg CO_2/ kg	
Brown coal:	0.98 kg CO_2/ kg	(Note: Hard coal has at least three times the calorific value of brown coal, brown coal hence generates on balance more emissions than hard coal!)
Natural gas:	1.78 kg CO_2 per standard cubic metre	(In terms of the same calorific value, natural gas causes the lowest CO_2 emissions!*****)
Heavy oil:	2.8 kg CO_2 per litre	= 442.4 kg/barrel
Diesel:	2.5 kg CO_2 per litre	= 9.4 kg/gallon
Petrol:	2.24 kg CO_2 per litre	= 8.4 kg/gallon
***** In terms of the calorific value, the **"emission intensity" ratio** is as follows: •**Crude oil** = 1.0 / •**Hard coal**= 1.17 / •**Brown coal** = 1.41 / •**Gas** = 0.65.		

(Because every fossil fuel has got a different content of carbon in reality the CO_2-potential of all fuels are slightly varying mainly depending were it has been taken out of the soil)

Assuming that the these CC transfer and free CC market costs are – initially – evenly distributed to all groups of consumers (private consumers, (producing) industries and the government as a consumer of fuel and resources), the **primary** cost effects of the climate certificate can be quantified for the first three stages (over a period of 30 years). This leads to the "price increase picture" shown below in Table 9 and in Table 9.

Table 8**:** Cost increases for various fossil fuels due to the CC transfer price burden[42] of FRPs in industrialized countries in ten-year increments – given a parity between US$ and €

		2015-2024	2025-2034	2035-2044sq
➢ **Hard coal:**	US**$/€** per tonne	5.5	13.75	27.5
➢ **Brown coal:**	US**$/€** per tonne	1.96	3.9	9.8
➢ **Natural gas:**	US**$/€ - cts** per Nm^3	0.356	8.9	17.8
➢ **Heavy oil:**	US**$/€ - cts** per litre	0.56	1.4	2.8
	US **$ /€** per barrel	0.885	2.2	4.4
➢ **Diesel:**	US**$/€ - cts** per litre	0.5	1.25	2.5
	US**$/€ - cts** per gallon	1.9	4.75	9.4
➢ **Petrol:**	US**$/€ - cts** per litre	0.45	1.125	2.5
	US**$/€ - cts** per gallon	1.7	4.25	8.5

Note: In case new techniques like a CO_2-free fossil fuels fired power station (Vattenfall 2005) would be installed, the equivalent amount of fossil fuels would be CC- and CC-cost-free, therefore significantly cheaper.

A brief stock-taking in advance: The actual price effects – as far as the rising costs are determing the prices (see below VII.D.) – will remain fairly moderate worldwide for the following reasons.

The FRPs of industrialized nations receive an initial stock of CCs at the CC transfer price of US$2 per CC corresponding to around 90% (plus some auctioned CCs) of their last year's demand. (Wicke, 2005, p179seq) The resultant (costs-increases 'born'[43]) price increases – for example, by less than US$1 per barrel corresponding to (US$ or €) 0.5 /

[42] For the problem of price increases due to rising overall costs respectively to marginal costs refer to VI.C. and VI.D..
[43] Refer to the preceding footnote

0.45 ***cent*** per litre of diesel / petrol – are of an order of magnitude equal to the almost daily price fluctuations.

As far as the actual price increases are concerned: There can be also a marginal costs determined price behaviour and above that: The 'cap and trade born' CC-prices and the resultant imposition of a tax like fee for CCs for the use of fossil fuels may be significantly passed back and therefore be born the producers and sellers of the various fossil fuels. (Ref. to VI.D.)

Above that: There exists the economic problem that FRPs might not evenly distribute their CC-related price increases, depending on the price flexibility of demand, and price-rigid responding motorists, for instance, could be burdened heavier than more price-flexible companies which can resort to less CO_2-intensive fuels and resources. However, such behaviour is certainly "normal" behaviour which can be (and is certainly also) displayed with each frequent increase in mineral oil and gas prices.

Table 9**:** Maximum conceivable cost increases for FRPs for their share of CCs to be purchased at the free CC-market for the conceivable maximum CC-price (increased price caps in ten year's increments) – given a parity between US$ and €

		2015-2024	**2025-2034**	**2035-2044**
➢ **Hard coal:**	US**$/€** per tonne	**Max.:** 82.5	165	248
➢ **Brown coal:**	US**$/€** per tonne	**Max.:** 29.4	59	88
➢ **Natural gas:**	US$**/€ - cts** per Nm^3	**Max.:** 5.34	10.7	16
➢ **Heavy oil:**	US$**/€ - cts** per litre	**Max.:** 8.4	16.8	25.2
	US**$/€** per barrel	**Max.:** 13.4	26.8	40
➢ **Diesel:**	US$**/€ - cts** per litre	**Max.:** 7.5	25	37.5
	US$**/€ - cts** per gallon	**Max.:** 28.2	56	84.6
➢ **Petrol:**	US$**/€ - cts** per litre	**Max.:** 6.75	13.5	20.3
	US$**/€ - cts** per gallon	**Max.:** 25.5	51	76.5

Author's note: Orders of magnitude because: a) The composition of fossil substances (C-content) is not constant / b) assuming an exchange rate of 1:1 between US$ and €)

The FRPs of developing countries receive their CCs either 100% at no cost or at a modest costs (in maximum the additional costs will be like in índustrialized countries up to US$2/CC) and corresponding to the extent of their business and industrial activity of the previous year (plus the average estimated CO_2-growth of the national economy, Wicke, 2005, p182seq.). In the case of these countries too, the cost-driven increases in prices for mineral oil / petrol by half a US cent per litre would be tenable - given even a CC allocation to FRPs at transfer prices. But of course: A 0.5 cents per litre price increase might have higher relative price impacts (which means a higher percentage price increase) in those (developing) countries that have a low tax burden on fossil fuels like gasoline or diesel.

The above-stated maximum CC-costs with a price cap of US$30 per CC during the first 10 years, appears to be very high with US$13.4 or €13.4 (assuming an exchange rate of 1:1) per gallon of heavy oil compared to market prices of between US$20 and US$35 and up to US$55 in 2005. According to Hillebrand et al.[44], the costs of certificates

[44] Refer to Hillebrand, B./Smajgl, A./Ströbele, W./Behringer, J.-M./Heins, B./Meyer, E.C.: Zertifikatehandel auf dem Prüfstand. Münster 2002, p. 105 and following.

needed to sell brown coal correspond to around 21% of the entire production costs at a certificate price of €10 per tonne of CO_2, whilst these costs account for just around 13% of the total costs in the case of gas-fuelled power stations.[45] This effect of reducing CO_2 emissions is definitely desirable from an ecological point of view! (Favouring CO_2-free or low-CO_2 energy sources.)

VI.B. The CC scarcity over the course of time and the resulting increased cost burden on fossil fuel and resources

The CC-cost driven incentive effect of the GCCS as a 'hybrid' quantity/price control system to reduce CO_2 and to stabilize CO_2 globally is in fact very complex which immediately becomes apparent when looking at the development of CC scarcity on global and single markets. In purely 'qualitative' terms, the (economic) incentive effects can be described as follows (Wicke, 2005, p231seq.):

When that ***system starts*** (hopefully 2013 to 2015), there will be ***no global scarcity*** as total emissions of then approximately 30 billion tonnes of CO_2 are assumed. Regional scarcity will be compensated for by the CC transfer system. FRPs must acquire a small share of the CCs required at national auctions of remaining quantities of CCs held by the NCCB.[46] Individual expanding FRPs can purchase additional CCs on the free market. The incentive effect of the GCCS is limited because at least 90% of the world-wide basic supply to FRPs will be carried out at the initial low-cost transfer price or, if necessary or being assessed reasonable in the eyes of developing countries' administrations, even free of charge in developing countries. Due to expanding FRPs (with increasing sales of fossil fuels), the CC market price will be higher together with the expectation of higher market prices for CCs in later years, because scarcity will increase world-wide. However, even the initially moderate market price of CCs together with later price increase expectations will trigger all market players to consider saving CCs ***and*** moderate cost-driven price increase signals on the end consumer markets will make energy saving and CO_2 reductions somewhat more attractive.

Within the scope of the ***first ten-year period (2015-2025) with a constant CC transfer price*** and with global CC and CO_2 quantities remaining constant, global and regional scarcity will increase: Developing countries can provide their FRPs with a growing number of low-cost (or even free) CCs[47]. This means that the quantity of re-transferred CCs that can be allocated to industrialized nations via the WCCB at the transfer price will decline in percentage steps. A yearly 1% reduction (of national emissions of the year 2015) is assumed for the allocation ***key*** (between above-average ***industrialized*** nations) for the CCs still available to industrialized nations. This is why not just the quantity of transfer CCs declines but also the share in the quantity of transfer CCs available also declines over the course of time in different industrialized nations. This means that the situation will become more difficult for FRPs: NCCBs in industrialized nations with their ever-smaller quantity of transfer CCs can only provide their FRPs with an ever smaller share at the transfer price based on the previous year's demand. As scarcity increases CC prices will rise in the auctions of the remaining national CCs. Prices on the international free CC market will increase if many FRPs expand world-wide or only wish to continue operating on the same level. The intervention price of US$30 per CC could be reached in stages on the free CC market.

The ***subsequent periods 2025-2034 or 2035 to 2044 etc. with CC transfer prices increased to US$5 and US$10*** (and based on the intervention price on the free CC market that is increased to US$60 or US$90) cannot be forecast precisely:

- On the one hand, the trend towards increased emissions in developing countries – and hence towards fewer transfer CCs for industrialized nations – will continue.

[45] Quoted from Burgi, M.: Die Rechtsstellung der Unternehmen im Emissionshandelssystem. Neue Juristische Wochenschrift (NJW), 2003, Issue 35, p. 2487.
[46] Refer to Wicke, 2005, p179seq.
[47] The National Climate Certificate Banks can allocate low cost CCs to their FRPs according to their last year's demand plus a well based estimated CO_2-growth of the relevant country. (Ref. to Wicke, 2005, p182seq.)

- On the other hand, both higher transfer prices **as well as** the significantly higher prices on the free CC market **as well as** the use of DCs ear-marked money (obtained by the CC-retransfer of surplus CCs) for a climate friendly development will also lead to a clear reduction in CC demand in developing countries (compared to a non-GCCS-situation) and a relatively greater supply on the free market because it will become increasingly worthwhile for FRPs and end consumers to produce and consume with lower CO_2 emissions.
- In industrialized nations – as soon as people start to realise that a truly effective limiting system will be introduced with the GCCS (this 'realization stage' hopefully approx. starting 2010) – an ever-growing trend will gradually set in towards lower-CO_2 production and consumption: The basic supply of low-cost CCs will become smaller and smaller. FRPs must include the costs for CCs bought in national auctions or on the free CC market more than before in calculating prices of fossil fuels and resources. And because of a tendency towards a marginal cost[48] driven price-behaviour of FRPs (ref. to VI.D.3) this will have an even stronger restraining effect on end consumers: Energy-saving and CO_2-reduction measures will become more and more worthwhile.
- On balance, the CO_2 growth effects of a growing global economy are opposed by a relative decline of CO_2 relevant production and consumption and therefore in the CC demand which will dampen or stabilize prices on the free CC market.
- If and when the price-cap intervention price will be reached can only be roughly forecasted after careful global econometric calculations, although even this is likely to provide just a rough indication.
- One thing appears to be certain: Since the price-cap intervention price (with price levels changing at intervals of 10 years each) is set at a level where the most important CO_2 reduction methods (such as, CO_2-sequestration in the case of very big point sources, such as fossil coal-fired power stations a mineral oil conversion operations plus safe and profitable storage in enhanced oil and gas-recovery techniques) are starting to be profitable (at between 20€ and around US$30 and above, IEA 2004(WEO p412), WEO 05 and Vattenfall 05[49]) ***and*** because many other CO_2-reduction techniques (such as renewable energies) and consumptions patterns will be introduced (ref. to VII.D.2.e. to 2.f.) it seems very likely that the market price will stay below the intervention price, which will be raised every ten years from 30 to 60 and 90 US$.

VI.C. The GCCS impacts on fossil fuel and resource prices: The influence of rising CC-costs at the transfer- and the free CC-markets

As far as the rising costs of CC-allocation (mainly on the basis of the relevant transfer price of CCs) and of possible rising CC-purchases in the free market (with increasing price caps in 10 years' increments) are relevant for the final market price is concerned, one has to state the following:

The importance of the above-quoted potentially ***maximum*** conceivable CC-costs on the free market (Table 9) for the determination of fossil fuel prices due to cost pushes must be put into the right perspective, and this for several reasons.

Even in the event that the maximum conceivable 'marginal costs' incurred by FRPs for purchasing CCs in the free market *are fully passed on to consumers*, the direct cost-driven effects on the sales prices of petrol or diesel should still *relatively moderate.* Even if the maximum CC-price should be reached at the free CC market (at levels of 6.75 or 7.5 cents per litre or 25.2 or 28.2 cents per gallon) at first glance there seems to be no reason why the small cost CO_2-relevant share of increased total costs should lead to equivalent increases of the fossil fuel prices: As far as the overall costs are relevant for the market price there seems to be no reason to assume that a more than just a minor marginal portion of the total costs for the acquisition of an initial maximum of 10% of all

[48] Which will be the price of CCs at the free CC market
[49] For more details refer to VI.B.2.b. and c.

the CCs required by FRPs in industrialized nations on the free market will be completely passed on to the price of fossil fuels and resources.

As far as there exists a strong competition at the end-consumer market and no price cartel – an assumption that might not be true at least in several states – any provider of fossil fuels and resources would catapult itself off the market if the FRP would try to pass this on in full to its customers. Rough cost based calculation: The basis allocation (at the beginning of the GCCS) will lead to 'basic additional cost' shown in Table 8. US$2 per allocated CC (for 90% of the products sold). For 10% of the fuel sales the FRPs would have to buy CCs for a maximum price of US$ 30, 60 or 90 (according to the relevant price cap in various ten years' periods). This would lead – total cost induced – the maximum conceivable 'supplementary additional costs' of 10% of the maximum cost increase for the specific fossil fuels shown in Table 9. In the first ten years period this would be equivalent to a total cost induced price increase of 1.2 cts/litre /4.5 cts(gallon of Diesel and 1.1 cts/litre /4.2 cts/gallon.

By the way of discussing cost-born price increases: If the FRPs really would pass on 'just' the described total cost increases on top of their market prices this would only partially have the maximum incentive for a CO_2-reduced development: The 'cost mix' of allocated CCs and the costs of CCs at the free market would give a reduced price incentive at the market compared to the situation that FRPs take the 'shadow' or 'marginal' price costs at the free market for the fossil fuels' price increases. (See below: VI.D.)

But nevertheless: Even if the price increases will consist 'only' in the described CC 'cost mix' price increase: All FRPs and consumers of fossil fuels and raw materials should understand the marginal costs and the maximum price cap (30$/60$/90$ in the relevant 10 years periods) on the free market as an "alert and short-supply" signal and consequently do their utmost in order to adopt production and consumption patterns which ensure minimum resource consumption and minimum emissions. In this context, (temporary) price peaks due to CC scarcity can serve as an additional warning and alert function! And above that: Different CO_2 intensity levels (in terms of calorific value) of the different fossil fuels[50] and hence the different relative CC price effects stimulate the use and consumption of natural gas as a lower-emission fuel – an ecologically clearly welcomed effect.

As far as FRPs in developing and newly industrialized countries – emitting below the tolerable world average of 4.9 t per head – are concerned: Depending of the decision of their governments respectively of their National Climate Certificate Banks they possibly would allocate permanently – on average of all DCs' FRPS – a sufficient amount of CCs – possibly free of charge. Therefore their conceivable 'total cost based' calculation might lead to even smaller increases as in industrialized highly emitting countries. For DCs' FRPs, the above-mentioned maximum prices in Table 9 are (on the basic assumption of a total cost-driven pricing policy) – in principle – only interesting as an incentive to reduce the growth rate of their consumption of fossil fuels and hence to sell CCs. By selling parts of their CCs on the free market, these increased and possibly maximum marginal prices at the free market would have, on balance, an emission-'reducing' effect in developing countries too. (Wicke, 2005, p182seq.)

The increasingly narrowing scope with regard to emissions and CCs even in the first above-mentioned period (described in above section VI.B.) will then also trigger gradual increases in prices for fossil fuels and resources.

Cost-driven price effects will be felt stronger during the subsequent periods (2025-2034, 2035-2044): The transfer prices as well as the CC price-cap maximum prices will rise as shown (refer to VI.B.). Since the annual CC initial allocation volume continues to be restricted to 30 billion – in order to achieve an ongoing restriction of the CO_2 volume – so that the "CO_2 squeeze" will increase world-wide (as intended in the interest of climate), this will, in principle, also increase CC prices and prices of fossil fuels and therefore: The incentive and "economic need" for low(er)-emission production, consumption and living

[50] In terms of ***calorific value***, the "emission intensity" ratio is as follows: crude oil = 1.0 / coal = 1.17 / brown coal = 1.41 / gas = 0.65 (see Table 7)

patterns increase. The German Council of Environmental Advisors underlines in this context: "The fluctuation in price (albeit subject to an upper price limit due to the 'price-cap' mechanism in the GCCS, author's note) is the correlate of the fixing of quantities that ensures that the respective emission reduction target is definitely achieved."[51]

However, despite the given intervention obligation once the 'price-cap' intervention price is reached: Since the 'price-cap intervention price' of the WCCB is increased every ten-years, there is a lesser risk that the WCCB will permanently sell CCs (almost) without limit at the initially (relatively) low (maximum) price of US$30 per CC and hence be forced to expand the volume of CO_2 that can be emitted far beyond the limit of 30 billion tonnes of CO_2 which is in conformity with the EU's concentration target. And: Even if prices initially will rise at a relatively moderate, however, perceivable, rate (in conjunction with a threat of increasing scarcity of CCs), such a rise will nevertheless lead to a very significant reduction in CO_2 intensity of production and consumption patterns world-wide.

VI.D. A conceivable 'marginal cost driven' price increase situation and the consequences for the GCCS

VI.D.1 Evidence for a conceivable 'marginal cost driven' price behaviour of FRPs

Up to now, the author 'only' has shown, which price effect the GCCS would have if the actual additional and therefore total CC costs (basic CC-allocation plus the cost of additional CC-purchases at the free market) would be passed on the consumers of fossil fuels. At first glance the following consideration (see VI.C.) seems to be realistic: As far as there exists a strong competition at the end-consumer market and no price cartel – an assumption that might not be true at least in several states – any provider of fossil fuels and resources would catapult itself off the market if the FRP would try to pass this on in full to its customers.

But contrary to this consideration: There seems to be some important evidence that the FRPs – as profit maximizing units in a market that is far from being an ideally polypolistic market (rather being – more or less – a supply oligopolistic market) – would behave like oligopolists in a very special market. And this would signify that the (oligopolistic) FRPs would at least try to pass on the marginal CC costs completely to the fossil fuels consumers. This consideration can be backed by the following two examples of evidence[52]:

- The determination of the German gasoline prices at the fuel stations must be described as completely marginal cost driven: "To a high extent the prices are – irrespective of changing tax-burdens – defined by the development of the Rotterdam 'spot market' that is to say the world market." (Kasten/Klepper, 2001, p27) In Germany there exists a high competition at the service stations between 'brand petrol stations' (Marken-Tankstellen) that are parts of integrated concerns (like Exxon, BP, Total, Shell) and the so called 'freie' (concern independent) petrol stations, that are purchasing their petrol at the international market or from integrated concerns. The fuel consumers at the service stations react highly price sensible. But irrespective of the real costs of the fuel in refineries of integrated concerns – those concerns nearly completely sell their petrol according to the changing prices at the Rotterdam spot market to their own and to the independent gasoline service stations. In other words: "The (independent) importers are the marginal providers at the German market. Their prices and their behaviour are determining the wholesales conditions." (Diederichs 1984, p205) "In normal situations therefore the Rotterdam spot market price is the determining wholesale price of the German mineral oil market. This implies that the German wholesale price is determined by the world market price." (Kasten/Klepper, 2001, p8)[53].

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[51] RSU (German Council of Environmental Advisors): Umweltgutachten 2002. Für eine neue Vorreiterrolle. Deutscher Bundestag publication 14/8792. Berlin 2002, text No. 473, p. 234.

[52] The authors would like to thank Gernot Klepper and Sonja Peterson , Institute for World Economis in Kiel, for a competent assessment of the conceivable and probable market reactions of FRPs in relation to CCs within the GCCS.

[53] In Germany there has been at least one situation at which the integrated concerns tried to knock the 'free petrol stations' out of market by selling their petrol to their own filling stations for price lower that the spot mar-

- The second evidence for a marginal cost driven price behaviour directly can be found within the European 'downstream' emission trading system and in the behaviour of power producing concerns in Germany: By way of a 'grandfathering' (according to subsequent emissions of those and other firms of the highly emitting 'heavy industry' in various years) the German government allocated the emissions allowances 'free of charge' to those concerns and other CO_2-emitting heavy industry firms. Irrespective of the fact of this "Zero cost"-allocation nowadays those firms try and (partly are successful) to rise the electricity rate to the end consumers because the 'emission allowance prices' at the relevant 'stock exchange' for electric power in Leipzig have risen to prices between 10 und nearly 30€ for one ton of CO_2-emissions (equivalent to one EU-emission allowance). In Germany the production of 1 MWh electricity power on the average is equivalent to an emission of "0.55 tons of CO_2. At price of 30€ per certificate (emission allowance) this would signify 11€ per MWh for the producers – but they have got nearly all necessary certificates as a present." The producers are very happy about the situation. "The market price for electric power is determined by the marginal costs. The power providers offer an additional megawatthour only in case, if the revenue is higher than the additional megawatthour.[54]. And only at that point the additional costs for the CO_2-certificates are relevant completely. Contrary to that the higher market price is relevant for the whole quantity of the sold electric power." (FTD, 8.6.2005) (Some spectators of that market even are supposing that this market is a non-competive but a somehow 'manipulated' market – at least strongly influenced in the direction of an 'artificial' high price for CO_2-certificates. This could be done by various divisions or even independent sub-firms of the four most important power generations concerns in Germany – in order to "produce" helpful arguments for the rising of prices for electric power, thus trying to rise the prices beyond the 'true' market oriented marginal price)

These evidences seem to be – rather important – indications that within the GCCS the (changing) additional marginal costs for necessary CC-purchases of FRPs[55] in the free CC market – in addition to the world market price for mineral oil products (and presumably other fossil fuel commodities) – would or shall determine the wholesale petrol and other prices for various fossil fuels. Therefore the above 'first glance' considerations about cost determined price increases would be falsified: Not the sum of actual total costs for the CCs[56] but the higher marginal free market CC cost would determine the additional price increase for the end-consumers of petrol and other fossil fuels.

On the other hand – and contrary to the above quoted example of the German gasoline market: The main reason for the uniform marginal cost driven behaviour – based on the marginal changes of the world market price – of all acting players is the following fact: The heavily competing independent service stations can't influence their costs as far as the gasoline supply is concerned – the (Rotterdam) world market price is the cost determining marginal level. As far as the additional costs for CCs are concerned, the independent competitors of the integrated mineral oil concerns' service stations would get much more competing elbow-room because their actual overall additional CC-costs are (far) below the marginal CC-costs at the free market. (In case they wouldn't enlarge their gasoline sales they even would not have to buy CCs at the free market at all – at least in the introduction phase of the GCCS[57]). Therefore the independent gasoline service stations would get the opportunity to sell their gasoline even to a certain additional margin cheaper than usual compared to prices at the integrated concern service stations – provided the latter stations (and their mineral oil concerns) would try to (fully) pass on the

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ket price and to a higher price to the (normally lower pricing) free petrol stations. The German federal cartel administration stopped this 'irregular' market behaviour. (Kasten/Klepper 2001, p21seq)

[54] For potential sellers of CCs (by reducing their fossil fuel and resources sales) there exists an equivalent marginal price incentive, *authors' note.*

[55] These are wholesale fossil fuel and resources providers at the first domestic trading level

[56] Actual CC costs for instance: 10% of necessary CCs bought at the free CC-market (prices Zero up to US$30), **plus** 90% of the FRPs' 'fuel sales necessary' CCs (certificate compliance within the GCCS) with an allocation price i.g. of US$2 ('normally' much cheaper than the CC purchases at the free CC market).

[57] On the other hand: Of course all FRPs have got to consider the option of selling parts of their allocated CCs and reducing their CO_2-relevant fossil fuel sales, which might economically favourable as well.

marginal CC-costs to the consumers. Because of this improved 'competition power' of the independent importers and gasoline stations it seems not all be sure, that there will be a full marginal cost driven price policy within the GCCS. Therefore even the first glance consideration of a purely (additional) overall cost price policy may be (very) likely – as far as there exists enough competition between FRPs at the relevant market and a pretty high price sensitive consumers (as it is the fact in the German gasoline retail market).

Taking into account both described views and the resulting possible price behaviours: It is impossible to make a clear cut prediction about the price behaviour of all FRPs for all fossil fuels: All FRPs world wide are in quite different situations regarding the ownership (state owned or private companies), the competition situation on the relevant market, the means and the willingness of the governments, to 'dictate' (overall) cost-based price increases and so on. Such a political will to influence the price policy of FRPs is very probable: It seems evident, that governments and politicians would have extreme difficulties to justify enormous 'climate policy induced' multi-billion 'windfall profits' for the big mineral oil concerns and other FRPs world wide by a marginal costs driven price behaviour – with enormous price increases in relation to the actual cost increases by their allocated and purchased CCs. That is why 'German energy utilities are fearing governmental regulations and dirigisme' as an political answer to their above described marginal cost driven price policy. (FTD 8.6.2005)

Therefore **both conceivable price behaviours** have to be taken into account when the final design of the GCCS shall be drawn in order to make it acceptable for the majority of countries and world wide majorities of voters. The only prediction to be made is the following: There seem to be big economic 'incentives' for a marginal cost driven price behaviour within the GCCS for the FRPs (in industrialized states as well in developing countries). But the FRPs have, because of their actual CC-related cost situation and of their competition situation at the market as well as theirs owners' and politics' influence, many possibilities and reasons for a more total cost-related price policy.

Above that one additional effect has got to be taken into account: The GCCS would – by additional CC-costs – imply a world wide tax-like extra fee (carbon-content differentiated) for fossil fuels. It will depend on the price elasticises of supply and demand to which extent the end-consumer prices will be actually increased. It is very likely that the suppliers of fossil fuels would have to reduce their supply prices to a certain extent. Based on model simulations the Institute for World Economy in Kiel (Germany) supposes, that up to 80% of the tax (respectively the price of CCs) will be borne by the fossil fuel producers and only 20% of that tax-like increase will be borne by the fossil fuel (end-)consumers with there smaller reactions concerning the fuel consumption [58]. Even if one supposes that the net price reducing effect will be not as high as quoted, it will be significant.

VI.D.2 The positive consequences of a 'marginal cost' driven price behaviour for the GCCS

In the – rather unlikely (see the previous sub-section) – case that all FRPs world wide would increase their fossil fuel prices according to the marginal costs at the free CC market (and no lowering of the suppliers' prices (energy net prices) would occur) this would have – in terms of mitigating climate change – a very favourable effect: The price-induced incentives for a climate friendly development world wide (by saving energy, higher energy efficiency, switch to zero or low GHG-emitting energies and so on) would be risen to the highest possible extent that can be reached by a global cap and trade scheme.

And this – at least in theory – is exact the targeted result of a global cap and trade scheme: To realize the globally tolerable maximum GHG-emissions world wide in order to have a maximum concentration of GHG in the atmosphere to prevent dangerous climate change with the least possible costs world wide. But: As shown with view to the competing wholesale independent importers and gasoline service stations and the ten-

[58] "Should a world-wide CO_2-tax raise the gross energy prices by 10%, than the net prices would drop by 8%, due to reactions of the suppliers. The targeted price increase therefore would be only 2% instead of 10%. Therefore the emission reduction effect would be equivalently smaller,…". Message by Prof. G. Klepper to the author on July 7th 2003. (Refer also to Klepper/Peterson 2003).

dency to an overall cost driven price behaviour of the FRPs: The GCCS definitely has not been designed in a text book typed cap and trade scheme manner to fully reach the above described theoretically ideal target – ecologically and economically. It has also, at least with the same intensity been designed in a manner that – while reaching its climate stabilization target – there remain good chances for acceptability world wide and therefore for implementation. And therefore – due to a relatively cheap basic CC allocation to FRPs – the overall CC-induced cost increases will or should not be equivalent to the marginal CC-cost increases – thus opening an à priori chance for a higher degree of acceptability. (But there must exist instrumental precautionary measures in order to still have a potentially high acceptance rate, in case marginal CC-cost increases would become dominant. Ref. VI.D.4)

VI.D.3 The acceptability-adverse consequences of a conceivable 'marginal cost' driven price behaviour for the GCCS

It is easily predictable that a completely 'marginal cost' driven price behaviour of FRPs would imply that the GCCS – as described in its 'original version' (Wicke, 2005, p100 and following) – would have no chances at all to be accepted at least by a majority of all parties (members of the so called Conferences of Parties of the UNFCCC and the Kyoto Protocol) – such an acceptance being a prerequisite of a conceivable later acceptance by all member states (unanimity principle!). The reasons for this are the following:

- Instead of – as an example – the above quoted (and predicted for the GCCS start up - years) least cost rise of one litre of gasoline or diesel by around a half or US$ or € cent per litre (around 1.8 US cents per gallon), there would be a GCCS/climate policy - induced immediate 'price jump' of up to around 7 cents a litre or up to 28 cents a gallon.
- There might be a tiny chance that such price increases could be tolerated at least by some industrialized countries with an already high tax burden on those fossil fuels and therefore high fuel prices (including various 'mineral oil' and surplus taxes). This would 'mitigate' the relative price increase in relation to the price situation before the GCCS was introduced. (At least in Germany the introduction of the do-called 'eco-tax' in 5 yearly subsequent stages with a total rise of 7.5 €cents was accepted by the voters' majority.)
- Contrary to this: Such a climate policy induced extremely high price jump would be completely unacceptable for most developing countries where the gasoline and diesel prices are – on average – much lower because of lower tax burdens and where the standard of living would be seriously affected by such a rise of the prices of fossil fuels. (May be there could be a compensation for that climate policy driven price increase and loss of purchasing power and standard of living, see below!)
- The situation for both country groups – developing and industrialized countries – would be politically tremendously aggravated by the already mentioned fact, that a 'marginal cost' driven price policy (<u>without</u> political corrections) by the (global) big mineral oil concerns and other FRPs world wide would lead to enormous 'climate policy induced' multi-billion 'windfall profits' of those firms – to be paid for instance by the end consumers (car owners) at the gasoline service stations.

In section VI.D.2. it has been shown that a 'marginal cost driven' price policy at all markets all over the world is pretty unlikely. But because of the big economic incentives for such a price behaviour – especially in situations where the competition is low at the relevant markets or where price cartels (whether being spontaneous (by identical price behaviour) or directly arranged) could dominate the market – this marginal cost driven price policy can't be ruled out at all in any cases.

Therefore some GCCS-'security belts' (see below) should and must be introduced for such a conceivably price behaviour and its very negative effect on the acceptability for the climate change efficient global cap and trade scheme GCCS.

VI.D.4 'Security belts' for the GCCS against GCCS-acceptability adverse marginal cost driven price policy of the FRPs: Avoiding wind fall profits and partial compensations for higher fuel and energy prices

VI.D.4.a. The 'windfall profit endangered' allocation system of the 'original GCCS'

It is evident that within a conceivable GCCS the national states and their national climate certificate banks (NCCBs) will have only limited influence on the price policy of FRPs. At least they shall not be able to 'dictate' by complicated regulations a purely overall cost-driven price policy of all their national FRPs. Therefore – and first of all –the GCCS should be readjusted in order to avoid the above mentioned climate policy induced windfall profits of the FRPs.

The main reason for conceivable and very likely GCCS-induced windfall profits would be (as 'designed in the 'original GCCS', ref. Wicke 2005, p100seq) the different CC-price of the basic allocation to FRPs – both in developing and in industrialized countries (see below) – and at the free market. The reason for this price differentiation in the 'original GCCS' is the intention to increase the acceptability of the GCCS: Irrespective of the climate stabilization target by capping the global CO_2-emissions at the level of 30 billion tons the price increases (as far as they are driven by the actual total costs) should be limited and price increases gradual. Preferably there should not be GCCS-induced enormous price jumps for the end-consumers that could not or would not be tolerated neither by the voting majority nor by the governments and parliaments of almost all states.

Therefore the basic allocation of CCs to FRPs by the National Climate Certificate banks in developing and in industrialized countries in the 'original GCCS'[59] is done as described and shown in the working principles (2) respectively (3) to (6) in the following boxes and in Figure 4 and in Figure 5.

[59] First amendment: The GCCS basic element 5 has been already modified (contrary to the 'original GCCS') in the sense that NCCBs of DCs are allowed to sell CCs at the free market to a strictly limited extent. (ref. III.B and below)

Working principles of the GCCS system:

A closer look at the **principles of operation** of the ***CC transfer market*** of the GCCS **– *part A* –** (refer to Figure 4) *(References to sections in Wicke, 2005)*

(0) The World Climate Certificate Bank distributes a total of 30 billion CCs per annum to all countries.

(1) The **WCCB performs the initial allocation** of the CCs ***at no cost*** to the NCCBs of developing countries and industrialized nations: (VI.B.2. and VI.D.2.)

Every country receives 4.9 ***free*** CCs = 4.9 tonnes of CO_2 per capita (basis: population of a fixed year, e.g. 2000).

(2) The **NCCBs of developing countries** (DCs) allocate the necessary CCs (at no cost or for the CC transfer price of US$2 or – at maximum – for last years' CC-price at the free market[60]) to the FRPs of developing countries with the following ***allocation basis*** (VI.F.3.):

- Proven CC demand of the FRPs during the previous year
- Registered CC demand for newcomer FRPs

Plus – at maximum - 'growth demand' of the specific DC: annual CO_2 growth forecast (of a designated independent supra-regional bank) for the specific developing country (VI.F.3.)

Distribution mode: 90-95% direct allocation ***plus*** CC 'balance' auction

(3) The NCCBs of developing countries obligatory re-transfer the surplus CCs (Per Capita CCs minus CCs allocated to FRPs according to (2)) to the WCCB ***at the transfer price.*** (VI.E.5.)

- Re-transfer quantity of surplus – CCs: First allocation to DCs according (1) ***minus*** DCs FRP allocation according (2)

(4) ***Surplus allocation to industrialized countries (ICs):*** The WCCB distributes all excess CCs from all DCs to the NCCBs of ICs ***at the fixed transfer price*** (US$2): (VI.E.6.)

Distribution key: Previous year's CC demand of different industrialized nations ***minus*** 1 percent p.a. (VI.F.2)

(5) The **NCCBs of industrialized countries (ICs)** allocate their complete CC fund = total initial application (1) plus surplus allocation (4) to ICs to their national FRPs at ***the CC transfer price*** (US$2) (III.F.2.) (possibly also to the last year's free CC-market price (ref. to VI.D.4.c. of this study)

Allocation basis in industrialized nations:

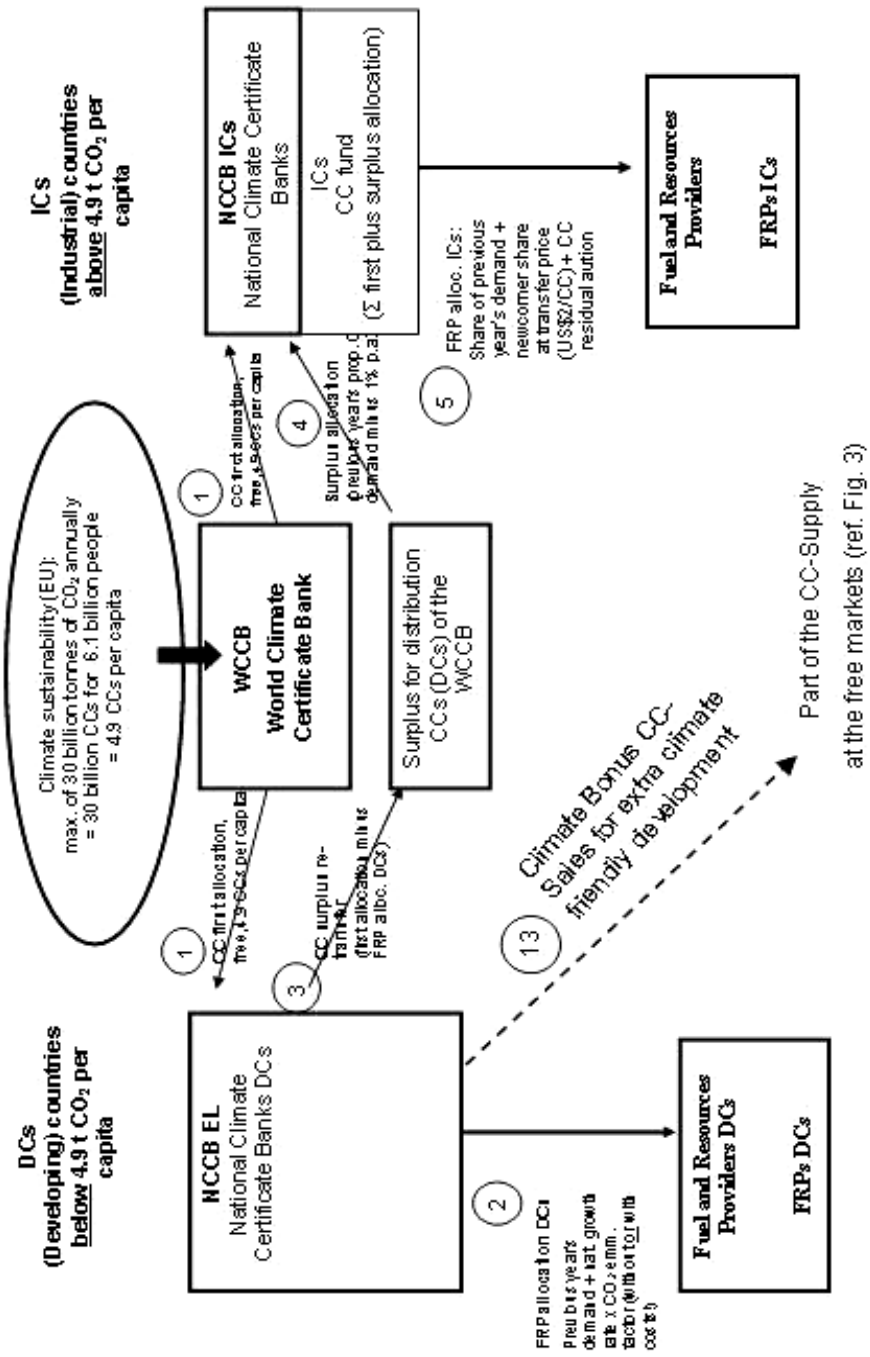
- Proven CC demand of the FRPs during the previous year
- Registered CC demand for newcomer FRPs

Distribution mode: 90% direct allocation ***plus*** CC 'balance' auction

[60] Refer to the probable 2. amendment to the 'original GCCS' in section VI.D.4. especially in.D.4.c of this report

Figure 4: **A closer look at the principles of operation of the CC transfer market of the GCCS (part A)**

(Description see precedent page)



Working principles of the GCCS system – an overview :

A closer look at the **principles of operation** of the **CC transfer market** of the GCCS **– part B –** (refer Figure 5)

(References to sections in Wicke, 2005)

(6) The FRPs of industrialized nations pay for the allocation of their CCs ($2 per CC, or for preceding years' CC-price in the free CC-market[61]) by the NCCBs of industrialized nations according to the CC 'distribution' as follows(Ref. VI.F.2.)

- 90% of the registered and allocated CC quantity at the transfer price plus
- balance for CCs bought at an auction at the auction price

(7) The NCCBs of industrialized nations transfer to the WCCB the price of the CCs on the basis of the transfer price in accordance with the number of CCs allocated during excess allocation.

(8) WCCB "credit note" to the 'SDEP trust account' (VI.E.5./VI.G.2.) for individual NCCBs of developing countries in accordance with the (transfer price) value of the excess CCs re-transferred (according to (3)).

Developing and newly industrialized countries prepare programmes and measures according to the **national SDEP** (**S**ustainable **D**evelopment and **E**limination of **P**overty) **plan** (Refer to VI.G.2.a.)

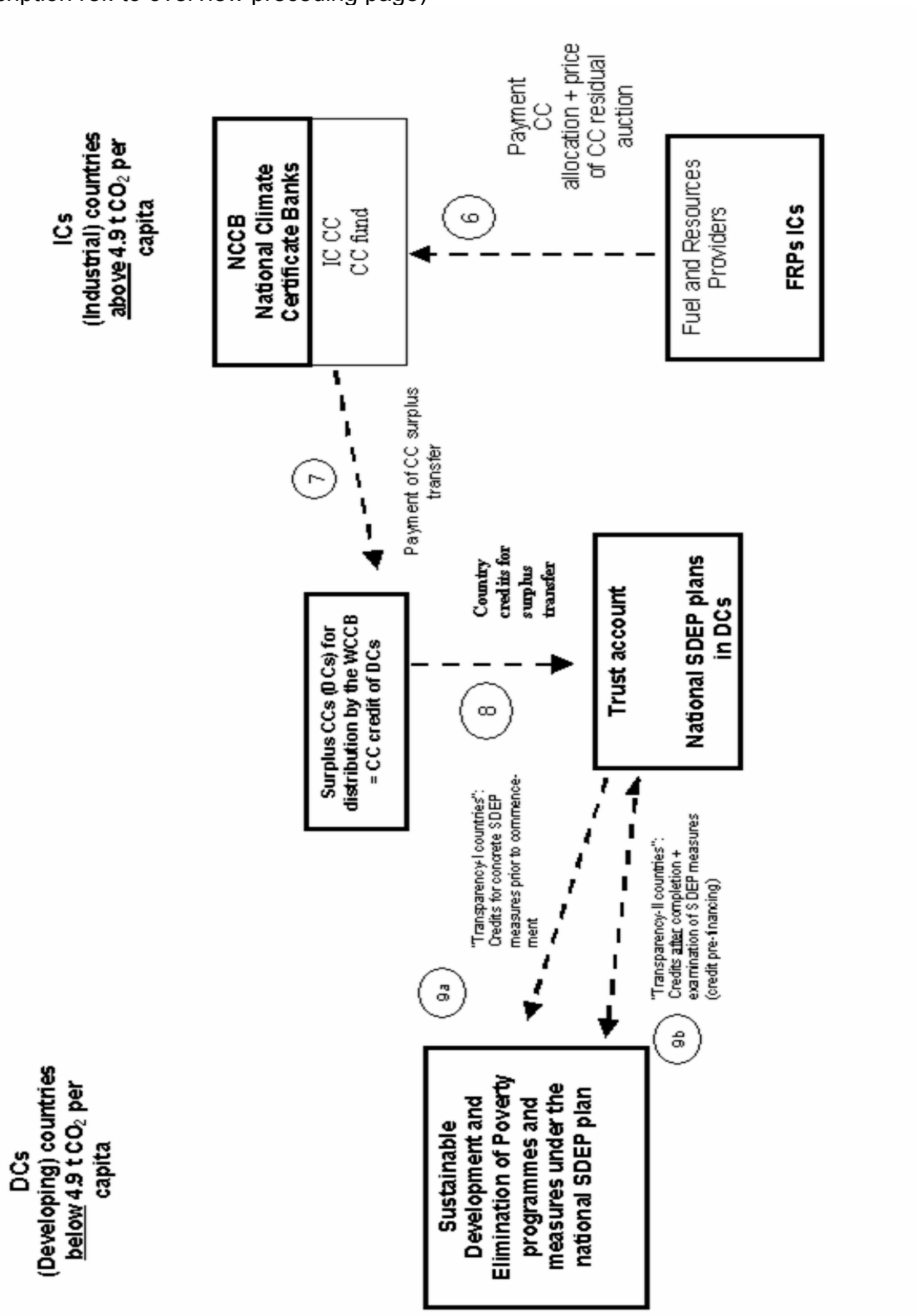
(9a) Transparency-I countries (low risk of corruption and fraud) receive the money prior to commencing SDEP measures. (VI.G.2.b.)

(9b) Transparency-II countries (higher risk of corruption and fraud) receive the money ***after*** completion and examination of the SDEP measures performed (pre-financing on loan). (VI.G.2.b.)

[61] Refer to probable 2. amendment to the 'original GCCS' in sub-section VII.D.4.c of this report

Figure 5: **A closer look at the principles of operation of the CC transfer market of the GCCS (part B)**

(Description ref. to overview preceding page)



VI.D.4.b. A purely auctioning CC allocation system and its impacts

In order to avoid FRPs windfall profits one should narrow or even equalize the CC allocation and the free market prices:

The easiest way to avoid those windfall profits within the GCCS would be to allocate the total amount of national CCs (per capita distribution (1) plus surplus allocation (4) in Figure 4) by an auction of National Climate Certificate Banks. The price of the auctioned national CCs and the CC price at the global free CC-market would differ to a much lower extent than it would be the case by an initial zero or US$2-allocation. The national CC price differences would be 'merely' based on different CC scarcities at different national and global markets. But this could lead to significant CC price differences because – as demanded by fairness and climate change mitigation principles – there will be (under a strict global cap) a growing national CC-supply in developing countries and therefore an ever reduced CC-supply to industrialized countries. (Refer to GCCS working principles (in boxes) explaining Figure 4 and Figure 5)

- The positive effect of this 'auctioning allocation' would be that the revenue of the auction would be directed directly to the NCCBs. The there collected 'CC-money' could be taken for certain fuel price increase-compensation measures or for (additional) SDEP- policies and measures (see below). (SDEP = Climate friendly Sustainable Development (including adaptation to climate change) and Elimination of Poverty).
- But there would be at least two significant flaws:
  - A free auctioning very likely would have highly negative competition effects: The financially most powerful competitors (for instance the integrated mineral oil concerns) could auction up to one 100% of all available CCs thus installing at least a strict supply oligopolistic or even monopolistic supply structure.
  - This 'free auctioning case' (in addition to the (than) cost driven price jump for fossil fuels) very probably would lead to a (strengthened) market power induced price increase (according to a profit maximizing of FRPs). That's why probably a 'doubled' price shock could or would follow – with even higher non-acceptability consequences of the GCCS by governments and parliaments.

VI.D.4.c. A GCCS readjustment by a quantity proportional and a CC-market price oriented allocation: No windfall profits and compensation for purchasing power losses

Therefore for the design of the GCCS – in order to be as competition-neutral as possible – there seems to be (as in the 'original GCCS') no way but an allocation-distribution according to the actual CC-demand of a preceding period (in GCCS: the preceding year).

Given such a proportional distribution to existing FRPs and newcomers (Wicke, 2005, p180seq), in order to narrow the allocation price for FRPs to the CC-market as much as possible, the allocation price should be close to the actual CC-market price of the preceding year.[62]

- By such an allocation the total revenue (which would be nearly equivalent to the CC world-market-price) would inflow to the NCCBs, the national climate certificate banks. Therefore there can be no windfall profits of the FRPs, induced by the price differentiation of the allocated CCs contrary to the 'original GCCS' (see above).
- There remains – compared to the 'original GCCS' – the aggravated problem of the above quoted climate policy (GCCS) induced price jumps that would reduce the acceptability of the GCCS. Allocation of CCs, based on increased CC-market prices directly would lead to a price increase of the different fossil fuels dependent of the necessary amount of CCs needed for the sale of one unit of those fossil fuels and resources. (But contrary to an allocation of CCs to the FRPs for 2 or even zero Dollars per CC (in the 'original version' of the GCCS), there will be no (or nearly no) windfall profits.)
- Note: The alternative to the above outlined ‚market price' allocation could be – in principle – the taxation of the windfall profits. But: Because of practical problems (i.g. in-

[62] There could be some surcharges or deductions to the preceding years' CC market price according to the expectations for the CC-market price development in the following year.

formation about the actual windfall profit) there seems to be no serious chance to a windfall profit equivalent extra taxation of FRPs within the original GCCS.

- As already stated – in merely 'incentive terms' to alleviate climate change – the higher GCCS induced price increases would be welcomed (higher incentive for a climate friendly development and consumer and production patterns).
  But the acceptance problem because of price jumps for fossil fuels remains and must be eliminated or at least considerably mitigated in the here described allocation-modified GCCS. This conceivably could be done by the following compensation strategy:
- The total CC-allocation revenue of the NCCBs (as well as the surplus CC-transfer revenue of developing countries) should be strictly earmarked to very narrow utilizations:
  - Firstly this revenue could be taken to expand the policies and measures under the SDEP-Plan regime in developing lower GHG emitting countries (Wicke, 2005 p180 and 201) which directly could increase the GCCS-acceptance.[63]
  - Mainly in highly emitting industrialized and threshold countries (or – in DCs – in addition to expanded SDEP-Plan policies and measures) as (only) appropriate compensation measures there could be a (nearly) equal per capita distribution of the revenue of the described CC-market oriented allocation of CCs to the FRPs. This should be a compensation for the 'average citizen's' loss of purchasing power by climate policy (GCCS) induced higher fossil fuel prices.
  - Definitely there should not be a 'compensation' by reducing increased fossil fuel prices, which would lead to a nearly complete loss of the 'incentive power' of the GCCS for a climate friendly development! Instead there should be a nearly completely equal per capita distribution compensating distribution to all citizens irrespective of their actual use of fossil fuels. According to the various situations in different countries there should be – approved and supervised by the WCCB – different forms of equal per capita compensation measures. (If fraud and corruption should take place by implementing these compensations nation wide, WCCB and NCCBs would have to sanction those misconducts, Ref. Wicke, 2005 p.187, 198seq.)
  - These compensation measures[64] could be based – in relevant countries – on a possibly existing generally implemented tax system which includes all citizens (either by a general income or a general implemented value added tax) by an equal per capita tax reduction (and tax refunding to lower income groups) or an equivalent surplus tax reduction. (Before and during the implementing phase of the introduction of the German 'Ecotax' (Öko-Steuer) those 'income-neutral' redistribution schemes (as a reduction of the value added tax or as a per capita refunding in the form of a so called 'Eco-Bonus' have been discussed intensively in Germany. (ref. the summary of a study for Greenpeace by DIW 1994 p397)
  - In countries without such a general implemented tax system there could be a fair system (without or nearly no fraud) by (personal) payouts (without falsification possibilities) to all citizens in country specific forms that are most effective and fair.

[63] In DCs (as well in ICs) this revenue could be partly taken in order to boost RD&D measures for inducing additional CO_2(-cost) reducing technological change because of market deficiencies. Ref. to section VII.B.2. and Goulder 2004, p 27seq.

[64] I would like to thank colleague Prof. Jäger from the Potsdam Centre for Climate Impact Research (PIK) for some proposals in line with the following conceivable compensation schemes.

VII. Long term cost certainty by the GCCS and its mechanisms for induced climate friendly technological change

VII.A. GCCS: Cost certainty by the 'price cap' or 'security valve' in the free CC-market and other long term features

Aldy et. al (2003, p93seq.) state: "Another critical cost dimension influencing a country's willingness to accept and meet a climate commitment is the predictability – or certainty – of the costs it entails. A regime that provides greater certainty may promote stronger participation and compliance." In fact: Whatever climate change efficient 'Beyond Kyoto I' scheme should be introduced – every single state will ask what economic consequences such a system will have. Within a stringent global 'cap and trade' scheme the first economic question will be: If the global GHG emissions are capped – what will the price for the GHG/CO_2-emission allowances? Are there 'skyrocketing' prices that will squeeze all CO_2-emission relevant economic activities?

And above that – as already mentioned in II.A.: World economic leaders and 'her majesty government' of Great Britain "urge the G8 governments to "establish a long term, market-based policy framework extending to 2030, that will give investors in climate change mitigation confidence in the long term value of their investments. Establishing indicative signals extending to 2050 would also be beneficial." (World Economic Forum 2005, p3) The intention of the GCCS and its design is identical with those urgent demands of world's economic leaders.

VII.B. GCCS as a 'hybrid' quantity and price cap approach: The theoretical and practical problems with a strict CO_2-'cap'

In economic literature, there is a persistent debate on whether such a certificate model on the basis of a 'Cap and Trade' approach should be designed with an "absolute" global limit for CO_2 emissions. Such an approach might lead to unreasonably high "skyrocketing costs" for emission rights (referred to here as climate certificates, CCs) which would have no reasonable cost-to-benefit ratio considering the only very small contributions of present emissions (reductions) to climate stabilization.[65]

As early as 1974, Weitzman showed in a fundamental – generally accepted – article that with a sharp increase in marginal damage curves and a growing burden, the quantity-limiting certificate model (cap and trade) is the means of choice whereas in the case of marginal damage curves with a low rate of rise, preference should be given to the price or environmental duty (tax or fee) model.[66] In terms of climate protection, a marginal damage function should be assumed with a low rate of rise – in relation to ***current*** changes or non-changes in climate gas emissions. Because, the atmosphere contains a total 'stock' of around 27,100 billion ton-

[65] Refer here to summary report on this discussion in IEA / OECD 2002a, loc. cit., p. 117 and following, p. 147 and following and – among others – the following contributions and proposals by various authors concerning hybrid systems, price caps, safety valves, etc.: Pizer, W.A. (1997): Prices versus Quantities Revisited: The Case of Climate Change. Discussion paper 98-02. Resources for the Future. Washington D.C. October 1997; Kopp,R./ Morgenstern, R./Pizer, W./ Toman, M: A Proposal for Credible Early Action in US Climate Policy. Resources for the Future. Washington 1999. (http://www.weathervane.rff.org/features/feature060.html); McKibbin,W.J./ Wilcoxen, P.J.(1997): A better Way to Slow Climate Change. Brookings Policy Brief 17. Brookings Institution. Washington DC. (http://www.brookings.edu/comm/PolicyBriefs/pb017/pb12.htm); Kopp,R./ Morgenstern, R./Pizer, W.: Limiting Cost, Assuring Effort, and Encouraging Ratification: Compliance under the Kyoto Protocol. (http://www.weathervane.rff.org/features/perisconf0721/KMP-RFF-CIRED.pdf); Schlamadinger, B./Obersteiner, M./Michaelowa, A./Grubb, M./ Azar, C./Yamagata, Y./Goldberg, D./Read, P./Kirschbaum, M.U.F./Fearnside, P.M./Sugiuyama, T./Rametsteiner, E./Böswald, K.: Capping the Cost of Compliance with the Kyoto Protocol and Recycling Revenues into Land-Use Projects. In: The Scientific World 2001 (Vol. 1), p. 271-280; Aldy, J.E./Orszag, P.R./Stiglitz, J.E.: Climate Change: An Agenda for Global Collective Action. Prepared for the conference on "The Timing of Climate Change Policies". PewCenter on Global Climate Change. October 2001 and Jacoby, H.D./Ellermann, A.D.: The "Safety Valve" and Climate Policy. MIT Joint Program on the Science and Policy of Global Change. MIT.Cambridge, MA. February 2002 (http://web.mit.edu/globalchange/www/MITJPSPGC_Rpt83.pdf).

[66] Weitzman, M.L.: Prices versus Quantities. In: Review of Economic Studies. Vol. 41. (1974) October edition.

nes (27.1 ***trillion!)*** of CO_2[67], whilst (around 2010) annual emissions total approx. 29.3 billion tonnes.[68] In this case, preference should be given to working with a price-control mechanism in order to avoid paying too high a price for relatively small "climate benefits". However, the lasting nature and accumulation of climate gases in the atmosphere must also be considered: "If a price instrument leads to less mitigation in one period, this has long lasting effects on subsequent periods. Thus, these adjustments tend to favour – in relative terms – quantity instruments."[69]
Ultimately, the recommendations from this scientific discussion suggest that quantity control by itself – where the consequence of 'skyrocketing prices' would also be put up with it if necessary – cannot be justified and this is why the 'hybrid systems' policy is recommended. Their main advantage being "their ability to associate some of the advantages of a price mechanism with those associated with a trading regime. Permit regimes already demonstrated important advantages in achieving an international agreement."[70] Aldy, Orszag and Stiglitz also sum up: The most promising approach "to achieving emission reductions in the near-term is implementing a hybrid system of emission quotas with a maximum permit price. Such a policy reflects both environmental goals and economic concerns, by balancing the risk associated with climate change with the risks associated with excessively costly emission reductions."[71] Even more important is that these highly recognised authors consider it possible that a hybrid system could put to rest reservations against measures to counteract climate change "even in the United States, and could build upon the basic structure of the Kyoto Protocol."[72] (*underlining by the author)*

With the GCCS 'structure' presented here, the 'Beyond Kyoto – An new GCCS' author (Wicke 2005) has completely adopted this recommendation for the following reasons:

1. There is no doubt that short-term measures have almost no effect on climate. Due to systematic problems in conjunction with the recording and evaluation of medium and long-term damage[73], a cost-to-benefit/damage analysis will always overestimate the current emission reduction costs compared to long term climate de-stabilization damage (including the problem of discounting the damage to a 'present value') in such a manner that conventional cost-to-benefit considerations will never "advise" responsible behaviour in relation to future generations.
   Economists should examine whether their own science simply fails when it comes to inter-generation problems.[74] By the way: This is one of the basic deficiencies of the so-called Copenhagen Consensus, declaring climate change problem as the least important of current international problem, not worth while to put the assumed 50 billion dollar amount into solving the problem. (Lomborg 2004)[75]

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[67] IEA / OECD 2002 a– International Energy Agency / OECD: Beyond Kyoto – Energy Dynamics and Climate Stabilization. Paris 2002, p.151.
[68] IEA 2002 a– International Energy Agency: World Energy Outlook 2002. Paris 2002, p. 413.
[69] IEA / OECD 2002 a– International Energy Agency / OECD: Beyond Kyoto, loc. cit., p. 153.
[70] Ibidem, p. 122.
[71] Aldy, J.E./Orszag, P.R./Stiglitz, J.E.: Climate Change: An Agenda for Global Collective Action. Prepared for the conference on "The Timing of Climate Change Policies". PewCenter on Global Climate Change. October 2001, p. 29.
[72] Ibidem.
[73] RSU (German Council of Environmental Advisors): Umweltgutachten 2002. Für eine neue Vorreiterrolle. Deutscher Bundestag. Publication 14/8792. Berlin 2002, text No. 521and following.
[74] The detailed information drafted by the German Council of Environmental Advisors (RSU 2002) on this subject supports this opinion. (Refer to: ibidem.)
[75] There are mainly two reasons why Lomborg and his master-scientists in the Copenhagen come to such a low ranking: (1) According to Dr. Ottmar Edenhofer, PIK Potsdam - a very 'conservative' model, that normally leads to extremely high estimates of the costs of an efficient anti-climate change policy, that has got to start early in present times to be effective. (2) The second reason is even more important – and this is a systematic deficiency of long-term inter-generation cost benefit analyses: The future benefit of a significantly reduced costs of climate change induced damages will always be in magnitudes lower than the actual costs in the present and in the near future, because one has to discount the future benefits by a certain discount rate (normally between 2 and 5%). To pronounce the methodological and 'common sense' problem straight forward at hand of a hypothetical case (ref. Lomborg 2005): With the cost-benefit analyses method of Lomborg and his famous colleagues they clearly would show: There is a nearly Zero benefit of protecting half of the world and its inhabitants of drowning, caused by climate change induced melting of all glaciers of the world, because it

On the other hand, conceivably extreme economic dismissals through the ruthless implementation of an absolute limiting regime (e.g. a very strict CO_2 contraction regime) cannot be accepted (nor implemented, see below) in light of what are only relatively small improvements in the climate situation.

2. However, these objective economic problems should not be cause for international community to believe that it need not act or that it can rely on largely ineffective climate-related environmental duties or charges. This would mean the accumulation of an ever growing quantity of climate gases in the atmosphere, no stabilization at a higher temperature level and leaving it to future generations to deal with the climate fate made for them by the generations of mankind living before them.
3. This is why the demand by the European Union for climate stabilization at 550ppm of CO_2 and the decisive commitment to the emission path needed for this (initially for the 21st century) that its fixed at 30 billion tonnes of CO_2 from 2015 onwards remains correct and undeniable and is therefore the basic objective of the GCCS. (In section VIII.E.) there will be shown a GCCS PLUS = Kyoto PLUS – system targeting towards a 450 ppm CO_2-concentration in order to reach the main EU-target by a temperature stabilization of plus 2°C above the pre-industrial level (1760).)

VII.C. GCCS-acceptance reasons for a price cap

Therefore: According to the basic target of the UNFCCC, Art.2 'to prevent dangerous anthropogenic interference with the climate system' there has to be a sufficient climate change mitigation and a stabilization of the climate to a still acceptable level that prevents this 'dangerous interference'. This should be concretized by a still tolerable increase in global average temperature respectively in an equivalent stabilization of a maximally acceptable CO_{2equ}-concentration in the atmosphere. Therefore a fixed global GHG/CO_2-emission cap (or alternatively an emission cap that is 'downgraded' in the course of time) plus a trading system should be the appropriate means to reach those climate stabilization targets.

But an ecologically committed climate policy must keep the economic consequences of a system in the mind. Therefore: The problems of strictly fixed GHG emission quantities (irrelevant of the resultant effects on price, economy and growth) remain not just a dilemma for economic theory but also a very real problem in two ways:

- There is no chance whatsoever that ***all*** governments and parliaments world-wide will accept a climate protection system where the economic effects on current generations alive in the respective countries are unclear and which could – perhaps – have disastrous economic effects (e.g. by 'skyrocketing prices' of fossil fuels). (As is generally known, the principle of unanimous vote applies when it comes to agreeing on or modifying the global climate protection system!)
- Even if through a political wonder the required unanimity for such a climate protection system would be declared by signing of such a treaty by the governments and all parliaments were to ratify this system, no government or parliament can be forced under international law to then also take part in this climate protection system if the economic effects (e.g. due to strongly rising prices for climate certificates (and hence for fossil fuels) and the resultant economic implications) are found to be impossible to bear and no longer acceptable. This means that a global climate system with such economic consequences would collapse as a result of a mass exodus by states out of GCCS.

The only solution to these problems can be to assure governments and parliaments from the very outset that the economic effects of the global climate system will remain acceptable on a lasting basis for all countries.

Within the scope of the GCCS, this assurance can be given, above all, by the following features:

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would happen in a time horizon between 50 up to 5000 years from now on. Therefore Lomborg at al. would give the advice: Let them be drowned - don't invest any sum in climate change mitigation – there exist nearly a zero benefit / cost ratio. Put the money into mitigating other, more actual world problems that have to be solved or mitigated too.

- The EU's moderate 'concentration' climate stabilization goal (maximum CO_2 concentration of 550ppm), possibly – in the longer range – the EU's 'temperature' climate stabilization target (ref. to Kyoto PLUS, sect. VIII.C.2).
- The basic population-proportional supply for all economies with a basic low-cost transfer and low-cost basic supply with climate certificates also ***supplemented by***
- a price cap for climate certificates on the free CC market (see below).

VII.D. The 'price cap/safety valve' guarantee over time on the free CC market by the WCCB through price and quantity stabilizing intervention

Within the scope of the GCCS, the WCCB can fix a maximum price for climate certificates by offering climate certificates on the CC market at that maximum price. If the WCCB guarantees, for instance, that it will offer CCs on the market at a price of US$30 in any quantity demanded, all other players on the FRP market and economic entities also affected by this market have the assurance that this price will not be exceeded.

Literature contains various details and proposals concerning the amount of such a price cap or safety valve. In principle, the scientifically most important advocates of the hybrid cap and trade system, Aldy, Orszag and Stiglitz, argue in relation to the adequate price-cap level as follows:

> "It is worth mentioning that the safety valve is *not* intended to set an inefficiently low carbon price over time. Indeed, the safety valve may allow a *higher* price of carbon over time than would otherwise be the case, ***because it provides assurance that the costs will not exceed that level."*** (Aldy/Orzag/Stiglitz 2001, p21)

This is why within the GCCS the following approach is proposed:

- The price cap or the WCCB's intervention price will be fixed at US$30 per CC or tonne of CO_2 for the period between 2015 and 2024. (The aforementioned authors refer to this price of "$30 per ton" of CO_2[76] "for illustrative purposes"). In the two subsequent periods[77]
- 2025 to 2034, this price will be increased to US$60 and to
- US$90 in the period from 2035 to 2044. (Wicke 2005, p.226seq.)

These clear figures and the other long term aspects of the GCCS provide "a long term, market-based policy framework extending to 2030 (and beyond that, note of the authors), give investors in climate change mitigation confidence in the long term value of their investments," as urgently demanded as address to "the G8 governments" by world economic leaders of the WEC, World Economic Forum. (2005, p3). And these long term policy framework conditions for CO_2/GHG reduction measures give all states, producers and consumers the opportunity by implementing CO_2-reducing 'early actions' to adjust to requirements which will become stricter over the course of time.

In climate terms, however, this result is a problem (that can be solved): It cannot be ruled out that the WCCB will in fact have to intervene frequently and sell CCs on the market in order to stabilize prices, in case CO_2-reduction measures should be more expensive than the price caps (increased every 10 years). In fact this development is not very likely because a price cap of $30 or 60 or even 90 would have enormous incentive effects, because at least one main CO_2-reduction technology (CO_2-sequenstration, "CCS" CO_2 capture and safe storage, ref. to VII.B.2.b.) will have costs of between 20€ and 'above 50US$' per ton of CO_2. [78].

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[76] Aldy et. al. do not explicitly refer to a 'tonne of CO_2' or 'tonne of carbon'. But the authors are convinced that they refer to US$30 per tonne of CO_2: Since one tonne of carbon is equivilant to 3.666 tonnes of CO_2, the proposed US$30 per tonne of carbon would be equivilant to around US$8.2 per tonne of CO_2. They obviously do not refer to this very low price, because Aldy et al. argue that environmentalists believe that such a high price will never come into effect because it is then cheaper to reduce CO_2 emissions. (Referring to Aldy et al., a dispute exists as to whether the market price will be higher or lower than US$30 per tonne of CO_2. Refer to Aldy, J.E./Orszag, P.R./Stiglitz, J.E.: loc. cit., p. 26.)

[77] These periods correspond to the constant and/or price-increasing interval for transfer prices between different nations via the WCCB clearing house.

[78] Compare this to: The IEA estimates the lower limit of the costs of sequestration (separation) of CO_2 from exhaust emissions from power stations (as one of the most expensive, but in terms of quantity most effective CO_2 reduction measure) at "over $50 per tonne of CO_2" (IEA 2004, p412). Vattenfall Europe (2005) with its "CO_2-free demonstrating coal power station" in Spremberg in the German federal state of Brandenburg expects additional cost for CO_2-sequestration with its "oxyfuel-process" till around 2015 a price of around 20€

Notwithstanding that: At first glance, the probable market interventions of the WCCB appear to be very questionable in terms of climate policy: Each time the WCCB additionally sells CCs that exceed the free first allocation to all countries on the basis of 30 billion CC-cap, and the different countries' populations, this means an increase in the emission quantity permitted which could endanger the European Union's "concentration climate stabilization target of 550 ppm CO_2" which is also the first moderate aim of the GCCS (for the Kyoto PLUS-target refer to VIII.B.2.). However, this must not necessarily be the case:

Revenues from the sale of CCs at the WCCB's intervention price should, in principle, be used to buy back CCs on the free CC market, as soon as the price is significantly lower than 30$. By buying back CCs and hence the additional demand by the WCCB on the free CC market with once again falling CC market prices can, if necessary, prevent any risk to the EU's stabilization target caused by previously too excessive CC buying. At the same time, the CC price would be stabilized at a relatively high level (below the intervention price) – with the consequence that CO_2 reduction measures at a cost level below this longer-term stable market price would be worthwhile and 'profitable'. [79]

Besides, there are proposals to apply what may be ongoing surpluses from such market intervention (with continuous intervention by the WCCB) directly to stabilize climate: Adopting and modifying a proposal by Schlamadinger and many other authors, the WCCB's revenue from the sale of CCs at the price-cap intervention price could be used to boost CO_2 sinks in developing countries through appropriate measures in the field of land use, land-use change and forestry[80]. However, in the case of the GCCS, this aspect is rather less important than within the Kyoto system.[81] This is also why, if necessary, major subsidy and development programmes by the WCCB, for instance, (to reduce the costs of) sequestration of carbon dioxide from power station emissions (which might not be necessary, see the Vattenfall (2005) example above) or the promotion of the development and cost-reduction of other promising CO_2 reduction techniques could have an even longer lasting positive effect on climate.

It was also noted elsewhere[82] that part of these funds could be used for a higher remuneration of their transfer CCs from countries with particularly or relatively low per-capita emissions in order to particularly help these countries - which are at times particularly vulnerable to the adverse effects of climate change – when it comes to measures designed to reduce the negative impacts of climate change (so-called 'adaptation measures').

Irrespective of how the revenue from CC intervention is used:

The GCCS is a so-called 'hybrid' quantity-price control system for climate gases: The quantity is limited to the CCs issued each year to all countries (under the yearly global cap of

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per tonne for the CO_2-sequestrartion process (capture, transport and storage). Note: In case new techniques like a CO_2-free fossil fuels fired power station (Vattenfall 2005) would be installed, the equivalent amount of fossil fuels would be CC- and CC-cost-free, therefore significantly cheaper. If the marginal costs for purchasing CCs in the free CC-market – in the first ten year's period – is 30$ and the cost for the tonne of CO_2-sequestration is 20€ as predicted by Vattenfall (2005), the implementation of this technology would be very profitable. The savings for coal used for this technology – because being burned with zero CO_2 – being 'unburdened' by additional CC-costs would offset the additional costs for sequestration, transport and storage!

[79] One realistic example has been shown in the footnote above. Moreover, through intervention by the WCCB the conceivable "sawtooth price curve" on the free market could be avoided as it would not be possible to 'bank' CCs as they are valid for one year only. It is feared that "due to planning uncertainties without banking ...there may be price peaks caused by stocking and a price collapse towards the end of the period as a result of stocks being sold." (DIW/ Öko-Insitut, etc., loc. cit., p. 21). This problem is by far less pronounced in the case of the CC system that starts with the FRPs than with the sector-based EU emission trading system.

[80] Schlamadinger, B./Obersteiner, M./Michaelowa, A./Grubb, M./ Azar, C./Yamagata, Y./Goldberg, D./Read, P./Kirschbaum, M.U.F./Fearnside, P.M./Sugiyama, T./Rametsteiner, E./Böswald, K.: Capping the Cost of Compliance with the Kyoto Protocol and Recycling into Land-Use Projects. In: The Scientific World. Volume 1 (2001), p. 271 and following.

[81] The problem in this case is located within the GCCS: As soon as the changes in sinks can also be included in the GCCS through suitable precautions (and hence increase (decrease) the CC budget on a country-specific basis), these measures will not achieve any climate improvement because (due to CC 'credits') developing countries will then require fewer CCs for consumption and production, for instance, through reforestation (and will be able to sell these CCs to industrialized nations at the transfer price via the WCCB). On the other hand, deforestation would lead to a higher basic demand among developing countries and fewer opportunities to sell CCs.

30 billion CCs) until the intervention price is reached. After the intervention price has been reached, the CC quantity and hence CO_2 quantity can be increased by selling CCs. Now it is "only" the incentive effect of the (high) CC price (as a quasi CO_2 duty or tax) that works on the market when it comes to dampening or limiting CO_2 emissions – but even this would still be a progress on a **global** scale compared to today's and tomorrow's nearly business-as-usual development – despite the Kyoto Protocol!. (Ref. to section II.A.)

VII.E. CC price stabilization also through CCs' one year validity

As already mentioned: The one-year validity term of the CCs implies, that it is ***not*** possible for a state or a FRP-company to transfer CCs to future years (no CC-banking!). This annual validity avoids any speculative price leaps that could result from banking because all surplus CCs must be offered on the transfer and free market in the year in which they are valid as they would otherwise lose their validity and their monetary value. This kind of banking could be carried out if the CCs were valid for longer, especially by certain developing and newly industrialized countries (with large CC surpluses), for instance, in order to influence the market or for speculation reasons, and would result in an undesired very strong shortage of CCs in certain years or time periods.

On the other hand, banking – in principle – could be of enormous importance in other emission trading programmes for certain companies, e.g. power suppliers, in order to 'secure CO_2 emissions' on a long-term basis from coal, oil and gas power stations.[83] Above that: The often quoted "when - flexibility" by banking of CCs (or emission allowances like in the European emission trading system) can help to improve the economic efficiency (respectively the cost minimizing capacity) of the system. The owner or buyers of those allowances can decide within the validity of the allowances (3 years presently in EU's ET-system) at which point or period of time the own use or the selling of the allowances get their highest value. (Böhringer/Löschel/Rutherford 2005, p.2)

In the case of the GCCS the above and below quoted 'urgently demanded' (by worlds economic leaders) "long term, market-based framework" for "investors in climate change mitigation" and therefore cost and profit certainty is given by the yearly basic allocation to FRPs and by the 'cost certainty' of the various price caps (in the course of time) within the GCCS. And the GCCS definitely reflects the fact, that the CO_2-reduction can be 'produced' much cheaper in future times (ref. to VIII.A. to D.): Within the GCCS the global CO_2-caps are designed in a manner, that the reduction of the 30 billion tons' cap starts either not before 2070 ('GCCS'-case) or not before 2030 (GCCS-PLUS case) – refer to Figure 2 in section III.B. and Figure 6 in section VIII.E..

VII.F. The economic mechanisms of a climate policy induced technological change by a 'cap and trade scheme'

Goulder (2004, p3) describes the mechanism how a global cap and trade scheme induces technological progress:

> "Direct emission policies include taxes on fossil fuels and CO_2-emissions caps. These policies raise the prices of carbon-based fuels, … by way of limits on the emissions associated with their use. This in turn stimulates technological change by increasing the reward (cost savings) for discovering a process that allows reduced consumption of such fuels, which are now more expensive."

In line with these remarks of Goulder and contrary to the above WEC's (2005, p3) opinion about the stimulation of only 'promoting efficiencies in energy use or manufacturing processes', the GCCS as an 'upstream' cap and trade scheme: In the following chapter VIII it will be shown that the implementation of the GCCS directly would lead to a climate-related enor-

[83] Refer to: UNCTAD (1998) (United Nations Conference on Trade and Development, Editor). Authors: Grubb, M./Michaelowa, A./Swift, B./Tietenberg, T./ZhongXiangZhang (1998): (Editor: UNCTAD (United Nations Conference on Trade and Development): Greenhouse Gas Emissions Trading: Defining the principles, modalities, rules and guidelines for verification, reporting & accountability. Draft Geneva August 1998. (Final version Geneva May 1999 (UNCTAD/GDS/GFSB/Misc.6, United Nations) in the web: http://rO.unctad.org/ghg/publications/intl_rules.pdf, S.22.

mous breakthrough by making carbon respectively carbon dioxide 'capture and storage' (CCS) in fossil electricity power plants (CO_2-free coal fired power plants) and – presumably – other (incineration) processes "in manufacturing industry and in the production of transportation fuels" (IEA 2004 p412) a profitable technology. This also stands for an increased market penetration by – up to now – nearly competitive technologies based on renewable energies like wind and biomass. These two examples - illustrative and for climate mitigation most important - will be discussed below.

The mechanism of climate policy induced technological change can be – more generally – theoretically described as follows:

"The imposition of climate control instruments can stimulate invention and innovation processes. The invention and innovation practices are carried out primarily by private firms through increased research and development (R&D). A technological innovation can become widely available by technologic diffusion processes. The induced innovation hypothesis recognizes R&D investments as profit oriented investments stimulated by relative price change. Climate policy measures that increase the price of fossil fuels augment the market for low carbon technologies. This effect creates incentives for increased R&D expenditures in the sectors affected by climate change. Increases R&D expenditures raise technological changes that lower the costs of low carbon technologies." (Summary of Porter and van der Linde (1995) by Kemfert (2005, p.4seq.).

Goulder (2004 p30) doesn't talk about an 'induced innovation hypothesis'. He is sure the climate policy induced technology change (ITC) definitely exists:

"Until recently, most economy wide climate change policy studies ignored ITC. Models that disregard policy-induced technological advances will tend to overestimate policy costs."

According to Goulder (2004, p13seq) those cost savings are in the range of 5 and 10% respectively 51% (at maximum) depending on the research findings (different models and impacts assessments) and the stringency of climate policy.

And above that: A carefully planned climate policy – announced many years before the climate policy in fact does start – can and will have very beneficial impacts on the costs as described by Goulder (2004 p.30seq.) as follows:

"Announcing policies in advance can lower the costs of meeting given targets for emissions abatement or reductions in GHG concentration. Illustrative results suggest that announcing a $25 per ton carbon tax 10 years in advance reduce discounted GDP costs by about a third to the same climate policy imposed no prior notice".

The GCCS is designed and should be implemented in a manner, that these induced technological changes and the described cost reduction will take place – as shown below in subsections VIII.B. to VIII.E. by incentives for the most important climate friendly technologies.

VII.G. GCCS: Providing a Cap and Trade mechanism for an induced technological change according to the urgent demands of worlds' economic leaders

By the implementation of the here described and analyzed GCCS as a conceivably realistic form of a Global Cap and Trade scheme, the investment, production and consuming gets the necessary policy framework "to establish clear, transparent, and consistent pricing signals" (WEC 2005, p.3). All participants of the global economy need such a framework in order to be directed by market incentives in the necessary climate friendly and sustainable direction. In this sense – as already quoted – the world economic leaders of the World Economic Forum 'in collaboration with her majesty's government' (UK) therefore "urge the G8 governments to

- establish a long term, market-based policy framework extending to 2030, that will give investors in climate change mitigation confidence in the long term value of their investments. Establishing indicative signals extending to 2050 would also be beneficial.
- Ensure that the policy framework is global in scope – utilizing a coordinated and consistent set of national or regional regimes, with maximum fungibility between regimes, and opportunity for future consolidation int a single regime.
- Define greenhouse gas emission rights through a cap-and-trades system or other market-based mechanisms that can be adjusted over time to reflect evolving scientific, technological and/or economic developments and that will help shape consumer choices.
- Address climate change as part of an overall sustainable development agenda, putting in place mechanisms which address the challenges of poverty, energy, and economic growth in emerging markets while mitigating greenhouse gas emissions." *(Underlining by the author for high-*

lighting the nearly complete fulfilment of those demands by the described GCCS)(WEC 2005, p.3)

The worlds' economic leaders quoted above evaluate the merits of their urgently demanded global cap and trade scheme – obviously aiming as a 'downstream' cap and trade schemes 'at the end of 'polluters' chain' (direct last CO_2-emitters)[84] as follows: "Properly designed emission trading programs can and will induce companies to reduce their emissions of greenhouse gases. …., The primary effect of such mechanisms (*Authors' note: 'downstream' systems at the end of the 'polluters chain', that directly influence only companies*) is to promote efficiencies in energy use of manufacturing processes; …" (WEC 2005, p.3).

Contrary to such a scheme, the design of the GCCS as an upstream system with pretty substantial marginal cost increases – differentiated – of all fossil fuels (in ten years' steps) and significant increases of the transfer prices respectively costs for the basic allocation (ref. to sections III.B. and VI.C. and D.) definitely intends more than just 'promoting efficiencies in energy use or manufacturing processes' but also "to stimulate major technological changes or breakthroughs" (WEC, 2005, p.3)

Of course: The GCCS – basically developed in the second half of 2003 – could not at all be inspired by the urgent call of above quoted world's economic leaders (WEC 2005) and by Vattenfall (as a big scale developer of the 'carbon dioxide capture and storage' technology, Vattenfall 2005 and see below) in 2005. The GCCS was designed to put a proposal on the table for scientific and political debate with the outspoken target to solve the most expensive environmental problem of this globe – the completely climate friendly restructuration of this planet's economy in order to prevent – as article 2 UNFCCC demands – "dangerous anthropogenic interference with the climate system" by definitely achieving EU's climate target. (Wicke 2005)[85]

But as a matter of fact the GCCS is fully in line with the four above quoted urgent demands of the worlds' economic leaders, presented to the G8 leaders for their summit in July 2005 and their decisions beyond this event. What's more: The GCCS – being an 'upstream' global cap and trade scheme, thus influencing by induced price signals all fossil fuel and resources consuming companies, private household, public institutions and policy bodies – will have a long lasting world wide effect on climate friendly production and consumption: The permanently GCCS-induced price increases (with price leaps every 10 years) of fossil fuels and resources – either being relatively small on the basis of overall costs, or being significantly higher by a probably mainly marginal cost driven price behaviour (ref. VI.C. and VI.D.) – definitely will not only 'promote efficiencies in energy use of manufacturing processes change' (WEC 2005,p3) but will – in the middle and long range – also promote and stimulate significantly climate friendly production and consumption patterns.

VII.H. GCCS: Providing funds for public stimulation programs for additional climate friendly breakthroughs

According to Goulder (2004, p.31) direct emissions policies like the GCCS should be supplemented by RD&D (Research and Development & Demonstration) promotion:
"To induce technological change and reduce GHG emissions most cost-effectively, both direct emissions policies and technological-push policies are required."

According to this the WEC (2005, p3) demands:

"….. a continuing emphasis on other public and private sector programs to stimulate the development and commercialization of new low carbon techniques is required. Technology-specific government support is essential for basic research that offers long-term prospect of

[84] Contrary to those 'downstream' schemes, the GCCS is an upstream system, starting at the first trading level as (indirect) CO_2-emitters by selling fossil fuels which – at the end of the product chain – lead to CO_2-emissions.

[85] Wicke is an environmental economist who – to a certain degree of knowledge – was and is specialized in the design of market oriented instruments for solving difficult environmental problems (ref. to the textbook Wicke, Umweltökonomie 1994 p.195-462).

success but remains too risky to attract private sector investment. This is especially relevant in areas where technological breakthroughs have not yet been achieved." (WEC 2005, p3)

With an implemented GCCS such CO_2-reduction specific programs by governments can be launched much easier: Every National Climate Certificate Bank (NCCB) gets – according to the population of a country – more or less extra funds out of the difference of

- the zero cost primary per capita-allocation plus (in industrialized highly emitting countries) the surplus-reallocation of CCs from the World Climate Certificate Bank (WCCB)
- and of the (normally) higher CC-price by the allocation to the national FRPs (ref. VII.D.4.a.).
- And above that: In case the CC-allocation-price to FRPs should be close to the free CC-market price (ref. VI.D.4.c.) there will remain very substantial amounts of allocation surplus revenues for the NCCBs.

In order to promote climate friendly R&D, part of those funds could be designed to those WEC-demanded R&D-programs. According to IEA (2005, p13) even for the relatively far advanced CCS technology a "major increase of RD&D investment" is necessary. Otherwise the technology will not "achieve its full potential over the next 30 to 50 years". Therefore the promotion of R&D remains an important part of a successful emission mitigation strategy.

Thus the GCCS could – as demanded by Goulder (2004) – provide both: A globally very efficient way of direct emissions policy thus inducing climate friendly technological change and – at least as financial basis – the appropriated 'fund raising' for an effective promotion of technology-push policies. By these combined and double targeted effects the GCCS could be an important instrument to induce technological change and reduce GHG emissions most cost-effectively![86]

[86] Refering to a remark of colleague Prof. Böhringer: This optimistic climate change outlook of the consequences of the GCCS is – of course – not equivalent to the security that an implemented GCCS would maximize the welfare whether of a certain country nor of the world. But: Which policy directed for reaching partial political goals can be sure of maximizing the total national or global welfare? The author Lutz Wicke is strongly convinced: To secure future generations of dangerous – if not (for vast world regions) even catastrophic climate change – seems to be the maximum a practical minded (environmental) economist can "produce" for national or global welfare.

VIII. Still tolerable climate change: Predictable GCCS induced climate friendly technological change and its tremendous positive impacts

There exist 15 or more options for the next 50 years, to intensify the introduction of already existing or 'current technology' in order to mitigate climate change to a still tolerable level. Pacala and Socolow (2004) call those options of already known and partly introduced emission reduction technologies or changeable consuming and production patterns 'stabilization wedges'. Their use can be extremely enlarged – starting from (nearly) zero at present to an extent, that they represent a cumulative total of around 100 $GtCO_2$ of reduced emissions over 50 years. According to Socolow (2005) a price for CO_2-emissions "in the neighbourhood of $100t/C (equiv. to around 30$ per ton of CO_2, suppl. by the author, this magnitude is proposed in the GCCS too) can enable commercialization of most of the wedges."

Some of those wedges with – according to IEA (see below) even much higher emission reducing potential as Socolow imagines – shall be discussed below.

VIII.A. Prevention of dangerous climate change by GCCS–induced global expansion of renewable energies and CCS- (CO_2-capture and storage-) technology

There still exists some hope that – irrespective to the "overshooting" by yearly global emissions into the direction of the 750ppm 'stabilization path' in the first three decades of the 21st century, shown in Figure 1 (in section II.D.) – world in fact can achieve EU's second (concentration) target of at least 550ppm CO_2. And above that, there even exist some chances (technological and policy options) also to come near to the 450ppm CO_2-concentration which is necessary to reach EU's 'temperature target'. The author is convinced (and will prove it in the following) that by implementing the GCCS – a "cost-effective portfolio of options for reducing CO_2" in which "renewables, (nuclear)[87] and CCS technologies …" (IEA 2005, p19), would be induced in such magnitude, that dangerous climate change as defined by EU's temperature target could be avoided. Within that portfolio – beside the global breakthrough of renewable energies, see below – the CCS technology could play a predominant role. This can be explained by the main findings of an IEA study about the prospects for CO_2 Capture and Storage (CCS). (IEA 2005)

The CCS is a technology which is up to now not installed at all at big scale power plants but with a high probability to be successfully introduced in the next ten to fifteen years. Up to the year 2005

"various small-scale pilot plants based on new capture technologies are in operation around the world. Only one power plant demonstration project on a megatonne-scale has so far been announced: the FutureGen project in the US. …Other demonstration projects are planned in Canada, Europe, and Australia." (IEA 2005, p15)

In case this technology would be successfully introduced world wide, it could have an enormous reducing effect on the "predominant human contribution to climate change. The burning of fossil fuels is responsible for at least three-quarters of anthropogenic carbon dioxide emissions". (IEA / OECD 2002, p39). More specific to CCS-inclined processes:

"Since power production is responsible for over 29% of global CO_2 emissions, capturing from electricity plants offers the best initial potential for capturing the CO_2 generated from fossil-fuels use. To a lesser extent, CO_2 can also be captured during the production of iron, steel, cement, chemicals and pulp and from oil refining, natural gas processing and the production of synthetic fuels (such as hydrogen and liquid transportation fuels from natural gas, coal or biomass). (IEA 2005, p15)

Given the assumption, "that all new capacity built in OECD countries after 2015 were equipped with CO_2 capture technology, and if this were to be matched by a similar amount in non-OECD-countries, CCS would cover 5% of total world power generating capacity in 2030." These 'merely' 5% of world's power generating capacity would result in a "reduction in CO_2-emissions … of 1.5 and 2 billion tonnes."(IEA 2004, p 413) It is very easy to imagine, which tremendous decreases of emissions will become reality if – up to the year 2050 – all

[87] The nuclear option put in brackets by the author, because for this option by an increasing number of conventional nuclear power plants in many states there exist enormous (acceptance and other) hurdles and quite a lot of important fears and barriers (security of the deposits of the nuclear waste, the level of security of the plants, terrorism and the enlargement of the number of nuclear weapon states by not fully controlled nuclear power plants).

new burning and processing capacities world wide, being suited for the CO_2 capture and storage technology, would be equipped starting 2015 with this technology:

"CO_2 capture and storage (CCS) could potentially allow for the continued use of fossil fuels while at the same time achieving significant reductions in CO_2 emissions. Indeed, the results of IEA analysis show that CCS could even play a key role in a scenario where global CO_2 emissions are roughly stabilized at 2000 level by 2050." (IEA 2005, p18)

This indeed would be an enormous break through in climate stabilization policy: If the quoted stabilization of CO_2 emissions at 2000 level by 2050 would be materialized, this would be – according to the IEA – an achievable level of around 23 billion tons of CO_2 per year by 2050. In case this could be achieved there exists still a realistic chance to come close to the 450ppm – irrespective of the 'overshooting' because of rising global emissions towards a path of 750 ppm CO_2-concentration in the first three decades of the 21st century (refer to Figure 1 in sec. II.D.)!

Note: These emissions in 2000 and – hopefully 2050 – of around 23 billion tons have got to be compared to the pretty likely 'reference scenario of IEA' with around 38 billion tons by 2030. This enormous increase of plus 90% compared to 1990 will take place, in case no very substantial political action of all (major groups of) emitting countries and no implementation of CCS for new fossil power plants in OECD countries will take place, starting in 2015. (IEA WEO 2004, p412seq)

In case "nothing but" CCS could be implemented up to 2030 respectively up to 2050, according to IEA the

"…CCS potentials are between 3 Gt and 7.6 Gt CO_2 in 2030, and between 5.5 Gt and 19.2 Gt CO_2 in 2050. This compares to 38 Gt CO_2 emissions by 2030 under WEO Reference Scenario. The fact that all scenarios show a potential on a Gt scale suggest that CCS technologies constitute a robust option for emission reductions." (IEA 2005, p.19)

Beside the CCS technology there exists an important role for the renewable energies[88], which can be increased, if those technologies have induced technological progress too :

"…More optimistic assumptions for the future cost reduction of renewables … would considerably reduce the future role of CCS" (IEA 2005, p.19)

and therefore a resulting significant increase of the importance of renewable energies – above the already reached importance. Their current importance has mainly been reached by some incentive or subsidy programmes of various countries but also by some market demand. (The possible increased importance of the renewable energies has been estimated in the "International Action Programme" for renewable energies with up to a CO_2 reduction of 1.2 billion tons by 2015[89].)

But there can be no doubt: In case CCS will become a marketable – therefore a not too 'costly' technology (ref. to the following subsection VIII.B.) – , there will be competition between the mentioned two low or zero CO_2-emission technologies. (For the big chances of the renewable energies under the GCCS refer to VIII.E.2)

As far as CCS is concerned one has got to know its strengths but also its differentiated importance:

"CCS would result in a significant increase in the use of coal … . As coal is considered a more secure fuel than oil and gas, the fact that coal remains *(in climate change mitigation terms, added by the author)* a viable energy options increases supply security … even in regions where the actual investments in coal are of limited scale.

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[88] The future importance of renewable can be estimated – although only till the year 2015 – by the results of the "International Conference for Renewable Energies, Bonn 2004". This conference 'ratified an "International Actions Programme, IAP", containing "197 actions and commitments from governments, international organisations and stakeholders from civil society, the private sector and other stakeholder groups participating in the conference". In case this IAP would be completely implemented "the global CO_2 emission will be reduced progressively leading to an estimated CO_2 reduction of 1.2 billion ton/annum in 2015." (Renewables2004, p.5) It has to be mentioned that over the course of time – compared to the above quoted estimates for CCS till 2030 respectively 2050 – the potential of renewable energies should be considerably higher than in the quoted potential up to 2015.

[89] Such a progress is very likely because of the enormous price increases on the fossil fuel markets and because of the climate policy proposed by world's economic leaders of the World Economic Forum (WEF 2005, quoted twice above) and in case the GCCS as a means for implementing WEFs urgent demands would be introduced. (see below sub-section VIII.B.2.d.)

For regions with ample coal reserves, such as North America, China and India, CCS could result in lower imports and increased reliance of domestic energy sources….
The relevance of CCS differs by region. … CCS can become an important option in North America, Australia and parts of Europe. While the CCS potentials in China and India are important as well, the realization of these potentials will depend on the extent of global efforts to reduce CO_2 emission". (IEA 2005, p.19seq.)

One problem could arise in constantly using coal or oil for power generation including the CCS-technology. In certain regions, for instance in Central or Southern Europe, there are climate change predicted long periods of low precipitation or even droughts: This could lead to a significant shortage of cooling water for the power generation – and consequently to the need of a technology with less water use for cooling down the power generation steam.

VIII.B. The GCCS – induced breakthrough of CO_2-capture and storage technology for big emitting plants

In the following it can be shown, that an implemented 'global Cap and Trade Scheme' like the GCCS in fact can be the decisive economic stimulus and incentive for the breakthrough of the CCS-technology. The GCCS with its marginal CC / CO_2-emission price of 30/60/90 $ per CC/t (ref. to VII.A.3) in fact could boost such a climate friendly development world wide, as can be shown with the following example:

The IEA estimates the lower limit of the costs of sequestration (separation, 'capture') of CO_2 from exhaust emissions from power stations at "over $50 per tonne of CO_2" (IEA 2004, p412). More specific:
"At this stage, the total cost of CCS could range from 50 to 100 USD per tonne of CO_2. This could drop significantly in future. In most cases, using CCS would cost 25-50 USD per tonne of CO_2 by 2030 compared to the same process without. Certain early opportunities exist with substantially lower cost, but their potential is limited." (IEA 2005, p17)

These higher cost ranges mentioned by the IEA seem to be mainly due to the investigated sequestration (CO_2-capture and storage, CCS) methods (Gielen, 2003 p13seq., IEA 2005, p.98seq.). Contrary to that: Vattenfall Europe (2005) – one of the big European electric power companies (originating and headquarters in Sweden but also now being the third biggest electric power producer and supplier in Germany) – is much more optimistic about the future costs of this technology: In 2005 it has started its project "CO_2-free demonstration coal power station" in Spremberg in the German federal state of Brandenburg. Vattenfall expects additional cost for CO_2-sequestration with its "oxyfuel-process" till around 2015 at costs of around 20€. According to Vattenfall (2005) this demonstration power station (investment around 40 million €) will be in place (in Spremberg) and – hopefully – demonstrating a CO_2-free coal burning power station in 2008. This "oxyfuel-process" (planned in than near future also in big power plants!) shall have additional overall CO_2-costs of 20€ per tonne for the CO_2-sequestration process (capture, transport and storage!). This would be equivalent to less than 1 cent per kWh[90].

Interestingly enough: Vattenfall also – as the above quoted WEF world's economic leaders[91] – expects exactly the same incentives in the future. (These incentives are proposed in the already often quoted WEF paper (2005) and in the – for this report – basic 'Beyond Kyoto' book (Wicke, 2005): "The introduction of a global and long term acting by CO_2-emission rights (*tradable emissions allowances, supplement by the author)* – combined with a global price for CO_2-emissions". (Vattenfall 2005, p7)

As a matter of fact: Vattenfall's 'oxyfuel'-process and similar CCS-processes with overall costs below $/€ 30 per tonne of CO_2 already would be profitable in GCCS' first decade

[90] This estimate is done in analogy to an IEA-calculation (2004, p.412), that CCS-costs of 'over $50 per tonne of CO_2 "would increase the cost of the electric power produced by two to three cents per kWh". IEA states additionally that "the use of CO_2 in enhanced oil- and gas recovery … could put the net cost of CCS at only one cent per kWh." (Ibidem)

[91] Vattenfall's CEO Lars G. Josefsson being a member of the WEF (World Economic Forum) 'climate round table' (2005)

(2015-2024). The use of coal or other fossil fuels for these processes (being burned with zero CO_2 – emissions) would – of course – be free of CC-charge and costs[92].

Because the marginal costs for CCs in the free market in the first GCCS-decade can rise till 30€ from the very beginning of the GCCS (2013 or 2015) those CO_2-free processes would profit enormously from the implementation of the technology. The savings for "CC-cost" free coal used for this technology would – by far – over-compensate the additional costs (expected by Vattenfall: €20 per CC) for the process for sequestration, transport and storage!

Even if not all CCS-processes will be as 'cheap' as Vattenfall expects for its oxyfuel process: Latest starting from 2025 or 2035 when the CC-price cap (representing the highest possible marginal price in the free market and therefore the highest marginal costs for 1 tonne of CO_2 emissions) is risen from $ 30 to 60 or 90 the CCS will definitely be (highly) profitable:

Given the GCCS would be implemented in 2015 according to the previous GCCS description (ref. III.B.) with the quoted marginal cost of 1 tonne of CO_2-emission: Nearly all new CCS-suited CO_2-relevant investments would be 'forced' respectively be induced by profit-maximizing reasons to include CCS-installations. Even in case certain CCS-installations might not be profitable (higher average per tonne costs) in the first decade it nevertheless would be profitable over the total operating time: The average life span of power plants and other big manufacturing processes being between 20 and 50 years (IEA 2005, p32) . Those 'early actions' – in the current Kyoto I scheme being of no or only very small interest – would become profitable as soon as the Global Cap and Trade Scheme would be the indubitable structural change successor of the Kyoto I – regime. Therefore even the announcing of a $30 marginal price for 1 tonne of CO_2 presumably in 2010 (around 3 to 5 years before the conceivable start of the GCCS (2013 or 15) as a 'structural evolution of the Kyoto Protocol') and announcing the next price leaps 13 to 15 respectively 23 to 25 years in advance for the years 2025 and 2035 ($ 60 resp. 90) would have very beneficial impacts on the costs as described by Goulder (2004 p.30seq.) as follows:

"Announcing policies in advance can lower the costs of meeting given targets for emissions abatement or reductions in GHG concentration. Illustrative results suggest that announcing a $25 per ton carbon tax 10 years in advance reduce discounted GDP costs by about a third to the same climate policy imposed no prior notice".

Besides of those probable overall cost savings one additionally has to recall: CCS can not only play a role in reducing CO_2-emissions of new fossil power plants:

"CO_2 can also be captured during the production of iron, steel, cement, chemicals and pulp and from oil refining, natural gas processing and the production of synthetic fuels (such as hydrogen and liquid transportation fuels from natural gas, coal or biomass)". (IEA 2005, p15)

And as the author was told in July 2005 by IEA's expert Dolf Gielen: There seems to be progress in retrofitting of existing plants with the CCS technology. All those CCS-technologies might and should become profitable as soon as the marginal price of one climate certificate respectively emitting one tonne of CO_2 would reach 60$ or even 90$.

Therefore: With an implemented GCCS there exists a clear and very hopeful perspective. Nearly all such CCS-inclined new and existing big scale processes up to the year 2050 would be CO_2-free or significantly reduced – thus leaving mankind and all economies enough space for a further economic growth without serious harm to the climate: Although increasing temperatures could not avoided (and the resulting weather determined damages) at least EU's climate temperature target could be achieved, thus 'producing' a tremendous amount of reduced damage, that can be – in principle – be expressed in monetary value! (Ref. to section XI.A.)

VIII.C. GCCS – induced world wide acceleration of the market entry of the renewable energy technologies and its enormous CO_2-reduction impacts

Above the illustrative 'Vattenfall zero CO_2 emitting coal power plant (CCS)' -case: Of course not only those technologies will be boosted. The GCCS as a global cap and trade

[92] The owners of those (power) plants would have to certify, that they have burnt the fuels CO_2-free (or – reduced). On that basis the FRPs are no longer forced to hold equivalent certificates for these sales to those plants.

scheme – with the same opportunity or marginal costs for CO_2-reduction all over the world – would of course be THE breakthrough for all – up to now – nearly profitable technology based on renewable energies. Instantly, even – as shown above – those CO_2-free technologies would get an extra boost up to the extent equivalent to the marginal price of CCs at the free CC-market. (Otherwise purchases of CCs would be necessary, respectively the allocated CCs could be sold for the marginal price.) And this indeed would imply the breakthrough of those technologies world wide – and not only like nowadays – getting their market breakthroughs mainly in some states by direct state subsidies either by the promotion of R&D or – even more important – by subsidies of the price of the produced current (by using renewable energies) fed into the electric grids.

Note: Biomass power plants could get an extra, an additional surplus-boost: In case biomass fuelled power plants would be installed with integrated CCS-technology, those power plant owners would get even CC-credits in line with the marginal market price at the CC-free market (up the US$ 30/60/90-maximum level): Their power plants definitely would reduce the CO_2 existing in the atmosphere. The biomass power plants did reduce the CO_2 in the atmosphere by photosynthesis and above that: The equivalent CO_2 released by fuel burning would be sequestrated and safely stored.

It has been already mentioned in a footnote: The future importance of renewable energies can be roughly estimated – although only till the year 2015 – by the results of the "International Conference for Renewable Energies, Bonn 2004". This conference 'ratified' an "International Actions Programme, IAP", containing "197 actions and commitments from governments, international organisations and stakeholders from civil society, the private sector and other stakeholder groups participating in the conference". In case this IAP would be completely implemented "the global CO_2 emission will be reduced progressively leading to an estimated CO_2 reduction of 1.2 billion tons/annum in 2015." (Renewables 2004, p.5)

It has to be mentioned that over the course of time – compared to the above quoted estimates for CCS till 2030 respectively 2050 – the potential of renewable energies should be considerably higher than in the quoted potential up to 2015. On the other hand: Those commitments (61% of 'the actions and commitments were put forward by governments) – of course – are not binding. Hopefully "many actions are financed by the leading actor itself; 31% by governments and 6% by international organisations, whereas 14% are financed by the private sector or are market driven." The investment costs of all those actions and commitments of the IAP "corresponds to investments on the level of USD 326 billion". (Renewables 2004, p.5)

Therefore there exists only a very limited extent of the 'market driven' actions for an increased implementation of renewable energies. That's why the author is a bit sceptical about the realistic amount of really implemented future investment in renewable energies in the above quoted 300 billion range. Based on an not yet 'official' IEA publication (see the quotation at the end of this sub-section) the author is sure that the global incentives (of USD 30, 60 or 90 for each avoided tonne of CO_2 emission) by a global Cap and Trade Scheme like the GCCS would have a much greater permanent positive impact for the market breakthrough of the renewable energies than all the described "actions and commitments" of well-minded, climate protection committed "governments, international organisations, local and regional government, non-governmental organisations, research institutions and the private sector" at the Renewable 2004 – Conference (p.5).

Irrespective of this scepticism: The above mentioned level of the CO_2-reducing effect and the amount of important investments in renewable energies provides important information about the (presumably much higher) potential and the climate mitigation importance of renewable energies. That potential and even much more up to 2030 or 2050 really should be realized by the necessary economic incentives – put forward by a global cap and trade scheme like the GCCS!

IEA specialists (Unander, Mattson and Gielen, 2005, p2, p.13) confirm:

- "CO_2 prices can swamp the impact of all existing support policies,
- CO_2 permit price at 50$/t can drive the renewable share above 50% … in Global Electricity Generation." (*Underlining by the author*)

Remember: Production of electricity counts for around 30% of all CO_2-emissions (IEA 2005, p15). In case the renewable energies would come close to a 50% share (as just quoted) this would a tremendous global CO_2-reduction impact.

Considering additionally the above mentioned fact, that with permit prices of 30 up to 90 US$ per ton of CO_2 respectively per Climate Certificate within the GCCS the CO_2-Capture and Storage would become highly profitable too, one can expect that such CC-prices in fact

would lead into an acceptable future as far as dangerous climate is concerned. (Refer to the GCCS PLUS projection, described in sub-section VIII.E.2)

VIII.D. GCCS: A long term stimulation of climate friendly technological changes and consuming pattern and of increased energy efficiency: The building, transport and household sector

Other main sources of anthropogenic CO_2-emissions (other than big scale CCS inclined stationary processes) are positively affected by the GCCS too: Emissions of individual and public transport (cars, trucks, buses, trains, air-planes), housing (residential and commercial building stock), electric and non-electric appliances, heating and cooling. The above described mechanisms (section VII.F.) by Porter and van der Linde (1995) and Goulder (2004) are 'doing their job at hand' for the reducing of those emissions as well.

The first glance presumption should have an enormous impact: On one hand there exists on average nearly constantly increasing fossil fuel prices in the course of the last 35 years (an extraordinary increase in the first 10 months of 2005, which many spectators believe to be a long lasting substantial price and cost increases compared to the price level in the beginning years of this century). In case the GCCS would be implemented additional CC-costs on fossil fuels would occur (whatsoever overall- or marginal cost-driven, ref. VI.C. and VI.D.). This will give (by way of higher prices of energy or energy services, ref. Goulder 2004, p.3) substantial additional incentives for energy saving (or switching to less CO_2-emitting or CO_2-free energy production or fuels), higher energy efficiency, changes in consumer behaviours and products (i.e. cars and appliances) and production patterns. This in the middle and long range will lead – significantly demand driven – to higher efficient and less CO_2-emitting processes, products, means of transportation, appliances, better insulated buildings and so on.

The additional implementation of the GCCS would imply a world wide push: The climate friendly technological change and change of behaviours and demands – substantially already ongoing in some states with higher fossil fuels taxation and other (partly socio-economic) stimuli since many years would be transferred all over the world – by way of a global cap and trade scheme like the GCCS. Even those countries that are – up to now – non or only little interested in mitigating measures of climate change will become increasingly interested because all nations and producers and consumers will directly profit from a less CO_2-emitting style of life and production – based on the new incentive framework setting of the GCCS.

And these 'GCCS-born' (additional) market-, price- and profit–induced incentives will – as demonstrated by the above sketched very probable breakthrough in the CCS-process by Vattenfall – stimulate the market actors to significantly increased efforts in order to satisfy the increased more end-consumer oriented demand for low CO_2-emitting cars, appliances and so on. Therefore much higher chances for major climate friendly technological changes or breakthroughs or – also very important – gradual and constant efficiency increases in the described sectors are very likely! And – in the long range – the consumer behaviour will more or less quickly and more or less effective be 'directed' by price signals to a much more climate friendly way of life.

There might be – in the long future range – similar breakthroughs (like renewable energies and CCS-technology) on the consumer side of CO_2 emissions by the implementation of hydrogen and fuel cells technology. But such a forecast – according to IEA's very reluctant publications to those matters – can't be as precise as for the CCS-technologies, mainly because of still existing enormous technological problems and enormous supply chain – side provisions. And above that – IEA gives a very long term prognosis:

"The expectation is that in some decades from now fuel cells and CO_2-free hydrogen produced from fossil, renewable and nuclear energy source, will be entering the power generation market as well as the transport and residential sectors, thus playing a significant role in reduction emissions and enhancing global energy security" (IEA 2004b, p11)). The time frame in fact is a very long one, as IEA's Energy Technology and R&D Office Director reveals: "transition to hydrogen: next 2 – 3 decades, fully developed market: further 2 – 3 decades" (Hirst/IEA 2005, p7)

The reason for such a long term perspective lies – referring only to the hydrogen sector – in

"a variety of critical issues … to be resolved before hydrogen can take its place in the commercial pantheon of energy carriers. These include the hurdles in bringing down production cost, the challenge of building and paying for a global hydrogen infrastructure system (including transport, stor-

age and final distribution), and in development of end-use markets. In addition, one of the primary attributes of a hydrogen economy, its anticipated value in reducing CO_2 emissions from power sector, needs to be evaluated." (IEA/SLT 2003, p5)

Therefore it seems evident that the above described incentives of GCCS for an induced decline of CO_2-emissions in the non-big scale industrial sectors will have a much greater impact: 'Conventional' CO_2-efficiency improving of products, means of transportation, appliances, better insulated buildings as well as changed life styles and consumers' behaviour will be – at least in the first half of the 21st century – of much greater and very substantial importance than the implementation of the hydrogen market and the resulting changes of consuming and production patterns. The Commission of the European Communities (CEC 2005, p8) underlines this expectation by the following statement:

"It is also important to continue to increase energy efficiency. Estimates show that in the EU-15 it would be economically feasible to realize energy savings of up to 15% over the coming decade, while a technical potential of up to 40% exists."

There exists a high probability, that the "GCCS costs of non energy saving" of up to US$30, 60 or 90 per ton of CO_2 (starting in 2015/25/35), would in fact induce those quoted energy saving potentials within and outside of the European Union.

According to Socolow (2005) a price for CO_2-emissions "in the neighbourhood of $100t/C (equiv. to around 30$ per ton of CO_2, suppl. by the author) can enable commercialization of most of the wedges." Those 15 so called "stabilization wedges" in the areas of

- Energy efficiency and conservation,
- Fuel shift,
- CO_2-capture and storage,
- Nuclear fission,
- Renewable electricity and fuels and
- Forests and agricultural soils

have the potential of a cumulative total of around 100GtCO_2 of reduced emissions over 50 years. (Pacala/Socolow p.968seq.)

As shown above: The author of this report is – based on IEA-findings – pretty sure that CCS-technology plus renewable energy systems will do the necessary job for stopping yearly increased global emissions (and later substantial decreases) to a great extent. As described in this section GCCS and the resultant prices for CO_2-emissions will launch and enlarge the very important "stabilization wedges" in the field of energy efficiency and conservation.

VIII.E. Reaching EU's climate targets: The still achievable GCCS-induced climate change acceptable future

At first glance an objective spectator must have the impression, that it will completely unrealistic to reach a CO_2/GHG level of global emissions in order to achieve EU's temperature target: The very likely reference scenario (IEA projection 'forecast' (steep 'thick' line) in the following Figure 6) shows an enormous increase of the global CO_2 emissions in the first three decades of the 21st century up to the year 2030 of 38 billion tonnes of CO_2. This is an increase of plus 90% compared to the year 1990. This is equivalent to a tendency for directly heading towards a 750ppm concentration (ref. to Figure 1 in section II.D.).

But: Based on the above quoted new IEA-findings (IEA 2005, Unander, Mattson and Gielen, 2005)[93] there seems to exist a pretty good technological chance to realize a global development, that formerly had to been taken as not achievable during the "GCCS-modelling-phase" in 2003 and 2004 (Wicke 2005, p.7seq., 116seq.) Formerly, based on the results of IEA's 'beyond alternative policy scenario' (IEA 2004, p.411seq.), it seemed, that the only achievable but nevertheless very ambitious target would be to reach the 550 ppm IPCC-stabilization curve. According to the World Energy Outlook the quoted enormous increases of CO_2 of up to 38 billion tons could only curbed down to a minimum of 30 billion tons. (IEA 2004, p.413). Now, according to the new IEA-findings quoted above there indeed exists at least a technological possibility to limit and – later – reduce CO_2 emissions to 450 ppm CO_2 in order to achieve or at least to come very close to EU's temperature target.

[93] Ref. to the IEA modelling results in VIII.A. to VIII.C., summarized in no.9 and 10 in section VIII.F.

Now it is “only” a political task to come to an unanimous decision in the “Conference of the Parties” to install a Beyond Kyoto Scheme. Such a scheme like the GCCS must massively induce the global market break through and the global installation of renewable and CCS-technologies (at all CCS-inclined processes, hopefully even by a CCS-retrofitting of existing plants) and massively inducing globally much more climate friendly consumption and production patterns. The probability and the hardship and a possible strategy to install such a structural evolution of the Kyoto Protocol system beyond 2012 will be discussed in section XII.C..

VIII.E.1. The GCCS – strategy to achieve EU’s ‘original’ concentration target of 550ppm CO_2

In June 1996, the European Council has translated the ultimate objective of UNFCCC-Article 2 into a measurable and verifiable target as follows:

“… the Council believes that global average temperatures should not exceed 2 degrees above pre-industrial level and that therefore concentration levels lower than 550 ppm CO_2 should guide global limitation and reduction efforts …” (European community 1996)

In Figure 6 it is shown how the global emissions should be developed, given the start of the GCCS in 2013 or 2015, in order the reach the quoted 550 ppm minimum level:

From 2015 up to the year 2070 there should be a cap of 30 billion tonnes of CO_2 respectively in the GCCS by a cap of 30 billion CCs. Later – at around 2070 there should be a slight decrease in emissions according to the IPCC stabilization line for a 550 ppm level (of course according to the than newest scientific IPCC-findings).

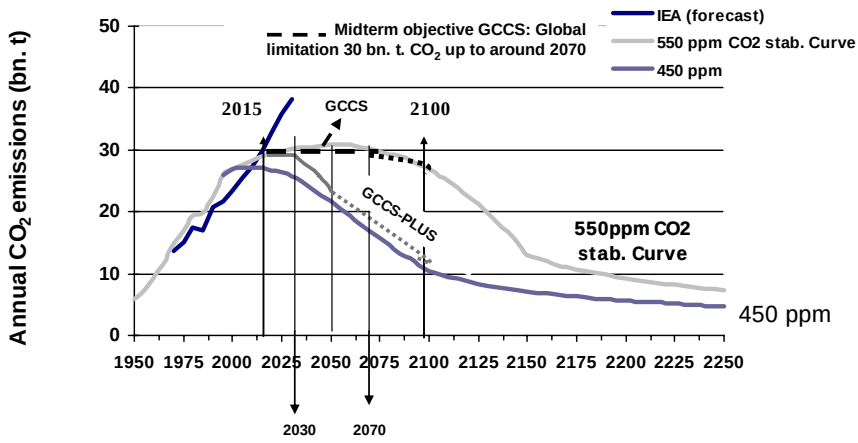
- Such a capping, which starts above the 2013/2015 level of global emissions (no CC-scarcity in the beginning), would imply a later significant scarcity of CCs because it “caps” CO_2-emissions “against” a business as usual development of a yearly average growth of 1.7% (IEA 2004, p75). This would consequently trigger the whole GCCS ‘cap and trade’ mechanisms described at length in this report and especially in this chapter VIII.
- By way of CCs marginal prices of US$ 30, 60, 90 in 2015, 2025 and 2035 the necessary climate friendly changes in production and consumptions (described in sections VIII.A. to VIII.D.) would be boosted, thus securing the above mentioned emission caps.
- Given the enormous potential of relatively inexpensive CCS- and some renewable technologies (according to Vattenfall (2005), IEA (2005) p.19 and Unander, Mattson and Gielen (2005), p.13) with prices between € 20 and US$ 25 to 50) and a lot of CO_2-reducing potential world wide induced by CC-related price increases, it seems very likely that the 30 billion emission (CC) cap will be realized over many years without (permanently and at most times) reaching the quoted price cap of the CCs at the free CC-market.

The GCCS therefore would imply that the potential of global CO_2 reductions would not be completely realized by the GCCS and that the GCCS would ‘only’ realize the second (minimum) target of the EU of 550 ppm CO_2.

VIII.E.2. The GCCS PLUS = “Kyoto PLUS” – strategy: Achieving EU’s ‘temperature target’ - global maximum increase of 2°C till 2100

According to the Commission of the European Community, which refers to a compilation of more recent studies estimating climate sensitivity (Hare/Meinshausen 2004), “…limiting the temperature rise to 2°C will very probably require greenhouse gas concentrations to be stabilized at a level even lower that 550 ppm $CO_{2eq.}$.” (CEC 2005b, p.5) This consequently would imply to reach at least the 450 ppm CO_2-stabilization curve of the IPCC shown in Figure 1 and in Figure 6.

Figure 6: „GCCS PLUS“ versus „GCCS“- targets : Reaching EU's temperature and EU's (minimum) concentration target:



Sources for Figure 6 (see also the footnotes to Figure 1

a)550ppm CO_2 path as a target: PowerPoint presentation by the World Resources Institute (http://powerpoints.wri.org/climate.ppt) according to IPCC 1995 a, p.10, and 1995 b

b)Energy-related CO_2 emissions: IEA 2002 a– International Energy Agency: World Energy Outlook 2002, p. 73 and p. 413. and IEA 2004

Because of the above mentioned findings of the IEA about huge, relatively inexpensive CO_2-reduction potentials, the GCCS can be further developed to the GCCS PLUS scheme with the target of (nearly reaching) IPCC's 450 ppm CO_2-stabilization curve. This can be called “Kyoto PLUS”. Such a ‘structural evolution” of the Kyoto Protocol (ref. III.C.) in fact could realize the “ultimate objective” of the Kyoto Protocol and the international climate change policy “to prevent dangerous anthropogenic interference with the climate system” (art.2 UNFCCC) to the above mentioned extent in line with EU's actualized ‘indicative’ 2°C target. (In fact the Commission of the European Community deliberately “does not mention a concrete emission target” beyond the above quoted “required greenhouse gas concentrations … for limiting the temperature rise to 2°C…”. CEC 2005b, p.5)

This GCCS PLUS–target would be realized by exactly the same GCCS-mechanisms as described above (and in sec. III.B. and following) but with a much ‘tighter’ cap as shown in Figure 6:

- Starting 2015 up to 2030 GCCC and GCCS PLUS would have the same CO_2- and Climate Certificate- Cap of 30 billion tonnes resp. CCs.
- In the twenty years between 2030 and 2050 the global cap would be reduced in yearly intervals of 0.35 billion tonnes of CO_2 respectively of CCs. This would be in line with IEA's projection about the accelerated global introduction of the CCS technology and renewable energies (IEA 2005 p.19 with prices between US$ 25 to 50, ref. to sub-sections VIII.B. and

VIII.C.) thus opening the option to reduce the global emissions up to the year 2050 down to the 2000 level of 23 billion tonnes of CO_2.

- Between 2050 and 2100 – according to IPCCs 450 ppm CO_2 stabilization line shown in Figure 6 – the global cap would be further decreased in yearly steps of around 0.25 billion tonnes, down to a level of 10 billion tonnes in 2100.

All those described reduction steps – of course – have got to be adjusted to the latest scientific (IPCC) knowledge.

By realizing those tighter (GCCS PLUS) caps, the economic consequence would be a – on average – a slightly higher marginal price for CCs and therefore for CO_2-emissions or for CC sales, thus inducing a higher level of CO_2-reduction according to the above and in Figure 6 described global caps.

And one has to consider too, that the reduction of the global cap to 23 billion tonnes of CO_2 by 2050 also implies, that the global average per head emissions should not exceed 3.8 tonnes. Only to this extent the World Climate Certificate Bank than yearly would allocate cost free climate certificates in 2050. Whereas between 2015 und 2030 every country would get 4.9 CCs or 4.9 tonnes per head, this amount would be decreased in 20 yearly steps by around 60 kg of CO_2. At first glance this would bring some difficulties for the GCCS PLUS acceptance because it would reduce the number of developing countries being below this average per head emission. On the other hand: The global accelerated introduction of the CCS-technology and of energy production by renewables would globally reduce CO_2-emissions to a great extent. Therefore it will be much easier for most countries to stay below or to come close to the mentioned new cap.

The conceivable starting of international talks about a structural evolution of the Kyoto Protocol by a global cap and trade scheme would start with the GCCS for the period till 2030. In the light of the experiences with the GCCS and the than newest scientific findings about climate change it would be up to future international decisions between after 2025 to decide whether to switch to GCCS PLUS after 2030 or stick to the GCCS.

VIII.F. 'GCCS-basics' for the macroeconomic model analysis

The most important, economically relevant, GCCS-related conditions[94] to be considered as constraints, price-fixing mechanisms and earmarking targets in a dynamic model analysis are enumerated below:

1. Constant global emissions of 30 billion tonnes of CO_2 (= 30 billion CCs) from 2015 on.
2. Via WCCB: Inter-governmental CC transfer price beginning at US$2, increasing to US$5, US$10, US$20 at 10-year intervals.
3. (Relatively) cheap basic supply of FRPs (minimum US$2 per CC up to an allocation price according to the free CC-price) in industrialized nations through transfer market transactions and CC allocation, initially (almost) demand-covering and subsequently declining.
4. Explicitly enabled increase in emission growth from CCs allocated at no cost to developing countries (DCs), the allocation to DC's FRPs ranging from zero cost up to an allocation price according to the free CC-price)
5. Transfer revenues of developing countries from surplus CC re-transfer (and a strictly limited CC-selling at the free market by the NCCBs of developing countries) available for (hopefully climate-friendly) national plans for sustainable development, adaptation to the adverse effects of climate change and elimination of poverty.
6. Free CC market for additional CC demand and excess CC supply of FRPs with a trend towards increasingly tight markets and rising CC prices.
7. Price cap on the free CC market initially (2013 or 2015) at US$30 per CC, rising to US$60 and US$90 in ten-year intervals.
8. Once the price cap intervention price is exceeded: additional CC supply by the WCCB until the price cap is ensured. When necessary, buying back of CCs (and other climate-stabilizing uses of the revenues from the sale of additional CCs).

[94] Ref. to Wicke 2005, p298seq with two supplements, described in this report in III.B. (5th GCCS-element) and in VI.D.4.a. respectively in VI.D.4.c..

9. The following findings of the IEA (2005) and others (Vattenfall 2005), (described in sub-sections VIII.B. and C.) will be taken into account in the following macroeconomic cost impact analysis as well:
   - Pretty low cost measures for capturing and securely storing of CO_2 (50 to 100 resp. 25 to 50 US$ in the years 2015 respectively in 2030 and following or even € 20 per tonne of CO_2, already between 2015 and 2020[95]
   - Similar costs for renewables are indirectly, but nevertheless clearly confirmed by IEA's specialists (by the prediction of renewables' global 'market breakthrough')[96].
   - For the aspect of clarity these findings are 'translated' in "backstop" technologies with costs of
     - 35$ per tonne of CO_2-reduction 2015 to 2030 and of
     - 25$ per tonne of CO_2 for the years after 2030.
10. The alternative respectively the 'supplementary' GCCS PLUS scheme (sub-section VIII.E.2.) is based on very realistic CO_2-reduction chances by GCCS-induced globally accelerated introduction and use of CCS- and renewable technologies and induced technological and changed consumption patters in the household sector. This - according to IEA (2005) would allow to come back in the year 2050 to the global CO_2-emissions level of the year 2000 (around 23 billion tonnes - quoted and described in section VIII.A. of this study).

[95] These findings are confirmed not only by Vattenfall but also by IEA (WEO 2004, p. 412):"The use of (captured) CO_2 in enhanced oil- and gas-recovery techniques could in certain situations offset part of the capture cost. Some optimistic estimates put the net cost of CCS only one cent per kWh," being equivalent to around 25US$ per ton of CO_2.

[96] Unander, Mattson and Gielen, (2005, p.13) confirm: "CO_2 prices can swamp the impact of all existing support policies,CO_2 permit price at 50$/t can drive the renewable share above 50% … in global electricity generation."

IX. Macro-economic Cost Impacts Analysis of the GCCS and GCCS PLUS (Prof. Dr. Christoph Böhringer)

IX.A. Introduction to the macro-economic impact analysis

The key elements of the GCCS laid out by Wicke in chapter III and in preceding subsection VIII.F. are driven by considerations on long-term requirements of climate protection, global cost-effectiveness, and fundamental equity rules (Wicke 2005).

Note: The author Wicke has supplemented the text of Christoph Böhringer by some explanations that refer to the text of the other parts of this report. These explanations are shown shadowed.

The exogenous prescription of global emission caps reflects recommendations by the IPCC to achieve the UNFCCC's stated goal of stabilizing "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC 1992, Article 2) and specified by a political decision of the European Union[97]: Owing to the large uncertainties on the benefits from greenhouse gas abatement (see Tol 2002), the GCCS emission caps and the frequently quoted EU-targets are not the outcome of a comprehensive cost-benefit analysis but based on recommendations from natural science on tolerable emission levels. The deliberate neglect of benefits from global warming implies that imposition of the GCCS on the global economy will necessarily lead to positive *global* adjustment costs as compared to a unconstrained business-as-usual situation.[98] It is thus important to keep in mind that positive cost impacts of GCCS do not provide an argument against its desirability from a more comprehensive economic perspective (i.e. including the benefits from avoided climate change, an expression of those benefits in estimated monetary value is presented in sub-section XI.A.2). In the current context, the cost impacts should be rather interpreted as the money to be spent for buying a target level of climate change insurance with the specific GCCS strategy.

In section XI.A.1. the target of GCCS and GCCS PLUS will be described as follows: GCCS and GCCS PLUS "merely" have got the "very simple" intention to realize the ultimate objective of UNFCCC-Article 2 to avoid "dangerous interference with the climate system", irrespective of any 'objective' benefit/cost calculation – as defined in that article. It still seems very ambitious and highly appreciable to realize these two targets, especially because there is a clear tendency towards a 750ppm CO_2-concentration (ref. to II.B. and Figure 1 in II.D.)

With respect to cost-effectiveness in meeting the global emission caps, the GCCS postulates global trade in CO_2 emission entitlements. International emissions trading will reduce the global costs of emission abatement to the extent that it exploits differences in marginal abatement costs across regions: Emission reductions should take place *where* it is cheapest to do so, regardless of the geographical location. Obviously, a comprehensive cost - effectiveness approach to greenhouse gas concentration stabilization or temperature targets would not only involve "where"-flexibility, but also "when", and "what"-flexibility. "When"-flexibility allows for intertemporal borrowing and banking, whereas "what"-flexibility allows to take decisions on *what* greenhouse gas should be abated under cost-effectiveness considerations. For pragmatic reasons, the current specification of the GCCS neglects aspects of

[97] In June 1996, the European Council has translated the ultimate objective of UNFCCC-Article 2 into a measurable and verifiable target as follows:"… the Council believes that global average temperatures should not exceed 2 degrees above pre-industrial level and that therefore concentration levels lower than 550 ppm CO_2 should guide global limitation and reduction efforts …" (European community 1996) This EU target has been reiterated by the following: According to the Commission of the European Community, which refers to a compilation of more recent studies estimating climate sensitivity (Hare/Meinshausen 2004), "…limiting the temperature rise to 2°C will very probably require greenhouse gas concentrations to be stabilized at a level even lower that 550 ppm $CO_{2eq.}$." (CEC 2005b, p.5) This consequently would imply to reach the 450 ppm CO_2-stabilization curve of the IPCC. That is why GCCS PLUS is striving for that concentration.

[98] In theory, the incorporation of existing market imperfections might lead to economic gains due to emission constraints even when abstracting from direct benefits of avoided greenhouse gas emissions.

"what"- and "when"-flexibility to a great extent suggesting that there is further potential to cut down global adjustment costs to the achieved stabilization and temperature outcomes.[99]

Given the public good character of the global atmosphere and the inherent free-riding incentives together with the lack of a supranational authority, greenhouse gas reduction cannot be achieved without international cooperation to be codified in a long-term international policy agreement. Reaching such an agreement is, however, crucially dependent on solving the fundamental issue of burden sharing: How shall abatement duties – or likewise emission entitlements – be allocated across countries? This issue has already dominated the negotiations under the Kyoto Protocol and proved extremely difficult to cope with – even though the short-term Kyoto abatement targets are very moderate in comparison with the long-term emission reduction requirements under GCCS. The GCCS addresses the crucial aspect of political feasibility in first place by the choice of a (necessarily normative) allocation-based burden sharing scheme which builds on the egalitarianism principle. The implied equal-per-capita allocation corresponds to the justice principle of "equality of resources", suggesting that all human beings should be entitled to an equal share of the atmospheric resource. It is the fair division criteria most often cited in the literature (see, e.g., Bertram 1992, Kverndokk 1995). Many developing countries have emphasized that acceptance of any emission constraint can be expected only if emission rights are allocated on an equal-per-capita basis (Rose et al. 1998). From the perspective of the industrialized countries, however, equal-per-capita entitlements would imply a tremendous deviation from current emission patterns (in other words and formulated somehow more precisely – from the current cost free emission patterns, but with the possibility of keeping the emissions by buying climate certificates from other countries) and – if applied on short notice – induce potentially large adjustment costs in industrialized countries with currently high per capita emissions. Therefore, the GCCS suggests some specific transfer schemes that could help to reduce the burden of an initial equal-per-capita allocation for industrialized countries.

It should be clearly noted that the GCCS constitutes a centrally imposed climate policy regime which presumes voluntary international cooperation of all countries. It thus neglects the huge free-riding incentives in the provision of climate protection as a global public good given the lack of a supranational authority: The rationale behind free-riding in climate policy is to save abatement costs while benefiting from abatement efforts of other countries. Although all countries could be better off if they behaved in a cooperative way, each country working only in its own best interest has an incentive to take a free-ride (leading to the well-known "tragedy of the commons"). For more specific considerations about the global public good problem and the GCCS refer to subsection XII.B.1.a.)

From a political economy perspective, the pessimistic view on the prospects effective and efficient voluntary international cooperation may be even worsened when accounting for the long-term nature of climate change and larger uncertainties on the benefits from greenhouse gas emission abatement: Major greenhouse gases, such as CO_2, are stock pollutants that remain in the atmosphere for several decades before they disappear due to the natural rate of decay. Short-term abatement efforts will then generate rather visible adjustment costs, but will only produce rather uncertain benefits in the very long-run – if voters are short-sighted, politicians may not have an incentive at all to undertake costly abatement. (These problems are dealt with intensively in section VII.B. – leading to the implementation of the resultant scientific advice of a so called 'hybrid system' into the here presented GCCS-Cap and Trade-Scheme.) Various critical assessments of the Kyoto negotiation process conclude that the fundamental incentive problems in climate policy have already played a major role in boiling down the environmental effectiveness of the Kyoto Protocol to rather symbolic policy (Böhringer 2002, Böhringer and Vogt 2003, 2004). It thus remains an open challenge as to how foster participation *in* and compliance *to* stringent long-term global greenhouse abatement activities that can not be resolved by central planner proposals like the GCCS. (refer to this problem XII.B.1.c. and XII.B.2.)

[99] In the underlying book (Wicke 2005, p.201seq.) it is shown, that GCCS should and con have an expansion of to all greenhouse gases. The 'when'-flexibility is partly integrated in GCCS PLUS by the first constant, later yearly decreasing global CO_2-cap. Refer to VIII.E.2.

Notwithstanding the appeal of the specific GCCS components, the prospects or feasibility of broader long-term political agreements in climate policies will ultimately depend on the implied (ex-post) economic implications in terms of the magnitude and distribution of adjustment costs across regions. Such a cost assessment can not be undertaken prima facie but require the use of numerical model techniques in order to assess systematically and rigorously the interference of the many forces that interact in the economy.

The impact assessment of the GCCS presented in this chapter is based on PACE-IAM (Böhringer et al. 2005), an integrated assessment model which combines economic aspects of climate policy with scientific knowledge of the dynamics of climate change.

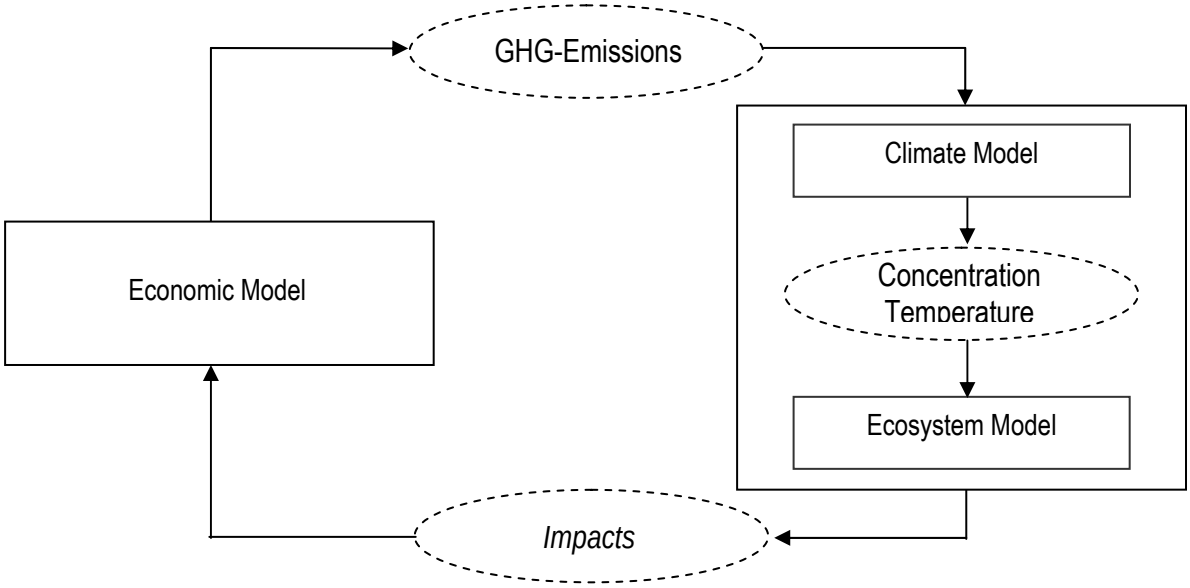
IX.B. Quantitative Framework for Impact Assessment: PACE-IAM

IX.B.1. Integrated Assessment

In order to quantify the economic implications as well as the climate impacts of policy proposals such as the GCCS one requires an integrated assessment model (IAMs) which incorporate key elements of economic and biophysical systems into one integrated system (Kelly and Kolstad 1999). As sketched in Figure 7 IAMs capture the causal chain how (i) economic activities trigger anthropogenic greenhouse gas emissions, (ii) emissions of greenhouse gases translate into atmospheric concentration, temperature shift, and climate change, and (iii) climate change feeds back via the ecosystem on the economy.

The integrated assessment model PACE-IAM (Böhringer et al. 2005) links a dynamic macroeconomic model with a simple geophysical module of climate change. The latter corresponds to the climate component of the RICE-99 model (Regional Integrated model of Climate and the Economy) (Nordhaus and Boyer 2000). It contains a number of geophysical relationships that link together the different forces affecting climate change. The economic module of the integrated assessment framework is formulated as a multi-sector, multi-region computable general equilibrium model of global trade and energy use. Due to the large uncertainties in damage estimates for climate change, the current version of PACE-IAM does not attempt to translate global warming into market impacts (such as productivitiy changes, capital depreciation) and non-market impacts (such as biodiversity losses, natural disasters) (Manne et al. 1995): There is only a one-way link between economic variables and biophysical variables.

Figure 7: Schematic structure of Integrated Assessment Models for climate change



IX.B.2. The Climate Sub-Module

Climate-change modeling is based on the geophysical module of the RICE-99 model. It contains a number of geophysical relationships that link together the different forces affecting climate change. The geophysical relations are simplified representations of more complex models and give a reduced form description of emissions, concentrations, and globally averaged temperature change. Economic activity leads to CO_2 emissions which affect climate through their radiative forcing. The accumulation and transportation of CO_2 emissions is modeled as a linear three-reservoir approach calibrated to existing carbon cycle models. The three reservoirs represent the atmosphere, a quickly mixing reservoir in the upper oceans together with the short-term biosphere, and the deep oceans. The accumulation of CO_2 emissions in the atmosphere leads to an increase in radiative forcing. This relationship is derived from large-scale climate models: The radiative forcing equation includes the forcings of other greenhouse gases (CH_4, N_2O, CFCs and ozone) and aerosols as an exogenous component. The climate-change equations link radiative forcing and climate change based on the three-box climate model representation. An increased radiative forcing warms the atmosphere with some time lag due to the thermal inertia of the different ocean layers.

In the RICE-99 environmental module only CO_2 is endogenously modeled. Other greenhouse gases and their radiative forcings are assumed to be exogenous. In PACE-IAM CH_4 as the most important non-CO2 greenhouse gas is endogenized in order to accommodate multi-gas analysis. The calibration of the extended environmental module is based on the MERGE climate module (Manne et al. 1994). Methane emissions result from different sources and are linked to economic activities in the economic model. These emissions build up a CH_4 stock. The increase in the stock of methane leads to an increase in the radiative forcing of methane. The latter is proportional to the logarithm of the ratio of the current to the initial level and takes into account the interaction effects of CH_4 and N_2O. The aggregate radiative forcing is again the sum of the radiative forcing for CO_2, CH_4, and the other exogenous forcings. The temperature equations remain unchanged.

IX.B.3. The Economic Sub-Module

The economic module of the integrated assessment framework is formulated as a multi-sector, multi-region computable general equilibrium model of global trade and energy use.

Emission abatement policies do not only cause direct adjustments on fossil fuel markets but produce indirect spillovers to other markets which in turn feed back to the economy. In a world that is increasingly integrated through trade, policy-induced adjustments of domestic production and consumption patterns will also influence international prices, i.e., the terms of trade, via changes in exports and imports. The changes in international prices, i.e. the terms of trade, imply secondary effects, which can significantly alter the impacts of the primary domestic policy. There are several studies illustrating the importance of such indirect effects (e.g. Böhringer 2002, Böhringer and Rutherford 2002, Böhringer and Welsch 2004/2005, or Babiker et al. 2004) already for relatively moderate greenhouse gas abatement policies such as the implementation of the Kyoto Protocol.

General equilibrium provides a comprehensive microeconomic-based framework for studying such price-dependent market interactions.[100] Furthermore, the simultaneous explanation of the origination and the spending of income of economic agents (here: regions) allows to address both, economy-wide efficiency as well as equity implications of policy intervention. Therefore, computable (or applied) general equilibrium models have become a central method for the assessment of the economy-wide impacts of emission policies on re-

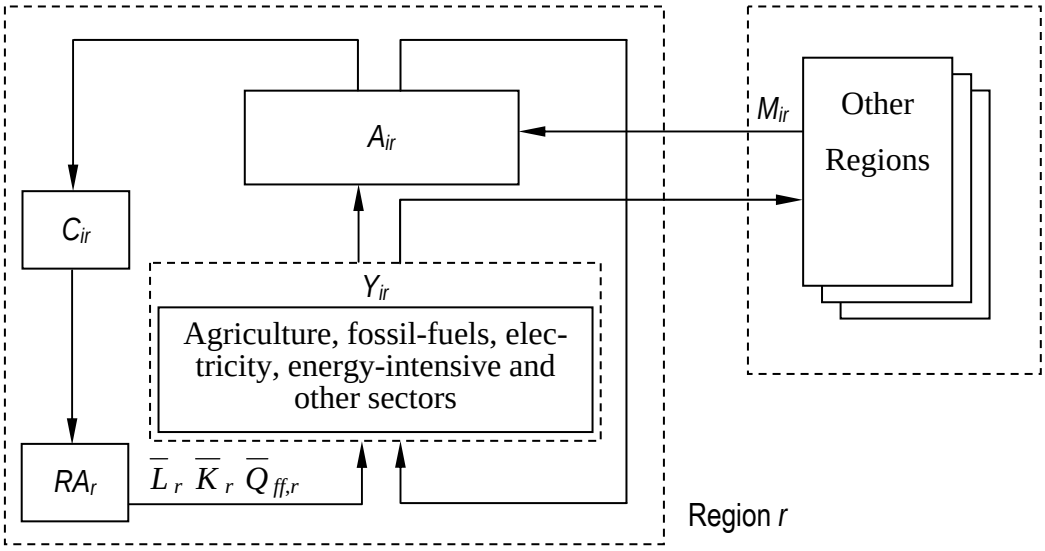
[100] Macroeconomic models mainly differ with respect to the emphasis placed on (i) econometric foundation of functional relationships, and (ii) the theoretical foundation of behavioral assumptions for economic agents. Referring to criterion (i), models can be classified as either econometrically estimated when driving equations are based on econometric techniques using mostly time-series data or as calibrated when parameters of functional forms are simply selected to fit a single empirical observation. Referring to criterion (ii), models may be distinguished between micro-/macro-founded approaches and simple accounting frameworks.

source allocation and the associated implications for incomes of economic agents (see, e.g., Weyant 1999).

Beyond the consistent representation of market interactions as well as income and expenditure flows, climate policy analysis calls for an explicit dynamic framework since climate change is an inherently dynamic problem and happens on larger time scales. To build dynamic features in the modeling of the economic behavior of households and firms requires an assumption on the degree of foresight of the economic agents. In a deterministic setting, the only consistent approach is to assume that agents in the model know as much about the future as the modeler: Agents have rational (intertemporal) expectations and consistently anticipate all current and future prices (Manne and Richels 1992). Figure VII-2 lays out the diagrammatic structure of the model's intra-period structure.

Primary factors of a region *r* include labor $\overline{\mathrm{L}}_{\mathrm{r}}$, capital K_{r}, and resources of fossil fuels $\overline{\mathrm{Q}}_{\mathrm{ff}}$ (*ff*∈{coal, gas, oil}). The specific resource used in the production of coal, gas, and oil results in upward sloping supply schedules consistent with exogenous fossil fuel supply elasticities.

Figure 8: Structure of the intra-period sub-module



Production Y_{ir} of commodities *i* in region *r*, other than primary fossil fuels, is captured by aggregate production functions which characterize technology through substitution possibilities between various inputs. Nested constant elasticity of substitution (CES) cost functions with several levels are employed to specify the KLEM substitution possibilities in domestic production sectors between capital (*K*), labor (*L*), energy (*E*), and non-energy intermediate inputs, i.e., material (*M*).

Final aggregate consumption demand C_r of the representative agent RA_r in each region is given as a CES composite which combines consumption of an energy aggregate with a non-energy consumption bundle. The substitution patterns within the non-energy consumption bundle as well as the energy aggregate are described by nested CES functions.

Non-energy goods used on the domestic market in intermediate and final demand correspond to a so-called Armington good (Armington 1969), i.e., a CES composite A_{ir} of the domestically produced variety and a CES import aggregate M_{ir} of the same variety from the other regions. Domestic production either enters the formation of the Armington good or is exported to satisfy the import demand of other regions. Fossil fuels are treated as homogenous goods across regions.

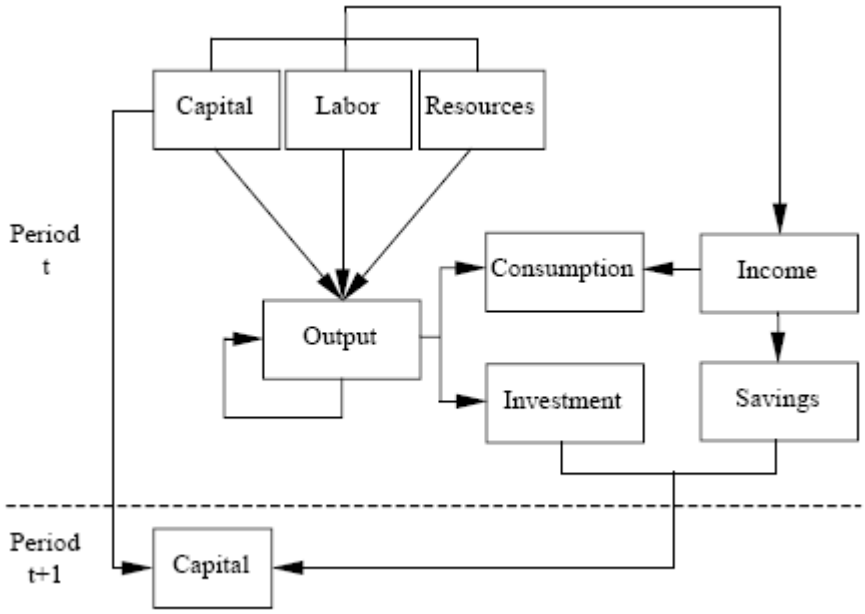
Endowments of labor and the specific resources are fixed exogenously. Within any time period, we assume competitive factor and commodity markets such that prices adjust to clear these markets. Carbon emissions are associated with fossil fuel demand in production and final consumption.

As to the dynamic model setting, the representative household in each region chooses to allocate lifetime income, i.e., the intertemporal budget, across consumption in different time periods in order to maximize lifetime utility. In each period, the agent faces the choice between current consumption and future consumption purchased via savings. Investment takes place as long as the marginal return on investment equals the marginal cost of capital formation. The rates of return are determined by a uniform and endogenous world interest rate such that the marginal productivity of a unit of investment and marginal utility of a unit of consumption is equalized within and across countries. Capital stocks evolve through constant geometric depreciation and new investment. Figure 9 sketches the basic dynamics of the economic module.

IX.B.4 Model Parameterization

In quantitative policy analysis, the effects of policy interference are measured with respect to a reference situation - usually termed business-as-usual (*BaU*) - where no policy changes apply. To perform numerical simulations, the concrete forms of the production functions (characterizing the technological options in production) and the utility functions (characterizing the consumption preferences of agents) must be specified.

Figure 9: Dynamic model settings



The procedure most commonly used in CGE analysis to select parameter values is known as calibration (see Mansur and Whalley 1984). Calibration of the free parameters of functional forms requires a consistent one year's data in prices and quantities (or a single observation represented as an average over a number of years), together with exogenous elasticities that are usually taken from literature surveys. The calibration is a deterministic procedure and does not allow for statistical test of the model specification.[101] Within the policy simulations, policy control parameters – such as carbon taxes or emission constraints – are assigned and a new (counterfactual) equilibrium is computed. Comparison of the counterfactual and the benchmark equilibrium then provides information on the policy-induced changes of economic variables such as employment, production, consumption, relative prices, etc.

For the base-year calibration, we employ the GTAP-6 database which provides detailed input-output tables as well as bilateral trade flows for up to 57 commodities and 87 regions for

[101] Large-scale CGE models have many functional parameters which must be specified with relatively few observations (as comprehensive time series are typically not available) This prevents the econometric estimation of the model parameters as an econometric system of simultaneous equations.

the year 2001 (McDougall et al. 2005). The elasticities underlying our numerical analysis are based mainly on econometric evidence as summarized, e.g., by Burniaux et al. (1992), Jomini et al. (1991) Sawyer and Sprinkle (1999), and Dimaranan et al. (2001).

In dynamic policy analysis, there is the need for additional information on the future *BaU* development. Apparently, the *BaU* projections are a crucial determinant for the overall magnitude of adjustment effects to policy interference. For example, exogenous policy constraints such as long-term stabilization or temperature targets will bind future economies the more, the higher the projected *BaU* growth in greenhouse gas emissions. Substantial differences in model-based analysis can often be traced back to different assumptions about the baseline development. Regarding long-term climate policy analysis, the issue of baseline projections becomes very critical in view of the tremendous uncertainties regarding BaU developments over several decades. Not only is there the question why one baseline should be preferable over another, but official projections based on expert analyses often stand out for large internal inconsistencies as the endogeneity of system relationships are not sufficiently incorporated.

Considering the regional resolution of the dynamic integrated assessment model, the most restrictive constraint comes from the availability of long-term baseline projections. PACE-IAM currently makes use of the WEC-IIASA database that includes projections for GDP, fossil fuel use and greenhouse gas emissions until 2100 for eleven geo-politically important world regions and six alternative long-term futures (IIASA 1998). A second constraint regarding both the regional as well as sectoral model resolution is related to computational robustness and the speed of the numerical solution process. In order to reduce the computational burden, the model dimensions for the current analysis have been aggregated to 4 world regions and seven sectors including primary and secondary energy sectors as well as an aggregate of carbon-(energy-) intensive industries**.** Table 10 **s**ummarizes the regional and sectoral aggregation of the model that is adopted for the impact assessment of the GCCS.

Table 10: Model dimensions

Production Sectors	**World Regions**
Energy	Europe (EUR): Western Europe without Germany, Central and Eastern Europe
Coal	Germany (GER)
Crude oil	Other industrialized regions (OOE): North America, Pacific OECD, Former Soviet Union
Natural gas	Latin America and the Caribbean (LAM)
Refined oil products	India (IND)
Electricity	China (CHN)
Non-Energy	Rest of the World (ROW): Africa, Middle East, Non-Industrialized Asia
Energy-intensive sectors	
Other manufactures and services	

Among the six possible futures till 2100 that are provided in the WEC-IIASA database, scenario A1 serves as the central case reference scenario. The A1 scenario builds on technological progress that permits greater exploitation of conventional and unconventional oil and natural gas resources, so they are phased out more slowly and their use is achieved without significant environmental or efficiency penalties (Jefferson 2000). Table 11 provides an overview of central indicators for the A1 reference scenario. Along the baseline the regional economies are calibrated to potential GDP growth rates as provided by the WEC_IIASA database; economic growth is driven by (Harrod-neutral) labor-augmenting technical change. Harmonization of GDP growth rates and emission projections is accommodated by an appropriate scaling of

baseline cost shares in the production of energy services.[102] The exogenous *BaU* emission trajectories determine to which extent the emission caps mandated by the GCCS translate into effective emission reduction obligations at the regional level.[103]

Table 11: Main characteristics of WEC-IIASA scenario A1 (IIASA 1998)

	Scenario A1
Carbon emissions (Gt CO_2)	38.5 (in 2030) ─ 42.5 (in 2050) ─ 50.6 (in 2100)
World economic growth (%/yr)	2.4
Environmental taxes	No
Carbon constraints	No

IX.C. Model Implementation of the GCCS Scenario

The main features of the *GCCS* due to Wicke 2005 (ref. also to sect. VIII.E.1. of this report) can be briefly summarized as follows: Global CO_2 emissions from fossil fuel use are limited to a cap of 30 Gt from 2015 until 2070, declining thereafter by 0.1 Gt per annum to reach a global cap of 27 Gt CO_2 in 2100. The concrete CO_2 ceiling is meant to be in line with the 550 ppmv stabilization of atmospheric CO_2 concentration that has been set out by the initial IPCC reports as a desirable long-term climate policy target (IPCC 2001) and was – in 1996 the 'concentration target' of the European Union, thought to be in line at those times with EU's temperature target of plus 2°C[104].. Under the *GCCS* proposal, the global cap is distributed across regions proportional to population (base year: 2000). In order to avoid larger transfers from industrialized to developing countries implicit to such an instant egalitarian emission (right) allocation rule, the *GCCS* foresees the re-transfer of excess emission rights (i.e. emission rights that are in excess of *BaU* emission demands) by developing countries to industrialized countries at an exogenously prescribed transfer price of 2$ per CC in the beginning of the system (see Chapter III). In addition, there is some safety valve which is adjusted over time in order to prevent CO_2 emission prices from exceeding certain thresholds. Such a safety valve may obviously imply a trade-off with environmental effectiveness. The time-dependent price cap starts in 2015 at a level of 30 $ per ton of CO_2, are raised to 60 $ per ton of CO_2 in 2025, and amounts to 90 $ per ton of CO_2 from 2035 onwards. (Because of relatively high safety valves, a large and permanent surpassing of the price cap in an environmental substantially negative manner is not very likely.) In addition, backstop technologies are assumed to be available at a price of 35 $ per ton of CO_2 between 2015 and 2030, and from 2030 onwards at a price of 25 $ per ton of CO_2.

A variant of the *GCCS* – thereafter referred to as *GCCS_PLUS* – prescribes an even more ambitious global reduction pathway to increase the climate effectiveness: In the scenario *GCCS_PLUS* the global CO_2 budget up to 2030 correspond to that of the *GCCS* scenario. Between 2030 and 2050 the cap is then linearly reduced by 0.35 Gt of CO_2 per annum

[102] Capital cost shares in the provision of energy services get inversely adjusted to energy cost shares, meaning that energy efficiency improvements are not costless but are linked to the increased use of capital.

[103] Beyond the baseline parameterization, additional determinants of adjustment costs may include the explicit representation of initial market imperfections (e.g. market power and labor market rigidities) and the scope of endogenous system responses (e.g. exogenous technological change vis-à-vis induced technological change). Due to the level of aggregation and the lack of data, it is hardly possible within the global PACE-IAM model to represent country-specific market imperfections. Likewise an appropriate treatment of induced technical change (with implicit externalities from knowledge spillovers) is constrained by a missing comprehensive theoretical underpinning and the lack of empirical data.

[104] "… the Council believes that global average temperatures should not exceed 2 degrees above pre-industrial level and that therefore concentration levels lower than 550 ppm CO_2 should guide global limitation and reduction efforts …" (European community 1996)

yielding a global limit of 23 Gt of CO_2 in 2050; from 2050 until the end of the century a further mandated decline of 0.25 Gt of CO_2 per annum yields a final cap of 10.5 Gt.[105]

The *GCCS* and *GCCS_PLUS* scenarios are characterized by exogenous global CO_2 ceilings where emission rights (Climate Certificates, CCs) (or likewise abatement duties) are distributed among all regions according to an explicit egalitarian allocation rule. Additional transfer mechanisms are designed to increase the overall political feasibility of such a climate policy architecture.

In order to illustrate the limited environmental effectiveness when only industrialized regions adopt emission constraints two further scenarios are specified. The scenario *Kyoto* presumes that all Annex B parties to the Kyoto Protocol (including the USA) maintain their Kyoto targets from 2012 onwards, whereas no emission constraints apply to developing countries. The scenario *Kyoto_Plus* assumes that Annex B parties stick to the Kyoto targets until 2020 and subsequently decrease these emission limits by 1 % per annum between 2020 and 2050 (keeping the limits constant thereafter).

All emission control scenarios allow for global “where”-flexibility, i.e. international emissions trading, in order to foster economic efficiency of regulation through the equalization of marginal abatement costs across space. Global “where”-flexibility implies a comprehensive future use of the so-called flexible instruments as provided by the Kyoto Protocol, i.e. cross-country emissions trading as well as project-based emissions trading (Joint Implementation or Clean Development Mechanism). The assumption of global “where”-flexibility also reflects the unambiguous opinion of climate policy experts that Post-Kyoto architectures of climate policy must be based on global emissions trading to reduce global economic adjustment costs and thus increase the potential for political feasibility (Böhringer and Löschel 2005).

For scenarios *Kyoto* and *Kyoto_Plus* global emissions trading implies that developing countries are endowed with their *BaU* emission levels throughout the time horizon. Table VII-2 summarizes the key features of the simulated climate policy scenarios. The availability of carbon backstop options at a price of 35 $ per ton of CO_2 between 2015 and 2030, and a price of 25 $ per ton of CO_2.from 2030 onwards holds throughout all scenarios.

[105] Apart from the difference in the imposed global emission limit, the *GCCS* scenario and the *GCCS_PLUS* scenario share the very same assumptions.

Table 12: Summary of scenarios

Scenario name	Characteristics
BaU	- Business-as-usual without binding climate policies (reference scenario A1 as of WEC-IIASA (IIASA 1998))
Kyoto	- Maintenance of Kyoto targets after 2012 by industrialized countries (Annex B) till the end of the model horizon (2100) - Developing countries are endowed with *BaU* emissions - Global “where”-flexibility - Carbon backstop options
Kyoto_Plus	- Maintenance of Kyoto targets till 2020 by industrialized countries (Annex B); decrease of Kyoto limits between 2020 and 2050 by 1 % per annum; maintenance of the emission limits in 2050 till the end of the model horizon (2100) - Developing countries are endowed with *BaU* emissions - Global “where”-flexibility - Carbon backstop options
GCCS	- Global emission cap at 30 Gt of CO_2 between 2015 and 2070; mandated decline of 0.1 Gt per annum from 2070 onwards to reach a global cap of 27 Gt CO_2 in 2100 - Emission allocation across all regions based on egalitarian principle with re-transfer of excess emission rights by developing countries (emission rights in excess of *BaU* demand) - Safety valve - Global “where”-flexibility - Carbon backstop options
GCCS_Plus	- Same as *GCCS* apart from prescribed global emission ceiling: between 2015 and 2030 global emission cap at 30 Gt of CO_2; between 2030 and 2050 linear reduction by 0.35 Gt of CO_2 per annum yielding a global limit of 23 Gt of CO_2 in 2050; between 2050 and 2100 linear reduction by 0.25 Gt of CO_2 per annum yielding a final cap of 10.5 Gt of CO_2.

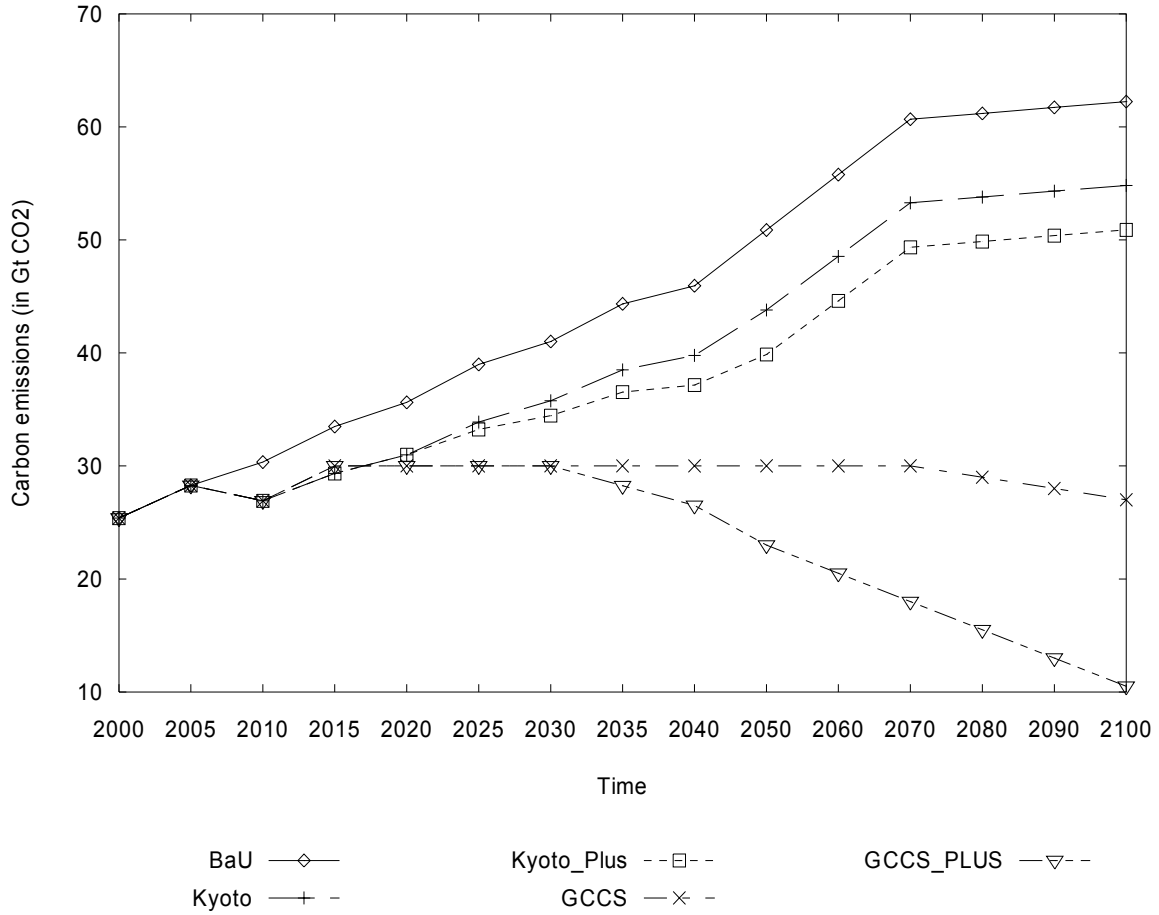
IX.D. Simulation Results

Figure 10 to Figure 14 visualize the climatic and economic implications of the alternative Post-Kyoto policy regimes as laid out in Table 12. Regarding the graphical exposition of results it should be noted that scaling of 5-year intervals between 2000 and 2040 is the same as for 10-year intervals from 2040 onwards.

Figure 10 depicts the carbon dioxide trajectories across the different scenarios. It becomes clear that neither maintenance nor further tightening of the initial Kyoto targets by

industrialized countries *only* can prevent a drastic increase of global carbon CO_2 emissions vis-à-vis current emission levels.

Figure 10: CO_2 emissions (Gt of CO_2)



The reason is that emission limits to industrialized countries are more than offset by the substantial increases of projected *BaU* emissions in the developing world. In contrary, scenarios *GCCS* and *GCCS_PLUS* impose stringent emission caps at the global level from 2015 onwards: Global CO_2 emissions in 2100 under *GCCS* are cut by more than half in 2100 as compared to the *BaU* emission level; under *GCCS_PLUS* the mandated emission decline at the end of the century amounts to more than 80 % vis-à-vis the business-as-usual.

Figure 11and Figure 12 translate the carbon dioxide trajectories for the different scenarios into concentration and temperature change through the climate sub-module of the integrated assessment model. Whereas *Kyoto* and *Kyoto_Plus* fail by far to achieve CO_2 concentrations below 550 ppmv at the end of the century, the *GCCS* strategy brings down concentrations to roughly 500 ppmv by 2100. (But the concentration is still growing – and therefore according to IPCC-stabilization lines – reaching a 550 ppm concentration in later years, ref to Figure 1 in section II.B.. Under *GCCS_PLUS* concentration levels are stabilized around 450 ppmv. The differences in the emission trajectories over time explain the deviations in global temperature increase across the scenarios. *Kyoto* and *Kyoto_Plus* effect a rather moderate reduction in temperature increase vis-à-vis the *BaU*. The reductions in temperature increase are much more pronounced for scenarios *GCCS* and *GCCS_PLUS*. In the GCCS case the temperature rises up to around 2.6° by 2100, but the temperature increase has a slope, which indicates that the temperature rise will go further on (presumably into the range of plus 3°Celsius. In the GCCS_PLUS scenario, the temperature increase at the end of the century amounts to 2.35 °Celsius which is roughly one degree Celsius lower than for *BaU* and it seems that the increase has come to a stop, respectively to a stabilization at that level.

Marginal abatement costs are sketched in Figure 13. For scenarios *Kyoto* and *Kyoto_Plus* CO_2 values remain below 25 $US per ton of CO_2 despite of the substantial missing reduction targets by the industrialized world (in particular for the scenario *Kyoto_Plus*). The reasoning behind is that larger low-cost mitigation options by developing countries (endowed with their *BaU* emissions) can be exploited via comprehensive global emissions trading. Under scenarios *GCCS* and *GCCS_PLUS* the CO_2 values increase sharply 2020 onwards reflecting the stringency of the global cap vis-à-vis the *BaU* emissions. It hits the backstop price in 2040 for *GCCS* and in 2035 for the more stringent *GCCS_PLUS*. The exogenous safety valve does not become binding for both scenarios, i.e. *GCCS* as well as *GCCS_PLUS*.

The evolution of marginal abatement costs coupled with the activity level of backstop options is a major determinant of the inframarginal adjustment costs reported in Figure 14 as percentage change in GDP compared to the *BaU*. GDP losses under the environmentally less effective scenarios *Kyoto* and *Kyoto_Plus* hardly exceed 0.5 % per annum whereas they are substantially higher under the more restrictive scenarios *GCCS* and *GCCS_PLUS*.

Figure 11: CO_2 concentrations (in ppmv)

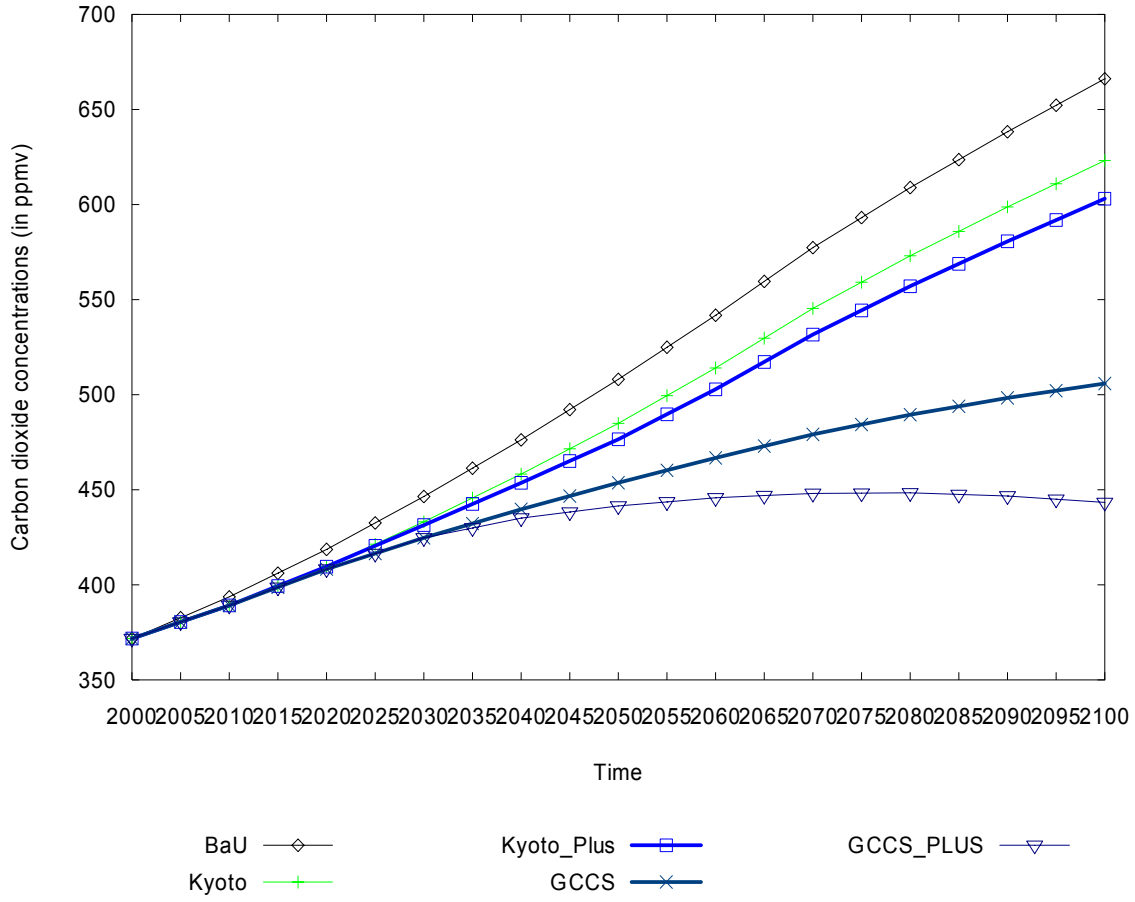


Figure 12: Global mean temperature (in °C compared to the pre-industrial level)

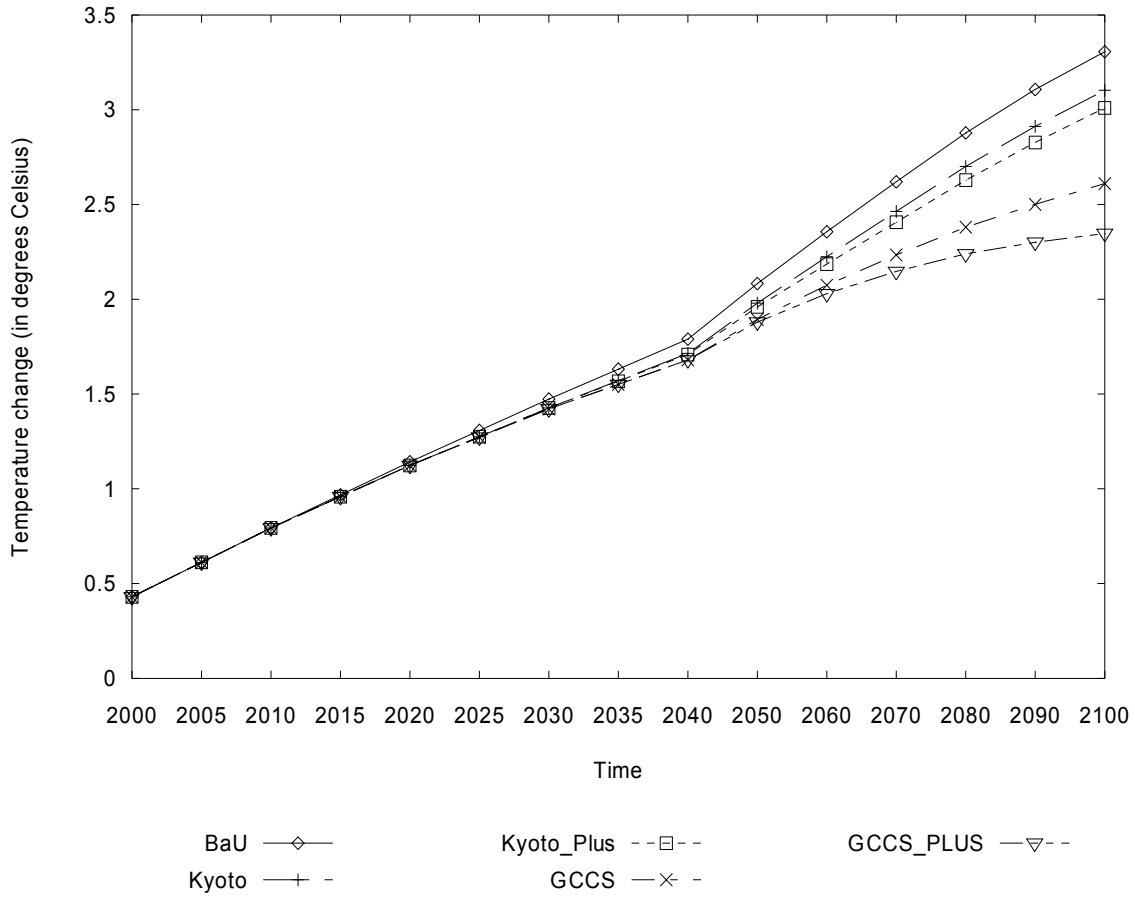


Figure 13: CO_2 Value (in $US per ton of CO_2)

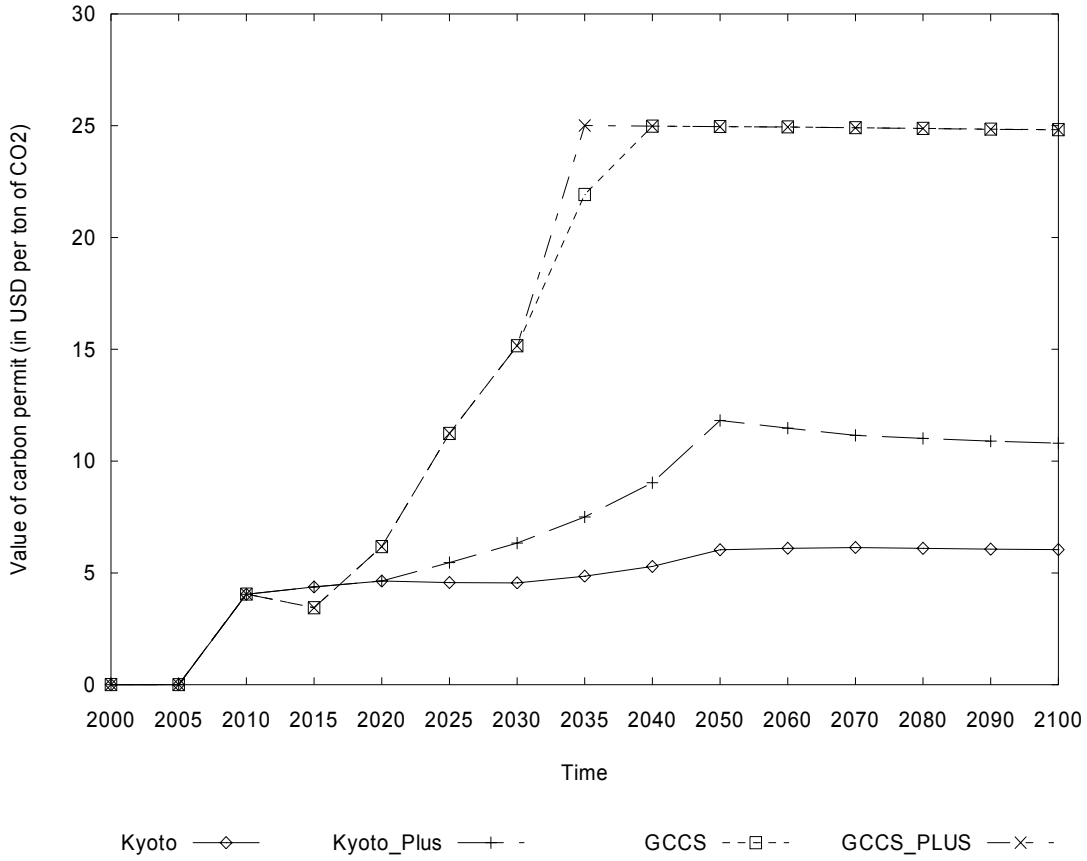
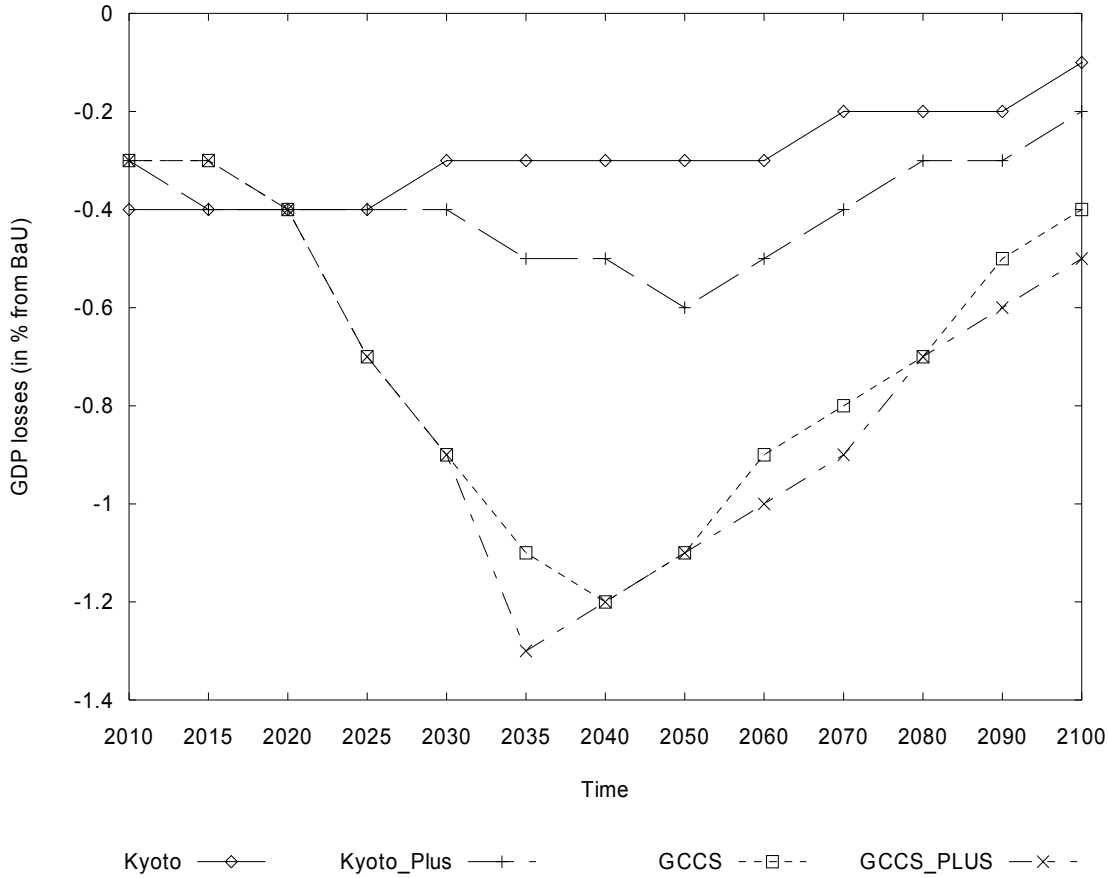


Figure 14 Global GDP (in % change from BaU)



Welfare changes – measured as Hicksian equivalent variation in lifetime – are reported in Table 13. At the global level, the results follow straight economic intuition. The more binding the global emission cap becomes, the larger are the induced adjustment costs: Constraints on the use of fossil fuels reduce overall factor productivity and lead to a decline in real income. However, even for the most ambitious scenario *GCCS_PLUS*, the gross global adjustment cost (i.e. neglecting all benefits from emission abatement) is less than a third of percent in overall global income.

Table 13: Welfare impacts (% change in lifetime consumption[106])

	GER	EUR	OOE	CHN	IND	LAM	ROW	World
Kyoto	-0.05	-0.08	-0.07	0.06	0.00	-0.05	-0.07	-0.06
Kyoto_Plus	-0.07	-0.12	-0.12	0.14	0.04	-0.06	-0.08	-0.08
GCCS	-0.15	-0.11	-0.31	0.16	0.97	-0.27	-0.58	-0.22
GCCS_PLUS	-0.17	-0.15	-0.33	-0.01	0.74	-0.35	-0.71	-0.29

Abbreviations: Europe **(EUR)**: Western Europe without Germany, Central and Eastern Europe / Germany **(GER)** / Other industrialized regions **(OOE)**: North America, Pacific OECD, Former Soviet Union / Latin America and the Caribbean **(LAM)** / India **(IND)** / China **(CHN)**/ Rest of the World **(ROW)**: Africa, Middle East, Non-Industrialized Asia

[106] Just for explanation: The 0.29% **change, respectively loss in lifetime consumption** of the world by implementing GCCS PLUS means: The world would need to be given 0.29 % of its business as usual income, to be materially and economically as well of as without the climate efficient GCCS or GCCS PLUS policy. Therefore the change in lifetime consumption is an accurate intertemporal welfare measure of the impacts of a policy change.
In contrast to that measure, **GDP is** (a) The total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports. (b) GDP: The monetary value of all the goods and services produced by an economy over a specified period. It includes consumption, government purchases, investments, and exports minus imports.

At the world-regional level, there are three important factors that determine the adjustment costs for a particular region. The first of these factors is the reduction target, i.e., the effective cutback requirements relative to the *BaU* path of emissions: Larger cutback requirements in carbon emissions as a percentage of *BaU* emissions ceteris paribus lead to larger abatement costs. The second factor are the trade characteristics: The change in international prices induced by emission constraints on open economies implies an indirect secondary burden or benefit for all open economies which can significantly alter the primary economic implications of the domestic abatement policy (Böhringer and Rutherford 2002, Böhringer and Welsch 2004/2005). Depending on its initial trade patterns a region will gain or lose from these international spillovers, i. e., changes in its terms of trade.

With respect to carbon abatement, it is useful to distinguish spillovers from fossil fuel markets on the one hand and from non-energy markets on the other hand. Regarding spillovers on fossil fuel markets, a larger cutback in global fossil fuel consumption due to stringent global carbon emission constraints depresses the international prices of fossil fuels providing benefits to fuel importers and losses to fuel exporters. Imposition of the stringent global emission threshold – as mandated by the *GCCS* and *GCCS_PLUS* scenarios – has severe repercussions on fossil fuel demand and prices. On the producer side, the decline in fossil fuel demand depresses producer (supply) prices – the lower the supply elasticity the more responsive is the fuel price to a change in demand. At the regional level, the aggregate terms-of-trade effect on international fuel markets emerges from the region's trade position. ROW (Rest of the World (ROW): Africa, Middle East, Non-Industrialized Asia), for example, includes important exporters of oil and gas and therefore will experience substantial terms-of-trade losses; GER and EUR, on the other hand, is a large importer of fossil fuels and will benefit from the tendency towards a decline of international fossil fuel prices. Regarding spillovers on non-energy markets, countries are able to pass on an increase in production costs to other countries due to product heterogeneity in trade of the non-energy macro good. Whether a country will experience a terms-of-trade loss or gain on the macro good markets depends on its initial trade shares and elasticities (of export supply and import demand) as well as differences in the cost changes of macro good production induced by the abatement scenario.

Apart from emission reduction requirements and trade characteristics, the ease of carbon substitution reflected in the regions' production technologies and consumer preferences is the third major determinant of region-specific adjustment costs.

Terms-of-trade effects explain why some developing regions (here: LAM (Latin America) and ROW) may face welfare losses under *Kyoto* and *Kyoto_Plus* even though they have not adopted emission ceilings vis-à-vis their business-as-usual development and one would have expected rather welfare gains for these countries as they engage in international emissions trading. Regarding the political feasibility of the environmentally effective *GCCS* and *GCCS_PLUS* scenarios, the welfare implications for CHN and IND as key developing regions within future climate negotiations are of critical importance. The simulation results show that both regions gain in welfare under *GCCS* due to the application of the egalitarian principle for allocating emission rights. On the other hand, welfare losses for aggregate developing regions LAM and ROW are non-negligible and may well exceed the specific adjustment costs of industrialized regions. GER and EUR as major protagonists of active climate policy in the direction of *GCCS* or *GCCS_PLUS* architectures only suffer from relatively modest adjustment costs – both regions benefit from terms-of-trade gains that partially offset their direct costs tied to larger effective emission reduction requirements.

Overall, it becomes clear that long-term stringent emission constraints as mandated under *GCCS* and *GCCS_PLUS* generate non-negligible global adjustment costs. However, the global cost incidence appears rather moderate and regional impacts for central climate policy players are in a range that may foster hopes for coping with the tedious burden sharing debate in the global greenhouse.

IX.E. Appraisal of the value of the macro economic impact analysis

An important caveat on the presented numerical analysis should be kept in mind: Although the integrated assessment model captures important aspects of long-term emission control

schemes, it is only a crude approximation of the real world's technologies, preferences, endowments as well as climate dynamics. This applies in particular to longer-term analysis where substantial uncertainties about the future development prevail. Caution is therefore in place against too literal an interpretation of the numerical results.

X. The transfer cost and revenue impacts of GCCS and GCCS PLUS to various world regions and selected countries

Unfortunately it was impossible in the foregoing macro economic impact analysis to disaggregate the data down to more than one country (Germany). So the findings illustrated in chapter IX can indicate only the effects of GCCS and GCCS PLUS for pretty large world regions, as shown in Table 13 for the following seven world regions: Europe **(EUR)**: Western Europe without Germany, Central and Eastern Europe / Germany **(GER)** / Other industrialized regions **(OOE)**: North America, Pacific OECD, Former Soviet Union / Latin America and the Caribbean **(LAM)** / India **(IND)** / China **(CHN)**/ Rest of the World **(ROW)**: Africa, Middle East, Non-Industrialized Asia

X.A. Survey of the relative burden and gains by the transfer payments and revenues of different countries and country regions

To estimate in more detail how differently countries and country regions are financially affected by the global emissions constraints the GCCS transfer burdens and gains of different countries have been calculated in Table 6 in sect. V.D. (resumed in the following Table 14).

As already said in V.D. – this overview in the first column illustrates the different "CO_2 debts respectively CO_2 credits" of different countries. They are calculated under the assumption that 4.9 tonnes of CO_2 per head world wide can be tolerated starting in 2015 at least till 2030. Every surplus tonne will have to be paid by a transfer to developing countries at a very low rate of just US$2 per tonne of CO_2 respectively for one Climate Certificate. And the figures in the first column of Table 14 show the harm which industrialized nations – apart from their 'historical debt due to the accumulated atmospheric pollution' – (permanently) do to the world by polluting the atmosphere to far above tolerable average extent with waste CO_2 resulting from their production and consumption thereby using the atmosphere as a still extremely cheap climate gas "dump", which use is actually even free! And the "CO_2-credit" gives an indication about how much – at the quoted emission price of 2 US$ per ton of CO_2 – developing countries are contributing to the mitigation of the climate change by emitting less than the (according to EU's targets) still tolerable world average of 4.9 tonnes per head.

Above the probable amount of the transfer payments and revenues in the year 2015 Table 14 shows the gross domestic product (GDP) of individual countries as the most important indicator for economic performance, the per-capita income and the (fossil fuels' consumption-financed) per-capita transfer (with transfer payments marked "-" and transfer revenues "+") for the years 2015 and 2000 as well as the relation between transfer (2015) and GDP 2000 as the most important 'negative / positive indicator'. These numbers immediately show the reader the resultant negative effect or the financially positive effect for the different countries. These figures also are indicators and a criterion about the loss of purchasing power of the consumers in higher emitting industrial and newly industrialized countries because of the CO_2-intensity of their production and consumption with the framework of GCCS.

For the sake of clarity, it should be noted once again that **all users of fossil fuels and resources and not the taxpayers or the state are financing these transfer payments**.

The following discourse is not meant to individually comment on all the countries or groups of countries enumerated in the following. Instead, the author here will 'merely' address the general results in terms of financial (material) **disadvantages / advantages** on the part of those individual states which may be considered as (particularly) critical from the aspect of (political) acceptance of the GCCS. The **criterion of transfer payments/revenues vs. gross domestic product** will be commented upon, especially since this criterion (alone) characterizes the degree to which a country is faced with negative/positive results. (The absolute amount of per-capita payments/revenues or of the payments/revenues by individual countries is not the only and not a sufficient indicator for the extent to which a country is affected!)

It must be noted too: The figures in Table 14 are illustrative to give an indication in what "GCCS-transfer-position" a country would be, if the start of the GCCS would be in 2015 and if

the CO_2-emissions would develop as predicted till 2015. Within the GCCS the figures would be representative if no additional emission would take place till 2070. In the GCCS PLUS case these figures are illustrative only till 2030: After that year the global cap will decrease annually (and so the per capita distribution respectively the allocation of climate certificates by the World Certificate Bank to the National Certificate Banks as well). Therefore the transfer revenues would be declined, the transfer sums would grow after 2030 – even in the case that all countries would not increase (or change) their emissions from 2015 onwards.

The existing data stock must be generally seen under the following aspects.

1. The degree to which transfer paying countries (industrialized nations and certain newly industrialized countries with higher than the "allowed" global average per capita CO_2-emissions) are affected is quite different: This can be expressed by a (differential) increase in fuel and energy prices and a hence consumption-dependent transfer to be borne by all consumers(!) of fossil fuels and resources. This increase is dependent upon the CO_2 intensity of production and consumption and upon the level of the gross domestic product (GDP). In the case of all these countries, a really "correct" comparison of the above-mentioned parameters is only possible by comparing identical annual figures.
   (As described in the appendix to Table 6, forecasts until the year 2015 are in fact available for the CO_2 emission values of the year 2015 (and several extrapolations could be carried out to this effect), but no forecasts were published for the gross domestic product in 2015 in the then available, nominal dollar or euro values of the countries enumerated in Table 6 and in Table 14. This means that the strongly distorted comparison of transfer payments in 2015 in US$ (prices) of this year to the respective GDP of the year 2000 in the prices and US$ values of the year 2000 can unfortunately not be avoided.)
   Therefore one should, for example, consider that the relation between transfer payment and GDP which is above 1% when comparing the Ukraine or Kazakhstan on the reference level of the year 2000 would be **less than 1%**[107] in the case of an average (nominal) growth of 3%[108] from 2000 to 2015.)
2. All countries can reduce their CO_2 intensity until the year 2015 and beyond and hence reduce the climate-protection-related (GCCS) burdens or increase the extent to which they benefit. ('Early actions' are hence 'rewarded'.) In the case of the (most) ***favoured developing countries***, a mostly very strong (forecast) ***CO_2 emission growth rate*** is already assumed – refer to Table 6 – which can, without doubt, be reduced without any significantly adverse effects on economic growth. And in case it should become evident, that a GCCS is going to be implemented the development and the economic growth very probably would effected: It would make sense to invest in less emitting technology in order not only to get more 'transfer money' for retransferred CCs but also 'climate bonus' CCs which can be sold at the free market, in case the emissions of a developing countryare lower than the business as usual emissions. (Refer to Figure 4 in sub-section VI.D.4.a.)
3. With two exceptions (see below), the degree to which industrialized nations and newly industrialized countries are affected amounts to ***less than*** half a percent of GDP (same economic performance) of the year ***2000***, or even significantly below 1/10th of a percent for the vast majority of countries!
4. A ***very large number*** of important ***developing and newly industrialized countries will be very strongly favoured (GCCS-'gains')*** with a transfer share of more than or close to 1% of GDP (2000). (These favouring rates will, however, decline as a result of economic growth (of GDP) until the year 2015.)
5. When looking at the amounts of transfer payments by industrialized and some higher emitting newly or partly industrialized countries, one has got to keep in mind, that the imposition of global tax typed additional costs by climate certificates the additional costs would be borne to a significant extent by fossil fuel producers because of a significant net price reducing effect and only to a lower extent by the fossil fuel end consumers.

[107] Average growth of 3% over a 15-year period leads to an increase in GDP of over 60% (and almost 40% with 2% growth).
[108] In US$ values in 2015

Table 14: Transfer sums, gross domestic product (GDP), per-capita income and transfer (transfer payments: - / transfer revenues: +) in 2015 and 2000, and the transfer (2015) / GDP 2000 relation

Country / country group	Transfer sum 2015	Gross domestic product 2000	Per-capita income 2000[109]	Per-capita transfer 2015	GCCS-induced transfers in 2015 in percent of national income 2000
	Million $/€	In million $	In $1000	In €/$	
EU member states: UK	- 678	1,429.670	25,200	-11.3	-0.047
France	-119	1,305.395	23,990	-2.0	-0.009
Germany[a]	-904	1,866.131	25,130	-11.0	-0.048
Italy	-415	1,073.121	20,130	-7.0	-0.039
Netherlands	-372	369.531	25,260	-23.0	-0.101
Lithuania[b]	+2	11.174	3,110	+0.6	+0.017
Poland[b]	-317	163.883	4,230	-8.2	-0.193
Czech Republic[b]	-190	51.433	5,250	-18.4	-0.369
North America					
USA	-11,518	9,810.200	34,370	-40.8	-0.117
Canada	-1,114	706.647	21,720	-36	-0.016
Mexico	-150	580.753	5,100	-1.5	-0.026
OECD Asia-Pacific					
Japan	-1,343	1,073.121	35,420	-10.6	-0.028
Australia / New Zealand	-814	388.462	20,120	-35.4	-0.210
Korea (South)	-421	461.520	9,010	-8.9	-0.009
Former Soviet Union					
Russia	-1,226	259.596	1,690	-8.4	-0.415
Ukraine[f]	-462	31.262	690	-9.4	-1.478
Kazakhstan[f]	-197	18.292	1,250	-11.8	-1.077
Political climate 'giants' in Asia					
China	+ 2,778	1,080.429	840	+2.2	+0.257
India	+ 7,019	460.616	450	+7.0	+1.524
South Asian countries°/Turkey					
Pakistan	+1,047	60.756	450	+7.4	+1.723
Bangladesh	+1,174	47.181	380	+9.0	+2.488
Indonesia	+1,255	150.196	570	+5.6	+0.836
Thailand	+13	120.968	2,020	+0.2	+0.010
Malaysia	-177	900.41	3,380	-8.1	-0.197
Philippines	+561	74.862	1,030	+7.0	+0.749
Turkey	-118	199.267	2,980	-1.8	-0.059
Middle East°°					
Kuwait	-121	35.830	17,900	-6.1	-0.318
Saudi Arabia	-292	188.721	8,120	-13.2	-0.155
United Arab Emirates	-249	70.200	29.620	-105	-0,355
Iran	-185	101.562	1,650	-2.8	-0.182
African states°°°					
Egypt	+286	99.428	1,490	+4.1	+0.288
Algeria	+69	53.455	1,580	+2.2	+0.129
South Africa	-415	127.965	3,060	-9.8	-0.324
South America**					
Brazil	+321	601.733	3,610	+2.2	+0.053
Argentina	+23	284.346	7,460	+0.6	+0.008
Chile	-6	75.515	4,810	-0.4	-0.008
Ecuador	+84	15.930	1,233	+6.5	+0,527
Peru	+200	53.466	2,060	+7.4	+0.374
Venezuela	+94	121.258	4,310	+4.0	+0.078

Sources: Wicke, 2005 p.285 (for important population and emission data and for the explanation of various special information ($_{a,b...\ to\ **\ and\ to\ °°°}$) ref. to Table 6 and the remarks there)

[109] Ref. to http://devdata.org/data-query/SMResult.asp?COUNorSERI-NY.GNP.PCAP.CDescale=1

X.B. Interest-related acceptance of the GCCS (based on its economic effects) by selected industrialized nations, newly industrialized countries and oil producing countries (in the Middle East)

The following can be noted with regard to individual countries or groups of countries.

1. In (most) of **the (15) 'old' EU member** states, the burden (in as far it has the effect of increasing energy prices) totals less than one twentieth of a percent (!) (i.e. less than 0.05%) and is hence within negligible and, in any case, acceptable limits. The Netherlands is the only country with a slightly higher value of around 1/10th of a percent. (Since the Netherlands on one hand nearly has with 16.6 tons a 60% higher per capita CO_2-emission that for instance Germany and since NL are - compared to other EU-member states - particularly affected by the effects of climate change, it will certainly accept the slightly higher burden within the framework of a GCCS system which ensures climate stability according to the EU targets.)
2. Among the **new EU member states** (as of May 2004), Poland (0.2%) and the Czech Republic (below 0.4%) are examples of countries which are affected to a larger extent. The resultant (energy) price increases and consumption-financed transfers appear to be tolerable, all the more so, because these countries will probably experience stronger growth by the year 2015 as a result of EU accession.[110] In the final analysis – and after some difficult negotiations within the EU – one should assume that the EU will support the GCCS, not least as a way to achieve its own climate stabilization targets, which are the targets both of GCCS and GCCS PLUS.
3. Given an implementation of the GCCS, the burden on the (at present) particularly climate-critical **United States of America** (failure to ratify the Kyoto Protocol) would correspond to around one tenth of a percent of its GDP in ***2000,*** i.e. on balance by very moderate (energy) price increases and a resultant consumption-financed transfer. In view of expectations of continued, strong growth for the US economy by 2015, the real burden will be ***significantly*** below 0.1 percent! Furthermore, the energy price level in the US is far below the average of a vast number of other (industrialized) nations, so that US consumers and industry will

   No matter how founded and justified the Byrd-Hagel resolution[111] by the US Congress (Clinton Administration) from 1997[112] and the US government's refusal to ratify the Kyoto Protocol in 2001 (Bush Administration) may have been, one can hardly see any overburdening of the US (any more) in GCCsystem. (The ***GGCS would certainly not do any 'serious harm to the economy of the United States'*** and explicitly has got to do so! Without doubt, *the US in particular must also and should accept the GCCS*, otherwise there will be no GCCS!) Furthermore, the ***GCCS concept*** is consistent in itself and ***includes***, in particular, ***developing countries***. (This was another reservation which Byrd/Hagel and hence the US congress expressed with regard to the Kyoto Protocol.) Moreover, the ***USA would benefit more from an effective climate stabilization as a result of the GCCS.*** Without this stabilization or at least decelerated climate change they would be adversely affected by the strongly increasing negative consequences of climate change (e.g. ever increasing power of hurricanes (higher temperatures of e.g. the gulf of Mexico) or a rather serious threat of a 'cut-off'' of the North Atlantic or Gulf Stream with dramatic implications for the US, its economy and its population). Therefore: there exists some reason to expect that the US could and should – after long considerations und negotiations – support the GCCS.[113] (Readers insisting on equal treatment of all states are

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[110] If necessary, EU member states could agree to a new "burden sharing" system on introduction of the GCCS and hence some kind of relief for countries which are most affected.

[111] Byrd,R./Hagel,C.: Byrd-Hagel Resolution. 105th Congress. Report 105-54. Washington D.C. July 21, 1997.

[112] 'The exemption for Developing Country Parties is inconsistent with the need for global action on climate change and is environmentally ***flawed***. The disparity of the treatment between Annex I Parties and Developing Countries and the level of required emissions reduction, ***could result in serious harm to the United States economy, including significant job loss, trade disadvantages, increased energy and consumer costs, or any combination thereof.'*** (Byrd,R./Hagel,C.: Byrd-Hagel Resolution., p. 2.)

[113] Furthermore: The economic problems discussed by reputable US economists (including, for example, US Nobel Prize Winner Joseph E. Stiglitz) resulting from potentially unpredictable prices and transfers (refer to Aldy, J.E./Orszag, P.R./Stiglitz, J.E.: Climate Change: An Agenda for Global Collective Action. Prepared for

kindly asked to accept the author's apologies for his somewhat more extensive reference to the US in this context!)

4. As far as the other two North American states, i.e. **Canada and Mexico**, are concerned, the (energy-price increasing) burden on Mexico is not negligible, but certainly tolerable. Mexico as a newly industrialized country records – unlike the vast majority of developing and newly industrialized countries – above-average per-capita CO_2 emissions of 6.4 tonnes and – given a constant CO_2 emission level – will be faced with annual transfer payments of US$150 million. This will render it more difficult, however, hardly impossible for Mexico to agree to the GCCS. However, Mexico (unlike other developing and newly industrialized countries) will have no free emission growth capacity. This means that Mexico will have incentives for climate-friendly development by reducing transfer payments – a situation which differs from that of other developing and newly industrialized countries. (Their incentives are based on a possible constant flow of transfer revenues.
5. With regard to the OECD Asia-Pacific countries, i.e. **Japan, South Korea and Australia only Australia**[114] will be exposed to burdens at a level worth mentioning. The very robust Australian economy will certainly have no major problems 'shouldering' the burden of these transfer payments.
   Besides the problems in the above-mentioned calculation in Table 14 which are due to the fact that the emission data relates to Australia and New Zealand together, one should not forget the following: Australia's coal industry would be hard hit because the combustion of coal – no matter which country imports such coal – would become expensive because of the CC burden. This will lead to price pressure in the coal industry and hence to a worsening of the terms of trade between Australia and its trading partners. The oil exporting countries are also faced with this problem, albeit to a lesser extent because oil is less CO_2-intensive. (See below)
6. At first glance, the GCCS acceptance issue appears to be most difficult in the case of **Russia** and two USSR successor states, i.e. the **Ukraine and Kazakhstan**, which are mentioned here as examples. Whilst Russia will be faced with 0.4% transfer payments in 2015 compared to the GNP of the year 2000 (!) (and hence a burden around 4 times as high as the US (see above), Kazakhstan will have to pay close to 1.1% and the Ukraine close to 1.5% - the latter being the highest transfer payment burden of all the states listed in Table 14. (Although the Ukraine's economy generates medium CO_2 intensity (less than 10 tonnes of CO_2 – refer to Table 6 its (per-capita) income is relatively low at US$690[115]).
   Similar to the ratifying of the Kyoto Protocol, one must expect that it will be pretty hard to motivate Russia – without compensation – to sign and ratify a GCCS Agreement. (Russia is – like Ukraine – additionally faced with disadvantages as a coal and oil producing country. However, as a gas producing country, it would benefit from the GCCS. Refer to the next paragraph on this issue). Like in other (industrialized) countries, Russian consumers and companies will have to pay for the transfer amount via higher energy prices.[116] The same applies to the two countries, Kazakhstan and Ukraine, which are mentioned here as examples.
   It goes without saying that a **generally** defined "hardship clause" must be included in the GCCS for countries faced with special burdens. Such a clause would have to alleviate cases of hardship **without** reducing the incentives of the GCCS for climate-compatible behaviour.[117]

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the conference on "The Timing of Climate Change Policies". Pew Center on Global Climate Change. October 2001) have been fully considered by integrating their proposals ('price caps') and other elements (splitting up the markets into a transfer and a free CC market) into the design of the GCCS. This means that the – *justified – reservations by US economists could be eliminated or at least minimized!* (Ref: to Aldy/Orzag/Stiglitz 2001, p.26)

[114] New Zealand (integrated in Table 14 together with Australia) will not be problematic, because its per capita emission are at a similar level as Germany (therefore much lower than Australia's) and it is no coal or crude oil producing country.

[115] This is why the above-mentioned percentage for the Ukraine is so high.

[116] Contrary to the 'Kyoto situation', Russia and other former Soviet states would not be able to sell excess Assigned Amounts (AAs) ('hot air') to other industrialized countries such as to the European Union.

[117] In this context, the author cannot present a ready-to-apply "solution" to this problem. The author can, however, present the following principle as an approach worth considering. A ***general*** hardship compensation

7. The **oil producing countries in the Middle East** are hardly affected by the required transfer payments alone thanks to their high economic performance. Although the four countries listed as examples will in part have to pay very high per-capita transfer sums – via the consumption of fossil fuels made available for their citizens and businesses there at extremely low prices –, these payments which range between close to 0.2% and just above 0.3% of their GDP can certainly be 'shouldered' by these countries in view of their high per-capita incomes and high GDP (Gross Domestic Product).
   But: The main point of concern of these oil producing countries is undoubtedly – and not without reason – that the GCCS will generate incentives to save energy and to limit global CO_2 emissions. Although this will chiefly affect coal producers in view of a particularly high CO_2 intensity of both hard coal and, above all, brown coal (refer to Table 7[118]). But: It is to be expected – and to be feared **from the perspective of oil producing countries** (especially in the Middle East with a relatively high ratio of CC transfer payments vs. gross domestic product, see above) – that demand for crude oil will decline rather than remaining flat whilst demand for natural gas will increase. As a result, these countries will be concerned that the (relative) decline of oil prices (in part compensated for by higher gas prices) due to the GCCS mechanism will deteriorate the ratio of their export to import prices (terms of trade), so that they will receive, in real terms, less import products for, again in real times, the same level of energy and resource exports.
   In section VI.D.1. it has been shown, that there exist estimates about the price effect of a global tax on fossil fuels. According to these estimates the imposition of a global tax typed additional costs by climate certificates the additional costs would be borne to a significant extent by fossil fuel producers and only to a lower extent by the fossil fuel end consumers, because of a significant net price reducing effect.
   On the other hand: Because around 2015 there will exist a relatively “cheap” technology for the CO_2-free burning or using fossil fuels (‘CCS-technology’ 25 to 50US$ per ton of CO_2, refer to sections VIII.A. and B), that will overcompensate the marginal CC-costs (30, 60, 90US$), coal and crude oil can be sold with only limited price decreases. Therefore the revenue decreases of coal and oil selling will be limited. On the long range (after installing of the CCS-technology in most fossil fuelled power and other installations) “thanks to the incentives of the GCCS” – coal and oil can be used completely unaffected by climate restrictions.
   Nevertheless: In the first years of the GCCS-implementation, the oil and coal producing countries will have significant relative losses by the GCCS, because a decline of the net export price. This means that considerable diplomatic effort and, if necessary, compensatory measures will be necessary (beyond the real GCCS system i.g. within the World Trading Organisation, WTO) in order to motivate these countries (as well as other oil and coal exporting and producing countries) to join the GCCS.

X.C. Interest-related acceptance of the GCCS based on its economic effects by selected developing and newly industrialized countries

Table 14, taken from the study (Wicke 2005), that is underlying this report lists only a relatively small number of developing and newly industrialized countries. This is due to the following reasons. In most cases, no forecasts for CO_2 emissions in 2015 were available to the author for many developing countries (such as the many small island states of the AOSIS group = Alliance of the Small Island States) which would be important examples for developing countries with major benefits and gains. Furthermore, it was unfortunately only possible

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clause – i.e. relief for these and, if applicable, further countries would only be conceivable and make sense if the GCCS Agreement were amended by adding a generally valid clause pursuant to which – on exceeding a certain burden threshold expressed as a percentage of a year's transfer payments with the GDP *of the preceding year* (rather than a comparison of completely different years as was inevitable) – ***part*** of these burdens is made available in the form of a re-transfer payment sum at a constant level. Such payments would be contingent upon the implementation of climate-protecting measures for sustainable development ***in analogy*** to the SDEP measures shortly described in section III.B..

[118] According to this table, the "***emission intensity***" ratios of the ***calorific values*** of the different fuels are as follows:•crude oil = 1.0 / •coal = 1.17 / •brown coal = 1.41 / •gas = 0.65

for just a few countries to ***approximately*** extrapolate the (partly known) emissions of the year 2000 to the year 2015. (A provisional solution was found in some important cases[119]). But: The number of developing countries contained in Table 14 is definitely too small! Therefore – based on now available data and on the basis of some assumptions about the growth of CO_2-emissions - Table 15 and Table 16 give some more illustrative examples for the degree of the financial benefits of the GCCS for more developing countries.

The following can be noted on the basis of the countries studied.

1. Some examples of **Asian countries:** In 2015, very important developing countries, such as **India, Pakistan, Bangladesh** will receive transfer proceeds of between close to 1.5% and up to 2.8% as well as **Indonesia** and the **Philippines** (with close to or more than 0.8% of their gross domestic product and hence very high proceeds from their low and far below-average per-capita CO_2 emissions into the atmosphere). The absolute level of transfer payments per capita of between US$7 and US$9 is also very important for these countries. This is especially true because this money – refer to III.B. and (more detailed) to Wicke (2005, p.197seq.) – is to be used for measures designed to promote climate-friendly, sustainable development ***and*** to eliminate poverty. Other Asian states like **Sri Lanka, Bhutan, Nepal and Burma** are – based on a very low per capita CO_2-emissions and a very low (per capita) gross domestic product with GCCS payments in per cent of national incomes between 0.9 and 5.5% favoured very much too.
2. Nearly all **African countries** – as far as they are non-coal (non-oil) producing countries, (like South Africa, see below) – are very much favoured as shown in Table 16 GCCS payments at a margin of 2.5% up to 9.9% of gross domestic products (**Kenya, Uganda, Burkina Faso, Ethopia)** would be of great help for those countries for the implementation of their Sustainable Development and Elimination of Poverty (SDEP) Plans. In other words: Those countries – because of their very low CO_2-emissions per head – will be able to sell Climate Certificates for around US$ 9 per head of their population, a potentially high contribution for the fight against poverty. Even oil producing countries in Africa like **Algeria, Nigeria, Angola, Congo**(Brazzaville) **and Egypt** get financial benefits of the GCCS to an extent between 0.13% (Algeria) up to 1.9% (Nigeria) transfer payments related to their GDP (ref. to Table 14 and Table 16).
3. As far as the **AOSIS islands states** are concerned, which are often most endangered by the consequences of climate change and partly belong to the least developed countries only very few were listed in the statistic used in Table 15 and Table 16. With the exemption of **Kiribati** with a predicted 2015 per capita CO_2-emission level of 5.3 tons, all other 'exemplary' island states like **Tonga, Maldives, Seychelles and Grenada** have a predicted per capita CO_2 below the relevant level of 4.9ton/head and therefore get more Climate Certificates than needed. But these are pretty low transfers between 0.05 and 0.6% percent. Therefore: As far as those and other AOSIS islands states are highly endangered by climate change, with in GCCS / GCCS PLUS they will get additional funds for adaptation (ref. to section III.B. and Wicke (2005) p.175seq.)
4. In **South America** all 'exemplary' countries within Table 14 and Table 16**Argentina, Brazil, Venezuela, Panama, Costa Rica, Peru, Cuba and Nicaragua** – with the exception of **Chile** – will get (positive) transfers within the margin between 0,008 up to 1.0% of the gross domestic product – therefore being favoured by GCCS to a moderate up to a high extent.
5. In 2015, **China** with close to 0.3% (GCCS revenues compared to GDP) will also belong to the group of countries which are favoured quite substantially. With around 3.8 tonnes of CO_2 in 2015, China will remain around 30% below the per-capita world average of 4.9t[120] which is to be aimed at in line with the EU and GCCS/GCCS PLUS stabilization targets (ref. to sect. VIII.E.). Such a situation consequently means: The GCCS undoubtedly offers material incentives (annual transfer payments of US$2.8 billion) also to China. This makes it possible that China too – together with the **Group 77 countries** (i.e. the group of developing countries in the climate negotiations) – can and hopefully will support the GCCS.

[119] Refer to the explanations concerning the calculations in the box after Table 6.

[120] Refer to Table 6 as well as the discussion about C&C and its 'profitability' for China in section IV.C.3.A. in Wicke (2005, p.96).

Table 15: Important economic and climate data of some selected developing countries

Country / country group	Population in 2000	Assumed CO_2 growth-factor 2000 till 2015	CO_2 emissions in 2015	Tonnes of CO_2 emissions in 2015	GCCS-induced transfers in 2015
	Million		Million t	Per capita	Million US$
Asia & Oceania					
Bangladesh	137,95	1,66	49,468	0.358	+ 1253,14
Bhutan	2,06	1,66	0,630	0,305	+ 18,93
Burma	47,54	1,66	14,608	0,307	+ 436,70
Kiribati	0,09	1,66	0,479	5,322	- 0,08
Maldives	0,29	1,66	0,996	4,434	+ 0,27
Nepal	23,52	1,66	5,312	0,225	+ 219,91
Sri Lanka	18,59	1,66	18,426	0,991	+ 145,34
Tonga	0,10	1,66	0,215	2,150	+ 0,55
Africa					
Angola	12,39	1,66	7,968	0,643	+ 105,39
Burkina Faso	11,91	1,66	1,826	0,153	+ 113,07
Congo (Brazzaville)	3,45	1,66	1,245	0,360	+ 31,33
Ethiopia	65,59	1,66	5,976	0,091	+ 630,84
Kenya	30,55	1,66	16,766	0,548	+ 265,91
Nigeria	114,75	1,66	79,846	0,695	+ 965,05
Seychelles	0,8	1,66	0,372	0,465	3,548
Uganda	23,49	1,66	2,324	0,098	+ 225,60
South America					
Costa Rica	3,93	1,314	6,863	1,746	+ 24,79
Cuba	11,14	1,314	41,197	3,698	+ 26,78
Grenada	0,08	1,314	0,105	1,313	+0,58
Nicaragua	5,07	1,314	4,755	0,937	+ 40,18
Panama	2,95	1,314	7,500	2,542	+ 13,91

Sources: Population figures: IDB – Countries Ranked by Population – http://www.censud.gov./cgi.bin/ips/idbrank.pl and
Energy Information Administration: International Energy Annual 2003: World Population URL:http://www.eia.doe.gov/pub/internatio/ialf/tableb1.xls
CO_2-Emissions: http://www.nationmaster.com/graph-T/env_co2_emi
Calculations: Ref. to Table 6

Table 16: Transfer sums, gross domestic product (GDP), per-capita income and transfer payments for some selected developing countries

Country / country group	Transfer sum 2015	Gross domestic product 2000	Per-capita income 2000	Per-capita transfer 2015	GCCS-induced transfers in 2015 in percent of national income 2000
	Million $/€	In million $	In $1000	In €/$	
Asia & Oceania					
Bangladesh	+ 1253,14	45.470	0,33	+ 9,14	+ 2,8
Bhutan	+ 18,93	480	0,23	+ 9,34	+ 3,9
Burma	+ 436,70	7.990	0,17	+ 9,46	+ 5,5
Kiribati	- 0,08	---	---	---	- .....
Maldives	+ 0,27	560	1,93	+ 5,94	+ 0,05
Nepal	+ 219,91	5.340	0,23	+ 9,34	+ 4,1
Sri Lanka	+ 145,34	16.330	0,88	+ 8,04	+ 0,9
Tonga	+ 0,55	---	---	---	---
Africa					
Angola	+ 105,39	9.130	0,74	+ 8,32	+ 1,2
Burkina Faso	+ 113,07	2.570	0,22	+ 9,36	+ 4,4
Congo (Brazzaville)	+ 31,33	3.220	0,93	+ 7,94	+ 0,9
Ethiopia	+ 630,84	6.340	0,10	+ 9,60	+ 9,9
Kenya	+ 265,91	10.450	0,34	+ 9,12	+ 2,5
Nigeria	+ 965,05	48.980	0,43	+ 8,94	+ 1,9
Seychelles	3,548	620	0,78	+4,44	+0,6
Uganda	+ 225,60	5.730	0,24	+ 9,32	+ 3,9
South Afr					
South America					
Costa Rica	+ 24,79	15.950	4,06	+ 1,68	+ 0.2
Cuba	+ 26,78	6.730	0,60	+ 8,60	+ 0,4
Grenada	+0,58	410	5,13	+7.25	+ 0,14
Nicaragua	+ 40,18	3.950	0,78	+ 8,24	+ 1,0
Panama	+ 13,91	11.620	3,94	+ 1,92	+ 0,1

Sources: Gross Domestic Products URL:
http://www.eia.doe.gov/pub/international/iealf/tableb2.xis
Calculation: Ref. to Table 15

South Africa, in particular, continues to be a difficult or even very difficult case among the developing and newly industrialized countries enumerated in Table 14. Although South Africa also records *on average* a relatively high per-capita income, it also features a particularly high CO_2 intensity with a forecast level of 14.2 tonnes of CO_2 per capita in 2015, particularly due to the extensive use of coal (especially for power generation) mined in South Africa. South Africa too is another country for which a *generally* valid hardship clause would have to be implemented. This will be a particularly difficult task because it will be hard to interpret the strong per capita GDP imbalance on a national level in conjunction with a relatively high average per-capita income as a generally definable 'special case' and as a special burden.

One conceivable solution – in analogy to the "case" of the strongly burdened Ukraine – might be to make a constantly high amount available to **South Africa** despite the necessary payments for the GCCS transfer. This amount could then be used for ***targeted*** measures for eliminating poverty and promoting sustainable development for the estimated 60% to 80% of the South African population living under the poverty line (similar to the SDEP plan measures shortly discussed in section III.B.)[121]!

To sum up: Except for the very "problematic case" of South Africa identified in Table 14 as well as – after a careful examination –as well as Mexico which was already mentioned in conjunction with the 3 North American states (and possibly some AOSIS states with a small population and a higher development or a touristy infrastructure), practically all developing and newly industrialized countries will have a material and financial interest in the GCCS. (In the case of some AOSIS-States this is confirmed by way of the combined benefits of the equal per capita distribution and additional extra funds for adaptation and protection measures against the adverse effects of climate change! (ref. to section III.B. and Wicke (2005) p.175seq.))

Therefore: After long discussions and a closer evaluation of the material and ecological[122] benefits of the GCCS the groups of developing and newly industrialized countries could thus become pioneers and protagonists for a structural evolution of the Kyoto System towards the GCCS (or more generally towards as Global Cap and Trade Scheme).

This consequently would mean, that – together with the above-mentioned developing and newly industrialized countries and the European Union – up to three quarters of the world's population and up to three quarters of all states could and would (hopefully) support the GCCS (and GCCS PLUS).

X.D. The effect of the GCCS on regions in industrialized countries – the example of the German federal state of Baden-Württemberg

X.D.1. Cases of climate-related damage avoided in Baden-Württemberg

The initially most important aspect of the introduction of an efficient climate protection system like the GCCS for the federal state of Baden-Württemberg is the fact that the rate at which climate-related damage in the federal state rises will be slowed down and – given a climate stabilization as intended by the EU (refer to I.B. and I.C.) – at least a climate ***stabilization*** at around plus 2.3°C will be possible from the year 2100 on.

According to Prof. Seiler, Director of the Institute for Meteorology and Climate Research (IMK-IFU) at the Karlsruhe/Garmisch-Partenkirchen Research Centre, past (as well as present, 'ongoing' world-wide) emissions for the period from 1990 to 2030 alone lead to very clear and strongly negative climate-related effects for southern Germany and Baden-Württemberg (Seiler 2003). The relevance of the related forecasts is backed by the results of concrete, region-specific climate and weather models. Some of the particularly negative re-

[121] For more details refer to Wicke (2005) p. 187seq., section VI.G.2.

[122] Preventing further climate change-related danger for their countries and transfer funds for adaptation and prevention measures in order to ward off such dangers.

percussions by the year 2030 on Baden-Württemberg (and Bavaria) identified by Seiler are summarised below.

Effects in summer:

- Threat to forests due to draught, fire and spreading/reproduction of pests
- Regional flood situations due to intensification of rainfall events (thunderstorms, course of low-pressure areas)
- Floods in residential areas due to inadequate dimensions of sewer and canal systems as well as soil compaction
- Health-related consequences due to high temperatures and the spread of diseases and pathogens

Effects (winter/spring):

- Increase in water outflow levels (higher rainfall with reduced evaporation, melting snow) with floods and soil erosion
- Increase in the altitude of the snow line by around 300 to 400m and significantly fewer days with snow cover at altitudes above 1200m

Effects (autumn, winter, spring):

- Increased damage to trees due to wet snow in forest ecosystems due to more intensive snowfall
- Storm damage due to intensification of hurricane lows with higher wind speeds and changed courses

One important new study (PIK 2005) about “climate change – effects, risks and adaptation” highlights the following climate change impacts up to the year 2050 (Umweltministerium Baden-Württemberg 2005b, p.1seq.):

- Up to the year 2050 there will be an additional warming in Baden-Württemberg according to the region between 1.2 up to 1.7° Centi-Grades.
- There will be a massive adaptation pressure for plants and animals as well as for humans, which will be quite differentiated regionally in different parts of the federal state.
- The present picture of nature and landscape will be significantly changed.
- The conditions of life will be changing significantly too.
- Together with (climate change born) ecological changes new germs of diseases very likely will appear.

These – according to two different studies – quoted and other damage in the federal state of Baden-Württemberg will be significantly intensified even further up to 2100 and later as a result of climate change which has been already started by increasing emissions in recent and present years and in the years to come. With the introduction and enforcement of the GCCS respectively of GCCS PLUS, it will be possible on a global scale (and hence also for Baden-Württemberg) to limit such damage – according to the definition and goals of the European Union (refer to sections III.C. and VIII.E.) – to such an extent that one can just avoid classifying this future situation as *'dangerous anthropogenic interference with the climate system'*.

X.D.2. GCCS-related burdens upon Baden-Württemberg

The implementation of the GCCS and the related reduction or stabilization of carbon dioxide emissions are not possible without additional costs – as with any other effective climate protection system. Consequently, citizens and business in Baden-Württemberg are affected by this situation as follows.

In line with the system and its design, the national transfer payments by industrialized nations and the costs incurred by FRPs when acquiring CCs on the free market are distributed more or less equally[123] to all consumers of fossil fuels and resources and to buyers of prod-

[123] There exist two problems already referred: (1)FRPs might not evenly distribute their CC-related price increases, depending on the price flexibility of demand, and price-rigid responding motorists, for instance, could be burdened heavier than more price-flexible companies which can resort to less CO_2-intensive fuels and resources. However, such behaviour is certainly "normal" behaviour which can be (and is certainly also) displayed with each frequent increase in mineral oil and gas prices. (2) FRPs might increase their prices according to their marginal costs at the CC free market. (Refer to this case and the potential ‘remedy’ in sect. VI.D.4.)

ucts made therefrom, such as electricity or plastic products. Given an equal passing on of such costs[124] the burdens resulting from the GCCS would have to be passed on to businesses and households in Baden-Württemberg in the "form" of the price increases "quantified" in Table 8 as a result of the CC transfer prices plus certain price increase effects (accounting for a more or less large share) which can be due to the free CC market (refer to Table 9). (But: There might be a marginal price driven price behaviour, ref. to sect. VI.D.) The actual level of these GCCS-induced price increases is a function of the "CO_2 intensity" of the German economy and the European economy linked to it as well as the CC prices forming on the free market.

The GCCS burdens and hence the increased prices to be borne by consumers of fossil fuels and resources in Baden-Württemberg can be hypothetically calculated for different scenarios as follows.

- Baden-Württemberg succeeds – as planned and despite the current plans and the decision to abandon nuclear power – to limit its emissions (permanently) to the original target value of around 65 million t[125] for the year 2010. Supposing this would also represent the entire CC-relevant potential of Baden-Württemberg[126], this would translate to total per-capita emissions of 6.25 tonnes of CO_2. Subtracting the free allocation of 4.9 t of CO_2 from this sum, this results in a volume of 1.35 t. In purely mathematical terms, Baden-Württemberg with all its households and businesses would then have to bear a CC burden for transfer payments to countries with below-average emissions of around €30.8m, with the total German burden amounting to €904m[127]. (Baden-Württemberg would then record significant below-average per-capita consumption compared to a forecast of the German per-capita level of 10.4 tons.[128] (***Note***: It is, however, very unlikely that Baden-Württemberg will actually achieve (or permanently 'keep') the target set in the environmental plan if the federal state really opts out of nuclear energy.[129] This means that the "transfer burden" on citizens and business would in fact be (significantly) higher.) Moreover: Since the transfer price of US$/€2 is charged for ***all*** the CCs allocated to FRPs in Germany and Baden-Württemberg[130], the CC-related price increase of €148m (calculated) must be paid for the complete CO_2-relevant consumption of fossil fuels and resources in Baden-Württemberg.
- These total consumer-payments of €148m from the year *2015* on would correspond to around 0.0502% of Baden-Württemberg's gross domestic product in *2000* (totalling around €295 billion[131]) (and **hence amount to less than one quarter of the transfer quota in relation to the prospective German transfer**). Since gross domestic product will certainly have grown significantly by the year 2015, the total burden in 2015 due to this CC transfer and these total payments **will correspond to far less than five hundredths of a percent of Baden-Württemberg's GDP**! Even if the potential (almost) completely abandoning of

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[124] Refer to the footnote above!

[125] According to Baden-Württemberg's environmental plan (now being replaced in respect of Baden-Württemberg's climate policy by the 2005 'Climate concept of Baden-Württemberg' (Umweltministerium Baden-Württemberg 2005a) with a predicted CO_2-reduction potential of 2-4 million tons per year), CO_2 emissions are to be reduced to a level of below 65 million tonnes by the year 2010. (Baden-Württemberg Ministry for the Environment and Transport (editor): Umweltplan Baden-Württemberg. Stuttgart 2001, p. 67. Fahl et al. suppose that emissions in 2015 should be below 61 million tonnes of CO_2 given an update of the targets laid down in the Baden-Württemberg environmental plan. (Refer to Fahl, U./Blesl, M./Rath-Nagel, S./Voß, A.: Maßnahmen für den Ersatz der wegfallenden Kernenergie in Baden-Württemberg. (Institut für Energiewirtschaft und Rationelle Energieanwendung Universität Stuttgart, (IER). March 2001, p. 45.)

[126] Refer to section III.H.2.b. concerning the CO_2 potential according to the 'simplified IPCC reference approach' assumed with the GCCS.

[127] Concerning the calculation approach, please refer to section V.B.1. (directly after table 4)

[128] Refer to Table 6 in section V.C. which also describes the calculation basis for the forecasts.

[129] Fahl, U. et al. expect that – as a result of already abandoning nuclear energy in 2015 – CO_2 emissions will already be back to around 85 million tonnes in 2015 and that they will rise to around 95 million tonnes by the year 2030. (Fahl, U. et al.: loc. cit., p. 51 and following.)

[130] This price must be paid in all industrialized nations in accordance with the allocation method described in section III.F.2. and (briefly) repeated in section IV.B. ***even though*** the German National Climate Certificate Bank has also received 4.9 CCs for each of the 11.4 million citizens of Baden-Württemberg, i.e. altogether around 56 million climate certificates.

[131] Gross domestic product of Baden-Württemberg according to http://www.statistik.baden-wuerttemberg.de/Veröffentl/Statistische_Berichte/4151_02001.pdf

nuclear power would lead to higher total emissions in Baden-Württemberg[132], the resultant burdens would in any case still be bearable!

- It should be underlined once again that the CC transfers are paid by the National Climate Certificate Bank rather than from the national or federal or federal-state budgets, with the National Climate Certificate Bank being financed from the fixed-price allocation and the auctioning of a small part of the CCs to FRPs. The costs of adaptation to the climate targets according to the Baden-Württemberg environmental plan as quoted by Fahl et al. would also have to be financed by consumers of electricity (and heat) via higher energy supply costs resulting from the use of regenerative energy sources and/or energy sources with a lower CO_2 content and the related costs of production structures. (Such costs, however, are explicitly **not** GCCS-related but are due to abandoning the use of nuclear energy.)

Summarizing these arguments: The GCCS-born costs have got a magnitude that Baden-Württemberg should to be able to bear the costs as well as the GCCS-related price of climate stabilization - without substantial economic reductions. At the same time – within the framework of the globally effective GCCS – Baden-Württemberg would be prepared to cope with climate change that will go far beyond what is currently foreseeable and the resultant, additional negative effects!

X.D.3. The GCCS-related opportunities for innovative and flexible businesses in Baden-Württemberg

In case a global cap and trade scheme likeKyoto PLUS (based on GCCS respectively GCCS PLUS) would put on the table of international negotiations with some reasonable chances to be implemented (refer to XII.C.) there would arise significantly stronger incentives for early actions in the form of investments in climate friendly technology which the present Kyoto climate protection system does not demand and for which this system does not offer any incentives. All the stakeholders would understand that emitting climate gases into the atmosphere, i.e. contributing towards climate damage, in future will be no longer free of charge, but that it must be paid for. It goes without saying that this incentive mechanism will be particularly strong against the background of a resolution to introduce such a climate protection system or any equivalent thereof.

By that time at the latest, any feasible and then even more rewarding climate protection measures will be taken also and especially in Baden-Württemberg in order to reduce or avoid the price burdens on fuel and resources providers who are forced to buy certificates and who pass these costs on to consumers. Furthermore, Baden-Württemberg's industry, which already boasts a particularly high innovative level, will develop and implement more than ever before technical methods and processes in order to actually benefit from the "profits and advantages due to climate protection" which will then increasingly become available. Climate-compatible behaviour will then pay off more than ever before for all stakeholders, i.e. consumers, vehicle owners, industry and governments.

In case a global cap and trade scheme would be installed, Baden-Württemberg will particularly benefit from such a success. The demands which the GCCS places upon the federal state's population and its industry are – as shown – reasonable. Given the installation of a world-wide, market-economy-based climate protection concept, economic opportunities and prospects will be particularly good for Baden-Württemberg's industry and business with their outstanding level of innovation. Methods and processes for boosting energy efficiency and for protecting the climate, which have already been successfully deployed, as well as newly invented technical processes yet to be introduced will be developed and implemented to a particularly high degree especially in Baden-Württemberg where they can contribute towards boosting business in the federal state. In its environmental plan, the federal state's government itself points to the entire package of opportunities for Baden-Württemberg and its inno-

[132] Refer to the forecasts by Fahl et al., quote several footnotes above.

vative industry, including, for example, in the fields of energy research, the development of new energy technologies, as well as a host of climate protection measures related to "efficient energy use", "efficient energy supply", "increased use of regenerative energy" and "measures to avoid CO_2 emissions from the transport sector".[133]

The market-orientated, cap and trade based climate protection policy concept proposed here will make it possible to efficiently implement to a much larger extent than ever before the "profits and benefits of climate protection".

[133] Refer to the Baden-Württemberg, environment plan, especially p. 66, and p. 69 and following. Within the actual 2005 – climate concept of Baden-Württemberg similar approaches are of dominant importance. (Refer to Umweltministerium Baden-Württemberg 2005a.)

XI. Benefits and aggregated cost/price/transfer impacts of GCCS and GCCS PLUS as indicators for the economic acceptability of these global cap and trade schemes

The main task of this report is to evaluate the cost and price impacts of the GCCS in order to better estimate the chances of the acceptance and implementation of a global cap and trade scheme. The findings of the report according to these respects will be summarized in the second part XI.B. of this chapter. But it is also of high interest to get a deeper understanding of the potential benefits of the implementation of this scheme. This will – in short – be discussed in section XI.A.

XI.A. The benefits of reduced climate change impacts by the implementation of GCCS and GCCS PLUS

XI.A.1. Avoidance of "dangerous interference with the climate systems" as ultimate target of global climate policy by the implementation of the two global cap and trade schemes

GCCS and GCCS PLUS primarily have no intention to realize a global climate change mitigation system that guarantees a positive benefit/cost ratio. GCCS and GCCS PLUS "merely" have got the "very simple" intention to realize the ultimate objective of UNFCCC-Article 2 to avoid "dangerous interference with the climate system", irrespective of any benefit/cost calculation – as defined in that article. Meritoriously the EU in June 1996 made two specifications of that objective as already quoted: The European Council has translated this ultimate objective of UNFCCC-Article 2 into a measurable and verifiable target as follows:

"… the Council believes that global average temperatures should not exceed 2 degrees above pre-industrial level and that therefore concentration levels lower than 550 ppm CO_2 should guide global limitation and reduction efforts …" (European community 1996)

It still seems very ambitious and highly appreciable to realize these two targets, especially because there is a clear tendency towards a 750ppm CO_2-concentration (ref. to II.B. and Figure 1 in II.D.)

As shown in Figure 6: By implementing the GCCS-emission path the 550ppm CO_2-stabilization can be reached – but according to newest findings this definitely will not be enough to reach the plus 2°C stabilization by 2100[134]. Therefore only with an implemented GCCS PLUS- emission path (nearly) a 450 ppm CO_2-concentration can be (nearly) reached, and this would imply a pretty good chance to reach EU's underlying plus 2°C target. Besides of much reluctance to clearly define the threshold (because this is called a political question' or a 'value decision' by the IPCC, (TAR 2001/S, p3), at which dangerous interference with the climate start, there seems to be nowadays a very great accordance among 'climate change scientists' and activists, that the 2°C-target is the only one, that most of all scientists can agree on. (Ref. to European Climate Forum/PIK 2004)

The resulting benefits would lie – according to EU's definition – in the difference between dangerous and non-dangerous, that is to say still acceptable or bearable climate change and its resulting weather and other effects and especially the velocity and the growing force of those effects (for instance the magnitude and the frequency of extreme weather situations, e.g. hurricanes, cyclones and typhoons). The "benefits" of a decelerated climate change for instance would be a lower magnitude of those thunderstorms or of draughts and its resulting impacts – or speaking of an different form of climate change impacts : It makes a big difference if the total melting of Greenland's glaciers with an overall global rising of the sea level of 7 meters takes 500 or 1500 up to 3000 years – leaving the threatened part of mankind very

[134] According to the Commission of the European Community, which refers to a compilation of more recent studies estimating climate sensitivity (Hare/Meinshausen 2004), "…limiting the temperature rise to 2°C will very probably require greenhouse gas concentrations to be stabilized at a level even lower that 550 ppm $CO_{2eq.}$." (CEC 2005b, p.5) This consequently would imply to reach the 450 ppm CO_2-stabilization curve of the IPCC shown in Figure 1 and in Figure 6.

little or much more time for adaptation (for instance for building of adequate dams or a chance of gradual retreat from flooding endangered low lying areas). This example illustrates the bad truth about the "benefits" of an efficient climate policy too: The effect of such a policy will be "nothing but" the 'downgrading' of the threatening effects of climate change. But: "Avoiding dangerous climate change" - is exactly that what the global community in the UNFCCC was and is calling for. Nothing better can be reached!

XI.A.2. Conceivable monetary benefits of the introduction of GCCS PLUS according to DIW's "Wiagem model" calculations and the resulting benefit/cost ratios

As already stated before: It is not the intention of the author, that GCCS or GCCS PLUS should realize a global climate change mitigation system that guarantees a positive benefit/cost ratio. To realize the climate targets of the EU to prevent dangerous climate change by way of a – principally – most efficient cap and trade scheme has such a high benefit for mankind that no additional benefit/cost ratio–foundations seem to be necessary.

Irrespective of this remark: Of course those benefit/cost-calculations have a high political impact in order to convince reluctant governments and companies to start as well into an efficient climate policy. In such a calculation one has to compare the benefits of – for instance – an implemented cap and trade scheme by avoiding a certain percentage of an otherwise unavoidable damage, expressed in monetary terms with the various (forms of) costs (ref. to section IV.A.), that arise from implementing such a scheme.

Claudia Kemfert, head of the environmental section of the German Institute of Economic Research (DIW) with her model WIAGEM for the first time – very bold and very interesting - tries to predict both: On the one hand – the costs of an efficient climate policy (as Chr. Böhringer from ZEW has done it within this study for GCCS and GCCS PLUS with his PACE-IAM model) – globally and for various world regions. On the other hand and above that Kemfert calculates the equivalent benefits of such a climate policy in the form of reduced climate change damage impacts, expressed in monetary values.

Beside the fact, that it is – at least – rather complicated to understand all published details of the calculation and the results of various model calculations of DIW – some parts of results for a 450 ppm CO_2 stabilization (as intended with the GCCS PLUS scheme as well) can be summarized as follows (ref. Kemfert 2005b, p212seq. plus some additional personal information):

- According to the WIAGEM-modelling the stabilization of global emissions on a 450ppm CO_2-concentration-level would result in (non-cumulated) costs (for the year 2050) of globally 430 billion US $ in 2002 prices (discounted with a 2% interest rate).
- The equivalent 2100 costs (in 2002 prices) would be 3 billion US $.
- DIW states, that a later start of an efficient global climate protection policy (2025 compared to 2005) (efficiency derived out of a mix of various policy approaches) would result in an additional plus 10% cost-margin – the later start implying a temperature increase of globally plus 3.5°C instead of 2°C as targeted by the EU – and with much higher climate change caused damages. (By the way: Realistically an efficient globally coordinated climate policy will – <u>if at all</u> – not start before 2013, when the first commitment period of the Kyoto Protocol ends and a 'new stage' of the KP could start.)
- Based on the assumption of a linear correlation between (higher or lower) temperature increases (resulting from climate change) and (monetary) damages in seven categories (ecology, forest, water, heating, cooling, health and numbers of deaths): DIW calculates, that the quoted invested 3 billion US $ in 2100 (and similar amounts in all previous years starting in 2005 in order to reach the 450 ppm CO_2-concentration - stabilization) would lead to a reduction of climate change damages up to 12 billion US $ in 2100, 'representing of around 5% of the predicted global gross national product' (p214).

Given the validity of those quoted results of the highly reputable DIW, one can resume: The damages resulting from a non-restricted climate change are (much) higher than the costs for an efficient restriction. An efficient climate change policy to reach 450 ppm CO_2 stabilization (nearly) equivalent to the plus 2°C-target "pays off". And this would consequently

mean: The realization of the GCCS PLUS scheme will and would be – speaking in monetary and in environmental terms – highly profitable.

Based on those quotations of the DIW one can be even more precise as far as benefit/cost ratios are concerned:

- DIW predicts with the above quoted 2100 figures an deficiencies excellent benefit/cost ratio of 4 to 1 (mitigation policy costs of 3 billion US $) compared to a reduction of climate change damages up to 12 billion US $, 'representing of around 5% of the predicted global gross national product'. Therefore the quoted 3 billion US $ costs would represent around 1.25% of the global GDP.
  Note: These quoted cost calculations deviate significantly from the PACE IAM model calculations of an implemented GCCS and GCCS PLUS in section IX.D.. In Figure 14 it is shown, that in the year 2100 the GDP-loss compared to the business as usual situation will be around 0.5% of the global gross national product. WIAGEM and PACE IAM are both CGE-models with – according to Ottmar Edenhofer, PIK, Potsdam Institute[135] – a low implementation of potential technological and therefore they usually have a pretty high estimation of the costs of an efficient climate mitigation policy compared to other pertinent macro economic models. (Ref. Edenhofer/Lessmann/Kemfert/Grubb/Koehler, 2006). But the deviations of both quoted CGE-Models are significant. One reason could and probably will be, that Böhringer in IX.D. did implement backstop technologies like CCS for fossil stationary plants and renewables and others. According to the pertinent literature, (ref. to sections VIII.A. to VIII.D.) there exist realistic backstop prices of 35$ per ton of CO_2 (between 2015 and 2030) and 25$ thereafter. Therefore the CGE-typed PACE IAM-model did predict much less and pretty moderate GDP-losses for definitely efficient climate policy by the GCCS PLUS-cap and trade scheme.
- Given DIW's reduction of climate change damage by 5% around the year 2100 and the here calculated 0.5% loss of global GDP (ref. to Figure 14 in section IX.D.) this would an extremely excellent benefit/cost ratio of 10 to 1!
- This would imply: Every dollar or euro, spent within the implementation of the most effective GCCS PLUS (because, if implemented, definitely realizing nearly 450ppm CO_2 and therefore realizing a stabilization of the temperature increase by around 2.3° Celsius, ref. to Figure 12 in IX.D.) will have within this most efficient global cap and trade scheme GCCS PLUS a benefit of 10 dollars or euros by reducing climate change damage expressed in monetary value!

XI.B. The political acceptability of GCCS and GCCS PLUS by integrating the results of the macro-economic, the price- and the transfer sum investigation

To get a better understanding of the political acceptability of the GCCS and of GCCS PLUS because of its economic impacts that arise from a GCCS-implementation one has got to integrate the results of the price-, the transfer sum investigation and the macro-economic analysis in this report.

XI.B.1. Acceptability of the GCCS in view of price increase impacts

The conceivable price effects by implementing GCCS and GCCS PLUS have been discussed in detail in chapter VI. The conceivable price- and other effects can be summarized as follows:

- Shortly after the GCCS-start there will be very moderate cost and price effects, i.g. plus 0.45 resp. 0.5 cts per litre or 1.7 resp. 1.9 cts per gallon of petrol resp. of diesel.
- CC-cost driven price increases in later years in the first GCCS-decade 2015 till 2024 in industrialized countries ('mixture' out of 2 $/CC allocation to fuel and resources pro-

[135] The author wants to thank colleague Dr. Edenhofer from PIK for a personal information about this aspect.

viders (FRPs) and max. 30$/CC at the free market) could amount to 1.4 resp 1.6 cts per liter or 5.3 resp. 5.9 per gallon of petrol resp. of diesel.[136]

- In developing countries (DCs) the price increases because of higher CC-costs should be much lower (up to zero percent): Those cost driven price effects will depend on the allocation system in DCs (DCs can allocate as many CCs as their national economy does need (including an expected CO_2-growth based on a projected economy growth) and they can allocate these CCs for 2$ or even for free). Nevertheless: Those fuel and resources providers (FRPs) in DCs that want to expand their sales of fossil fuels have to buy CCs at the free CC market with a maximum 'price cap'-price of 30$.
- As far as there exists no national regulation of fuel prices on national markets (such a price regulation exists in many Asian and other countries, see below), there will be a tendency of FRPs (in non-price regulated markets) to raise the prices of fossil fuels according to the marginal prices at the free market (maximum (price cap!) 30$ per CC) (Refer to section VI.D.). This would be equivalent to a significant increase of fossil fuel prices: 6.75 resp. 7.5 cts per litre or 25.5 resp. 28.2 cts per gallon of petrol resp. diesel.
- In case the 'marginal price'-induced price policy would be realized by FRPs (in non-regulated, free markets) and because of than very big difference between 'factual cost-born' and 'marginal costs-born' price increases, enormous 'GCCS-born' wind fall profits of FRPs (for instance multinational integrated oil concerns) would arise.
- The political consequences of the compilation of such aforementioned prices increases plus multi-billion windfall profits could not be politically borne by any (democratic) government. Therefore: At least in non-price regulated fossil fuel markets (and a marginal price behaviour of FRPs) there should be a CC-allocation according to the CC-price at the free CC market of the preceding year – thus (nearly) adjusting the primary allocation price to FRPs to their 'marginal cost' price at the free market. The consequences: No GCCS-born windfall-profit and high earnings of the national certificate banks (NCCBs). The earned money should and must be spent for an equal per capita distribution to all citizens of the relevant countries. (Refer to sub-section VI.D.4.c.)

Given those described GCCS-born price (and windfall profit) consequences in various country groups: What does that mean for the political acceptance of the GCCS?

- First of all one has to consider: Whereas GCCS – in general – is a uniform system, it differentiates between states above the globally tolerable 4.9t of CO_2 per capita-level (mainly industrialized countries) and countries below that level (mainly developing countries). The latter get enough CCs for their national economy (growth) and even surplus CCs, to be sold to the World Climate Certificate bank (later transferred for 2$ per CC to the ICs). Industrialized countries (ICs) have to buy CCs. FRPs ICs get only parts of required CCs by the national allocation and have to buy parts of their required CCs at the free market.
- Developing countries with low absolute fossil fuel prices (low fuel taxes and/or subsidies like in many Asian countries) and a living standard of less than one $ per day of a huge part of the population, – politically and socially – are pretty vulnerable by increased fossil fuel prices and resulting price increases at the (public) transport sector[137]. Big price increases without a compensation of the loss of purchasing power would be a great acceptance barrier for the GCCS. But: Many of those states have a price regulation and a subsidized fuel prices too.
- In principle those states with price-regulated and partly subsidized fuel prices can stabilize the fuel prices, irrespective of the factual GCCS-born cost increases. In those countries of course their will be a tendency too of national FRPs to 'marginal cost' born price increases. But: Because of the price regulation it will be much easier in those countries to limit at least price increases to the factual costs (CC-allocation price plus a very small percent of CCs, to be bought for an expansion of fossil fuel sales of cert-

[136] Given an at least 85% 2$/CC–allocation to FRPs and the need to buy for 15% of the CCs at the free market for the price cap maximum of 30$ per CC. Ref. to Table 8 and Table 9.
[137] Ref. Frankfurter Allgemeine Zeitung (FAZ): Asien stöhnt unter den hohen Ölpreisen. Sept. 29, 2005, p.16.

the costs of FRPs to buy additional CCs at the free CC-market). A potential change in public subsidies to keep the consumer prices near the same level as before could be coordinated with the so determined factual cost increases for CCs of the FRPs.

- Price regulation and subsidizing at the same level may and will not be possible for ever and therefore also GCCS born price increases can be unavoidable. The tendency of a (partly) marginal price behaviour of FRPs (price increase to a level of the CC-price at the free market) would imply a significant rise of fuel prices. To avoid political and social turbulences in such a situation the CC-allocation by national climate certificate banks (NCCBs) to FRPs should be changed. Instead of a free or a 2$ per CC allocation the allocation price should be close to the price of certificates at the free market. This would imply high CC-revenues of the NCCBs which get their CCs free of charge (4.9CCs per head) by the WCCB. In order to make the resulting price increases tolerable by vast parts of the national population this specific revenue (from the CC-allocation to national FRPs) should and must be spent for an equal per capita distribution to all citizens of the relevant countries. Above that one has to consider, that the NCCBs and the developing countries governments get a very significant amount of revenue from the sales of surplus CCs to ICs, that has got to be spent for the implementation of their plans for (climate friendly) sustainable development and elimination of poverty (SDEP-Plans).
- Such an equal per capita distribution is equivalent to an increase of income for the poor and most parts the population in those countries (which will normally not be levelled of by the increase of the fuel (and transport) prices). The implementation of the SDEP-Plan, financed out of 'GCCS-income' additionally will be of great benefit for the poor too. Therefore there seems to be a good chance, that the price impacts of the GCCS in developing countries could be politically 'handled' with no or only small political disturbances at the start of the GCCS. The GCCS-price cap (30 $ per CC and ton of CO_2) will be ensure that the price increase is limited.
- In case it is very likely that fuel and resources providers (FRPs) in industrialized countries would increase their prices according to the marginal price at the free CC-market the CC-allocation to FRPs should be (nearly) equivalent to the above described mechanism with prices according to the CC-price of the preceding year at the free market. (ref. to VI.D.4.c.) A nearly equal per capita distribution of the allocation income (preferably via a functioning tax-system) – according to the above described mechanisms in developing countries – will increase the acceptability of the GCCS in ICs too.
- Not withstanding such a general acceptability of the GCCS by the general public, acceptability problems with those groups of the population (mainly in the transport sector) that are most affected by price increases couldn't be avoided. And of course: A GCCS-born rise of the price at a maximum of around 6.75 resp. 7.5 cts per litre or 25.5 resp. 28.2 cts per gallon of petrol resp. diesel – which would mean a doubling or even higher increase of tax-like burdens in various countries with extremely low tax burden like the USA gasoline tax 18 cents per gallon would be a heavy burden for the public and the politicians. (Note: In Germany the Eco-tax has started with 3 euro-cents per liter and has amounted within 5 years to an additional levy of altogether of 15 cents per liter (respectively 55 cents per gallon. And remind: All citizens would and could get back a huge amount of these fossil fuel price increase burden by a nearly equal per capita tax reduction!)

XI.B.2. Acceptability of the GCCS in view of national economies' gains and burdens in transfer sums

The GCCS-impacts referring to the transfer sums can be summarized (ref. to X.B. to X.D.) as follows:

- Because most of the developing and newly industrialized countries in the (assumed) starting year 2015 of the GCCS have a per capita CO_2 emission (far) below the 'tolerable' per capita average of 4.9 tons they will get more or less significant transfer sums, to be used for the implementation of their SDEP-plans.

- Those countries that are most endangered by the adverse effects of climate change (i.g. AOSIS-countries) will get additional special aid (mainly for adaptation measures.
- Therefore more than ninety percent of all DCs and newly industrialized countries (including China) are favoured by the transfers of the GCCS. South Africa and Mexico will have a higher per capita emission: Therefore they would have to buy CCs for their CO_2-emissions. Possibly a general relief clause for those countries could be included in a conceivable GCCS-agreement. (ref. to X.D.)
- For most of the industrialized countries the transfer burdens would bearable, normally being only very small parts of the GDP (normally (far) less than one percent.) Australia would have a significant burden and would be affected by the GCCS impacts for fossil fuels (coal) producing countries.
- Some USSR-successor states would have a significant GCCS burden (more that 1% of the GDP) – which would mean that there should be some general relief clauses for those countries too in order to reach their acceptance (possibly in combination with favourable links to other international agreements).
- Oil producing countries with a (very) high per capita CO_2-emission (especially in the middle east) would – because of the high GDP – still have a tolerable transfer burden. But they affected also by the GCCS-price effects that principally will have an effect of lowering the price of crude oil at the world market and therefore their terms of trade. Nevertheless those changes in export and import prices of those countries should and could be tolerated because of the enormous increase of the crude oil prices especially in 2004 to 2005.

Therefore: Without neglecting the difficulty to convince some countries because of GCCS-transfer and other burdens, with some (general) relief clauses and linking the discussion about the GCCS with other international matters and agreements, there should exist the possibility to reach acceptance of the above named countries (or countries that are in a similar affected group).

XI.B.3. Acceptability of the GCCS in view of the marco-economic impacts

The macro-economic impact analysis in chapter IX has clearly shown that the costs for the implementation of GCCS/GCCS PLUS would imply a relatively modest reduction of the GDP (compared to the business as usual situation within the PACE IAM - model) both in the course of time of the investigated 21st century (ref. to Figure 14 in IX.D.). For the regions, whose effects have been explicitly calculated the welfare effects of the implementation of the GCCS and GCCS PLUS can be shown in table Table 17 which is identical with Table 13:

Table 17: Welfare impacts (% change in lifetime consumption[138])

	GER	EUR	OOE	CHN	IND	LAM	ROW	World
Kyoto	-0.05	-0.08	-0.07	0.06	0.00	-0.05	-0.07	-0.06
Kyoto_Plus	-0.07	-0.12	-0.12	0.14	0.04	-0.06	-0.08	-0.08
GCCS	-0.15	-0.11	-0.31	0.16	0.97	-0.27	-0.58	-0.22
GCCS_ PLUS	-0.17	-0.15	-0.33	-0.01	0.74	-0.35	-0.71	-0.29

Abbreviations: Europe **(EUR)**: Western Europe without Germany, Central and Eastern Europe / Germany **(GER)** / Other industrialized regions **(OOE)**: North America, Pacific OECD, Former Soviet Union / Latin America and the Caribbean **(LAM)** / India **(IND)** / China **(CHN)**/ Rest of the World **(ROW)**: Africa, Middle East, Non-Industrialized Asia

[138] The 0.29% **change, respectively loss in lifetime consumption** of the world by implementing GCCS PLUS means: The world would need to be given 0.29 % of its business as usual income, to be materially and economically as well of as without the climate efficient GCCS or GCCS PLUS policy. Therefore the change in lifetime consumption is an accurate intertemporal welfare measure of the impacts of a policy change.

Looking at those figures one has to state, that the macro-economic effects of the implementation of GCCS and GCCS PLUS (latter nearly reaching a 450ppm CO_2-stabilization) is rather limited – compared to the following considerations:
Within the first commitment period of the Kyoto Protocol between 1990 and 2010 (2008-12) the cost impacts for various Annex I countries are pretty low, because only some countries like Germany, Great Britain and others really made some substantial efforts to switch from the business as usual path to a more climate friendly path in order to comply with their reduction commitments. To a certain extent those efforts led to a higher climate und energy efficiency therefore being relatively easy to implement. This situation will be changed substantially in the future:

> "Cost concerns will become even more critical in the next stage of climate diplomacy. …. Any effort to deepen and broaden mitigation commitments will present larger cost issues that those encountered thus far. For developed countries, stronger commitments will push efforts past "no-regrets" measures like improved energy efficiency and force deeper shifts in capital investment."(Aldy/Baron/Tubiana, 2003 p86)

Besides of those different GDP-cost-consequences for various world regions and big states like China and India: The (negative) GDP[139]-effects in certain regions have in general a 'decent' magnitude, whereas the positive effect for India is substantial (an increase of lifetime consumption[140]) of close to one percent). In case those gigantic world regions like ROW would be divided in parts, non-oil producing developing countries and 'other oil producing and industrialized countries' would be viewed separately, one would get positive macro economic impacts to the first group too (for some states similar to India). Consequently the welfare losses of the latter group would be higher. The welfare losses of LAM (Latin America and Caribbean) should be investigated further. This group is pretty heterogynous too – 'typical' developing countries will be benefited too (in a magnitude below India's).

Besides of all those – limited – macro-economic benefits and burdens one has to bear in mind the extremely positive benefit/cost-ratio of an efficient global cap and trade scheme, that have been described above in subsection XI.B.2. as follows:

- Given DIW's reduction of climate change damage by 5% around the year 2100 and the here calculated 0.5% loss of global GDP this would an extremely excellent benefit/cost ratio of 10 to 1!
- This would imply: Every dollar or euro, spent within the implementation of the most effective GCCS PLUS (because, if implemented, definitely realizing nearly 450ppm CO_2 and therefore realizing a stabilization of the temperature increase by around 2.3° Celsius) will have within this most efficient global cap and trade scheme GCCS PLUS a benefit of 10 dollars or euros by reducing climate change damage expressed in monetary value!

Given that the "real" benefit/cost ratio of an efficient climate mitigation policy in the 'form' of a most efficient global cap and trade scheme like GCCS PLUS has got a similar magnitude as the described one: All negative economic impacts for certain world regions or nations are by far over-compensated by the benefits of an extra-ordinarily efficient climate policy. This would lead to a situation that it would make sense to financially compensate certain macroeconomic and other burdens by some reluctant developing and 'threshold' and some higher burdened countries in transition! (refer to X.B. and X.C.)

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[139] GDP is (a) The total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports. (b) GDP: The monetary value of all the goods and services produced by an economy over a specified period. It includes consumption, government purchases, investments, and exports minus imports.

[140] Lifetime consumption is an aggregate measure of welfare in order to compare the economic impacts of a climate or other policies, the so called Hicksian Equivalent Variation/HEV. It is defined as that positive or negative amount of money that the representative consumer must get additionally to his income in the starting situation in order to reach the same level of benefit like in the new equilibrium with the changed climate policy. By this measure of lifetime consumption it is possible to compare different policy scenarios in their impacts in relation to the business as usual development The above quoted percentage changes for instance for "world" can interpreted as follows: In the scenario GCCS_PLUS the world would need plus 0.29% of its total real intertemporal income (discounted to the year 2000 with a 5% interest rate), in order to have under GCCS PLUS the same real (material) welfare level as under 'business as usual' situation.

XI.B.4. Economic impacts of the GCCS and its political acceptability

The review of the economic investigations within this report leads to the following conclusions:

- The price effects (higher fossil fuel prices) are totally tolerable in DCs with price-regulated fossil fuels markets and in non-regulated markets it will be tolerable too in case the revenue from a market oriented CC allocation to fossil fuel and resources providers would be distributed on a nearly equal per capita distribution to all citizens.
- The transfer gains of most of the developing countries are significant and would boost climate friendly and sustainable development and growth as well as the elimination of poverty. The CC-transfer burdens of some developing and new industrialized countries and some higher emitting industrialized countries (with a low per capita GDP) can be alleviated be some general relief clauses. The oil and coal producing countries normally have a high GDP and could bear the GCCS-transfer- and negative export price impacts for fossil fuels.
- The GCCS implementation costs as welfare losses of an otherwise faster growing economy and losses of the GDP are globally extremely worth while: With a benefit/cost ratio of an efficient global cap and trade scheme the benefits of such a mitigation policy ‘produces’ for every dollar/euro a benefit of reduced climate change cost in the range of 10 dollar or euro. Therefore the cost burdens can and should be borne and therefore an economic compensation of economically higher burdened and economically lesser strong economies should be reachable. To get the absolutely need unanimous acceptance of the GCCS (PLUS) global cap and trade scheme there can and should be a burden sharing between those economically burdened and climate change related benefited countries.
- Irrespective of the economic effects in monetary value terms: Nearly all countries world wide will get great ecological benefits by very significantly reduced climate change and its otherwise more or less extremely negative physical impacts.

XII. Evaluation of the GCCS/GCCS PLUS and its chances and problems to be implemented as a structural evolution scheme of Kyoto I

After the above shown careful evaluation of certain economic consequences by implementing the analyzed global cap and trade schemes for various states, in this study the chances for an objective evaluation of the GCCS (and of GCCS PLUS) and also their perspectives of implementation has been risen compared to the (2003 till early 2005) 'Beyond Kyoto' book 'stage' (Wicke 2005).

XII.A. GCCS/GCCS PLUS – evaluation on the basis of the 'comprehensive standard system for evaluating the prospect of success of climate protection systems'

In section II.D. the 'comprehensive standard system for evaluating the prospect of success of different climate protection systems' has been introduced in order to evaluate as objectively as possible the current Kyoto Protocol according to 4 criteria and 19 sub-criteria. In the following such an evaluation on the basis of the same criteria and sub-criteria will be done also for GCCS and GCCS PLUS. The commented results of the evaluation are shown in the last two columns of Table 18.

To start with the **'paramount' criterion** of any climate protection system – '**climate sustainability or effectiveness**' – the important question here is whether the climate protection targets laid down in the system in question are also implemented and the climate goals be reached.

1. GCCS and GCCS PLUS in fact 'automatically' will produce incentives for a lowering of the emission increase in developing countries: The less emissions they release the higher the surplus of CCs is they can retransfer for the fixed transfer price of 2 (5 and up to 10) US$ respectively – by staying under the business as usual line – even by selling those surpluses at the free climate certificate market (ref. to III.B. point 5). Therefore: Both GCCS-schemes for the first will make a climate friendly behaviour of developing countries 'profitable', because they can thus earning for the implementation of their sustainable development and elimination of poverty (SDEP-) plans. Consequently this sub-criterion is fulfilled completely – 4 out of max. 4 points.
2. Both schemes are 'demanding' – indirectly – for fast, substantial reductions of industrialized countries' emissions: The higher the emissions are they higher are transfer payments. Above that all fuel and resources provider has got to buy climate certificates at the free market for a price up to 30/60 or 90$US, if they want to increase their fuel sales or can sell its CCs for the (high) free market price. Because within GCCS PLUS there exists an even more stringent cap (yearly global reductions starting in 2030, down from a 30 billion tonnes of CO_2-cap) the economic incentives will even higher. (Ref. VIII.E.2.) There GCCS PLUS gets 8 instead of 7 points (as GCCS) out of max. 10 points for the good performance in that respect.
3. As explained: The two cap and trade schemes will be – financially and economically – be very attractive for developing countries, thus giving a very good chance for a fast and active participation of developing countries in the international climate protection process. (4 of maximum 4 points.
4. By GCCS and GCCS PLUS developing countries get transfer money for their SDEP-measures and – being most endangered countries – additional money for adaptation to climate change. Therefore these to schemes provide a good deal of the financing of emissions reductions in developing countries (4 (3) out of 4 max. points). The GCCS PLUS is evaluated less positive in this respect, because as soon as (starting in 2030) there will be lower global cap, developing countries will get decreased transfer funds. (ref. to VIII.B.2.)
5. 'Early actions' of climate friendly investment are rewarded by cost savings in the future because of less CO_2-intensive production or consumption - as soon as there exists a relatively good chance that such a global cap and trade scheme would be implemented (4 out of 4 points)
6. Within such global cap and trade schemes there can be no shifting of emitting productions to non-included countries (as well 4 out of 4 points).

7. GCCS and GCCS PLUS induce a permanent interest of states, firms and individuals in a climate friendly behaviour – the global emission cap causes scarcities and resulting price increases that make a climate friendly behaviour profitable. (10 out of 10 points).
8. Both schemes have – by way of global caps – clearly defined climate protection targets, that can be reached in case the systems are completely implemented. (The probability of a significant and permanent surpassing of that cap by selling CCs by the World Climate Certificate Bank is pretty low: Renewable energies and the pretty inexpensive CCS-technologies are so called 'back stop' technologies that will be widely introduced as soon as the (future) marginal price per tonne of CO_2 of 30, 60 and 90 US$ will be 'visible' and very likely. (6 out of 6 points)
9. As shown in section V.B.: Within a global cap of energy related CO_2 emissions there exists no 'hot air' at all, that can jeopardize the targeted climate change mitigation strategy: All CO_2 emissions world wide would be within that global cap as long as long there exists a full compliance of all states with that certificate system. Therefore no additional CO_2-emissions beyond the internationally agreed global cap can be introduced in this system. In this sense: there can be no 'hot air'. But: Because this is partly a matter of definition – developing countries indeed get (before redistribution) internally unneeded surplus CCs – and to be on the pessimistic or 'secure' side of the evaluation the two cap and trade schemes get 2 out of 4 points regarding the sub-criterion of the avoidance of 'hot air'.

In total – besides of different evaluations of two sub-criteria – GCCS and GCCS PLUS are awarded with **excellent 45 out of 50 points regarding** the 'paramount' criterion of any climate protection system – **'climate sustainability or effectiveness'**. Nevertheless one has got to recall, that GCCS PLUS is striving for reaching the 2°C-target (equiv. to 450 ppm CO_2), ref. to section VIII.E.2.. On the other hand: GCCS is striving for the (much) less stringent target of 550 ppm CO_2 (nevertheless being pretty ambitious too – compared to the 750 ppm direction of IEA's reference scenario projection till 2030).

As far as the **economic efficiency** is concerned, in short the following can be said (for more details ref. to Wicke (2005), p127 to 138):

- There can be no doubt: The targets of climate protection can, in principle, be achieved at lowest costs possible with such a system of climate certificate trading (cap and trade) that is based on global and non-country-specific emission limits and the trading of surplus quantities. (Price regulating measures prevent the risk of 'skyrocketing prices' for emission rights that is extensively discussed in literature, ref. to sect. VII.B.) Therefore: 6 out of 6 maximum points for cost efficiency. (The necessary GCCS-market interventions with some deviation from 'optimal' cost efficiency could lead to somehow lower evaluation of that aspect.)
- Every national economy has – within the GCCS-schemes – full flexibility how to react on the market incentives by reactions of policy, individual firms or private households – thus minimizing GCCS adaptation costs. Above that developing countries get important financial assistance (4 out of 5 points).
- By the equal per capita distribution approach the structural differences can be considered only to a limited extent, therefore the most endangered countries will be equipped by additional funds for adaptation to the climate change effects. (3 out of 4 points)
- The growth of developing countries will be favoured by the funds for SDEP-measures in developing countries, the negative growth impact on industrialized countries by transfer payments and higher prices will be limited compared to other less market-oriented climate protection schemes. (2 out of 3 points)

In total GCCS and GCCS PLUS are awarded with 15 out of maximum 18 points as far as economic efficiency is concerned.

Table 19**:** Evaluation of the GCCS and GCCS PLUS in comparison to other climate protection systems studied in Wicke (2005)

		Actual score										
Overall evaluation of climate protection systems according to *main criteria A to D* and their subcriteria for ensuring fulfilment of the main criteria:	**Maximum score**	**Kyoto Pr.**	**Cont.Kyoto**	**MSA**	**NMSA**	**GTA**	**ETA**	**MSCA**	**CAN's FrW**	**(C&)C**	**GCCS**	**GCCS PLUS**
Part A: Climate sustainability (actual score ***(xx)):***	***50***	***(4)***	***(12)***	***(17)***	***(23)***	***(11)***	***(11)***	***(11)***	***(12)***	***(42)***	***(45)***	***(45)***
General incentive to reduce the increase of CO_2 in developing countries	**4**	**0**	**1**	**1**	**2**	**0**	**0**	**0**	**1°**	**4**	**4**	**4**
Incentive / compulsion for fast, substantial reductions in industrialized nations	**10**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3***	**5**	**7**	**8**
Fastest possible involvement of developing countries	**4**	**0**	**1**	**2**	**3**	**1**	**1**	**1**	**1**	**4**	**4**	**4**
Financing emission reductions in developing countries	**4**	**1**	**1**	**1**	**2**	**1**	**1**	**0**	**1****	**3**	**4**	**3**
Favouring "early actions" world-wide	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**4**	**4**
Avoidance of emission shifting effects	**4**	**0**	**1**	**2**	**3**	**1**	**1**	**1**	**1*****	**4**	**4**	**4**
Permanent interest in climate-friendly behaviour world-wide	**10**	**0**	**0**	**3**	**4**	**0**	**0**	**0**	**0+**	**10**	**10**	**10**
Quantified climate protection aim of the climate system	**6**	**0**	**3**	**3**	**3**	**3**	**3**	**4**	**3°°**	**6**	**6**	**6**
Avoidance of "hot air" world-wide	**4**	**0**	**1**	**2**	**3**	**2**	**2**	**2**	**1*****	**2**	**2**	**2**
Part B: Economic efficiency (actual score ***(xx))***	***18***	***(8)***	***(9)***	***(8)***	***(11)***	***(8)***	***(8)***	***(4)***	***(8)***	***(13)***	***(15)***	***(15)***
Cost efficiency: Minimizing global costs	**6**	**2**	**3**	**3**	**3**	**3**	**3**	**2**	**3***	**4**	**6**	**4**
Flexibility during national implementation (minimizing national costs) and financial assistance for development countries	**5**	**2**	**3**	**2**	**3**	**2**	**2**	**1**	**2***	**4**	**4**	**4**
Considering structural differences in climate-related requirements	**4**	**3**	**2**	**2**	**3**	**2**	**2**	**1**	**2****	**3**	**3**	**3**
Positive economic (growth) impetus	**3**	**1**	**1**	**1**	**2**	**1**	**1**	**0**	**1*****	**2**	**2**	**2**
Part C: Technical applicability (actual score ***(xx))***	***8***	***(7)***	***(6)***	***(7)***	***(7)***	***(2)***	***(2)***	***(0)***	***(6)***	***(5)***	***(6)***	***(6)***
Ability to fit into the international climate protection system and the negotiation process	**4**	**4**	**4**	**4**	**4**	**2**	**2**	**0**	**4°**	**3**	**3**	**3**
Easy applicability and control capability in order to ensure practical functioning	**4**	**3**	**2**	**3**	**3**	**0**	**0**	**0**	**2***	**2**	**3**	**3**
Part D: Political acceptance *(actual score **(xx))***	***24***	***(18)***	***(7)***	***(8)***	***(10)***	***(7)***	***(7)***	***(7)***	***(7)***	***(14)***	***(18)***	***(15)***
Fulfilment of the fairness principles												
- Promotion / non-prevention of sustainable development	**5**	**3**	**2**	**3**	**3**	**1**	**1**	**1**	**2***	**3**	**4**	**3**
- Stronger burden on industrialized nations bearing main responsibility and capable of bearing more burdens	**5**	**3**	**2**	**2**	**2**	**3**	**3**	**2**	**2***	**5**	**5**	**5**
Political acceptability												
- Acceptance by all key players (groups of players)	**5**	**4**	**1**	**1**	**2**	**1**	**1**	**1**	**1****	**2**	**3**	**2**
- Acceptance by the largest possible percentage of all contracting states	**9**	**8**	**2**	**2**	**3**	**2**	**2**	**3**	**2****	**4**	**6**	**5**
***Total score*:**	***100* max.**	***37***	***33***	***40***	***51***	***28***	***28***	***22***	***33***	***74***	***84***	***81***

Abbreviations: Kyoto-Pr.=Kyoto Protocol; Cont.Kyoto=Continuing Kyoto (Ecofys), MSA=MultiStage Approach, NMSA: New MultiStage Approach; GTA=Global Triptych Approach; ETA=Extended Triptych Approach; MSCA=MultiSector Convergence Approach; CAN'sFrW= CAN's Viable Framework for the preventing of dangerous climate change (C&)C=Contraction and Convergence Model; GCCS=Global Climate Certificate System; GECT=Global Earmarked Climate Tax

Source for GCCS: Wicke 2005, p. 110/111

Note: Some spectators might be more sceptical about the 'fitting into the international climate protection system and the negotiation process' and therefore evaluating the global cap and trade schemes in total 4 or 5 points in that 'technical applicability' respect. This would imply a score for GCCS/GCCS PLUS of 'only'

As far as **'technical applicability'** is concerned one has to consider that GCCS/ GCCS PLUS are structural evolutions of the KP because they are based on the flexible mechanisms of the KP (and their extension). Their implementation is not bound to some pretty complicated details of CDM or JI. Above that it is much easier to control the flows of coal, oil and gas across the borders and to a limited number of fuel and resources providers than to evaluate and control every single CDM- and JI-project. (Note: Thousands if not millions of such projects would have to be done within an alternative 'incremental evolution' of the Kyoto Protocol in order to have the same climate change decelerating effect plus (within the same follow up of the KP) a similar effect of cost efficiency (= minimizing of global costs) as within a global cap and trade scheme like the GCCS.)

On the other hand: GCCS and GCCS PLUS would be a (significant) change as far as there would be no longer any national commitments and no direct national implementation and realization of those commitments. In total: 6 out of maximum 8 points for 'technical applicability'. For more details refer to Wicke (2005, p138seq). Note: Some spectators might be more sceptical about the 'fitting into the international climate protection system and the negotiation process' and therefore evaluating the global cap and trade schemes in total 4 or 5 points in that 'technical applicability' respect.

Highly disputable is the aspect of the '**political acceptance**' (ref. to Wicke 2005, p144seq). Within the relevant sub-criteria shown in Table 19 only general evaluation of the political acceptability of GCCS and GCCS PLUS on various groups of countries is possible. (In a more detailed manner such an evaluation has been done for some individual countries – according to the individual cost and financial burdens – in previous sections X.A. to X.C..)

- First of all there seems to be a high probability that a very large percentage of all countries would – after a longer discussions about the pro and cons – accept the GCCS. For nearly all developing countries (G77 = Group of 77 and China, including AOSIS states as well as the group of least developed countries) – irrespective of the price effects (that can be made politically acceptable) – the GCCS would be profitable by gaining funds for the implementation of their SDEP plans and for an acceleration of their (hopefully sustainable) growth. The European Union – being really dedicated to combating climate change – after quite detailed discussions should after all accept such an efficient and global cap and trade scheme too. Because some more countries out of other groups should be willing to accept a global cap and trade scheme before the background of the sketched 'acceptance background', there should be at least a two third majority of all states for the GCCS. (Therefore 6 out of max. 9 points for the GCCS. GCCS PLUS gets only 5 points, because the higher emission reduction target of that global cap and trade scheme implies a lower tolerable per capital emission from 2030 onwards and therefore less financial funds for developing countries.)
- Nevertheless: Because some states within those groups will and might have a diverging opinion to GCCS this large majority of probably approving states might not be equivalent to a total group approval (groups of key players). And of course it will be difficult to convince most of principally opposing states like Australia, Russia and other former USSR-successor states, USA, South Africa, Mexico and various oil producing countries especially in the Middle East to accept GCCS and GCCS PLUS. That's why these schemes get only 2 points out of a maximum of 5 for the sub-criterion of 'acceptance by all groups of players'.

Because of the shown evaluation of GCCS and GCCS PLUS the **overall evaluation** of those two global cap and trade schemes closes with an **excellent score of 84 respectively 81 out of 100 points.** Therefore GCCS and GCCS PLUS must be termed in principle as extraordinarily well-suited climate protection system. (GCCS PLUS being even more suited for an adequate climate change mitigation but with higher demands for political acceptance.)

XII.B. Theoretical and practical problems and chances for the Implementation of an efficient Global Cap and Trade Scheme compared to further Kyoto commitment schemes

The above explained excellent scores of GCCS and GCCS PLUS is not identical with excellent chances for implementation. Whatever Beyond Kyoto I system beyond 2012 will be discussed, it will be of great difficulty to get an unanimous vote in the conference or in the meeting of the parties (COP/MOP). Therefore finally those chances have to be discussed in the following.

XII.B.1. The free rider / public good problem

Irrespective of the approach of international agreements for mitigating climate change there exist several big problems to install an effective climate protection system. The lack of a supranational authority aggravates the problems resulting from the public good character of the global atmosphere and results into the 'multiplied global commons problem' with climate protection, which can shortly be described as follows (Wicke 2002a, p.37seq.):

> Each individual private household, company or country contributes only to a small, at best to a restricted (USA, approx. 20%), degree to climate destruction. The contribution towards global climate protection is just as low and extremely restricted. This familiar collective asset problem with climate protection is aggravated further (with the trend towards 'free riders') by the following aspects:
>
> A climate-influencing reduction can only be achieved, if at all, by all the players affecting climate. This joint action, this ***global*** joint action will take on responsibility and to implement is not yet recognisable and can hardly be expected.
>
> As long as climate protection is not possible at no extra cost or even with added revenue (e.g. through energy savings), but continues to be linked with higher costs and sacrifice of whatever kind, citizens living today (and voters in the majority of countries) must be become convinced that they must bear costs and sacrifices (above all) in the interest of future generations.
>
> In view of the haziness of forecasts on the impact of climate development/climate change (even the IPCC doesn't dare to define quantitatively at what level 'dangerous interference with the climate' starts!), it is very difficult to forecast with certainty
>
> whether future generations in one's own country (one's 'own' children and grandchildren) will have 'climate disadvantages' or even advantages (e.g. more favourable climate) and
>
> when (in 10, 50 or 100 years?) the impact of the – minimum, usually not 'measurable' – effect of reduction of one's own actions will be felt.
>
> These are hence additional – completely uncertain – preconditions for the vast majority of voters to accept the disadvantages of climate policy for themselves. This implies with (almost) certainty that voters and politicians alike – just as with the "usual" political problems – will decide in favour of current welfare and – unfortunately – against the welfare of future generations. This is particularly true when it comes to serious restrictions and disadvantages which are to be expected (on the basis of current findings) in conjunction with the very high climate gas reductions rates required in particular in industrial countries and/or the serious emission-related 'growth curb' in developing and threshold countries. This is why each individual climate protection policy is doomed to failure, no matter how committed it is. This can already been seen, for example, with the initial, still very low reduction commitments according to the Kyoto mechanism (and the related, relatively slight increase in prices and disadvantages), for instance, in the blockade behaviour exercised by the USA. Nobody in the EU should "hide" behind the bad example set by the USA and should not be deceived: If really serious sacrifices are expected, the majority of European voters and European politicians will behave just like the political class in the US!
>
> At first glance, it appears that this fatal logic of the "multiplied global commons problem of climate protection" can only be overcome by an incentive-based climate protection system that makes it possible to mobilize the economic interest of all the players in climate protection and hence to boost eco-efficiency enormously and reducing mitigation costs to the lowest possible level.

The rationale behind free-riding in climate policy is to save abatement costs while benefiting from abatement efforts of other countries. Although all countries could be better off it they behaved in a cooperative way, each country working only in its own best interest has an incentive to take a free-ride (leading to the well-known ‘tragedy of the commons’)[141].

From a political economy perspective, the pessimistic view on the prospects of effective and efficient voluntary international cooperation may be even worsened when accounting for the long-term nature of climate change and larger uncertainties on the benefits from greenhouse gas emission abatement: Major greenhouse gases, such as CO_2, are stock pollutants that remain in the atmosphere for several decades before they disappear due to the natural rate of decay. Short-term abatement efforts will then generate rather visible adjustment

[141] This and the following section has been formulated by Chr. Böhringer.

costs, but will only produce rather uncertain benefits in the very long run (ref. to section VII.B.) – if voters are shortsighted, politicians may not have an incentive at all to undertake costly abatement. Various critical assessments of the Kyoto negotiation process conclude that the fundamental incentive problems in climate policy have already played a major role in boiling down the environmental effectiveness of Kyoto Protocol to rather symbolic policy. (Böhringer 2002, Böhringer and Vogt 2003, 2004). It thus remains an open challenge as to how foster participation *in* and compliance *to* stringent long-term global greenhouse abatement activities.

Because of these definitely existing problems and given the fact that the international community shouldn't resign before those and further problems the main question is: Can those problems be overcome more easily by the various approaches of incremental evolution of the Kyoto commitment system or by a global cap and trade scheme like the GCCS – based on a 'hybrid system' by 'a global emission cap and trade' plus a price cap (the latter functioning as an alternative 'tax' price)? In other words: Which approach opens a better chance for a climate change effective international agreement and a better chance for acceptability of such an agreement?

Without going into the details in this section of evaluating both systems systematically (as has been done in sections II.D. and in XII.A.): In fact, there seems to be some evidence that the global cap and trade GCCS-approach has got better chances to reach both mentioned targets in overcoming the aforementioned systematic public or common good problems more easily.

XII.B.2. Climate change effectiveness: Commitments versus global cap and trade

First of all it seems very clear, that – because of the 'free rider incentives' – Kyoto-typed national voluntary commitments of some national states will never result in a total amount, that there can be a limit and (later) a reduction of global emissions to an extent to come close to the intended target of avoiding dangerous climate change in order to reach a 550 or even a 450ppm CO_2-concentration:

- As shown during the Kyoto Protocol negotiation phase only industrialized countries and successor states of the Soviet Union (as 'countries in transition') were willing at all to commit to a certain restriction of CO_2-emissions growth respectively of a constant or even reduced emissions. As shown elsewhere these commitments over 20 years of a total reduction of those quoted states by 5.2 percent would have let to a reduction of the global CO_2-growth starting 1990 with 21.2 bn tons of $CO_{2equ.}$ to 27.7 bn tons (or plus 30.7%) instead of to 29.4 bn tons (or plus 38.7%) till 2010 (WRI 2001). Those commitments therefore were far to low – besides of the problem of not complying with their commitments (ref. to section II.B.) – to have a relevant impact on the velocity of climate change. (Note: a total 'stock' of around 27,100 billion tonnes (27.1 *trillion!)* of CO_2, IEA 2002a, p151 being in the atmosphere in 2010 ,IEA 2002a, p151). A resumed 'commitment' negotiation on the bases of 'completely failed' first commitment period (instead of the quoted 5.2 per cent reduction of greenhouse gases by 2010 an increase of 25.3 per cent of CO_2 of the OECD-countries) will have the same or even a worse effect concerning far to little commitments for reduction, that can change the negative tendency in the long run.
- Besides of the above quoted 'free rider' tendency the situation for second-term pledge of effective commitments has even been worsened dramatically: After the failure of most individual states of the quoted group of states to comply with their 1990 to 2012-commitments they will be even much more reluctant to commit to a significant reduction or limitation margin that possibly can't be complied to or will have negative effects to their specific national economy while not affected other economies are competing.
- Because of the before mentioned emission- and commitment-situation of industrialized countries developing and newly industrialized countries definitely once again and even with more emphasis will reject any limits of their emission growth!

Neither industrialized countries will make sufficient reduction commitments nor exists the possibility to integrate developing or threshold countries that have an especially high CO_2 emission growth. Therefore: There seems to be no chance at all that the Kyoto commitment

– approach will ever lead to the climate change related necessary global limits or even to the necessary reductions!

On the other hand there seems to exist a much better chance to define and – possibly – also to reach a climate effective global limit by a global cap and trade approach like the GCCS:

- Besides of possible controversies between states and their experts about the definition of 'dangerous climate change' there will be – after a phase of discussions – a consensus about a stabilization of the temperature increase between 2 and 3°C. And this would consequently mean – according to IPCC-findings – a CO_2-concentration limit (may be) between 450 and 600ppm. And for those and other concentration levels the IPCC shows stabilization lines for this century and beyond (ref. to Figure 2 in II.D.). These lines give a clear indication how much CO_2 can be emitted (for example totally over the time for instance till 2100) if such a stabilization shall be successful.
- No doubt: All international 'players' would know, if they decide to implement a global cap and trade scheme with the target to avoid dangerous climate change, that this would definitely imply serious global emission constraints. But contrary to the above outlined commitment approach: There would be **no** individual national commitments that have to be fulfilled mainly by a pretty difficult to implement and normally (to a high extent) ineffective national policy (incentives or political directions) and can be fulfilled by additional flexible mechanisms. Therefore with a high probability there will be no second term - commitments of industrialized countries.

  Contrary to this: The global constraints within such a cap and trade scheme would be 'imposed' by 'price based' cap and trade market incentives! Above that: GCCS has got a design that no economy would be overburdened and that all over the world there would be similar competitive situations related to emission restrictions. The national political system – together with the World Climate Certificate Bank – 'merely' has to make sure, that the elements of GCCS are implemented completely. (With a mixture of incentives and effective penalties and restrictions it can be made worth while for most participants to stick to the GCCS-rules (ref. to supervision and enforcement of GCCS: Wicke 2005 p195seq.).
- This situation – at least in principle – would make it much easier for national governments of industrialized countries to 'commit' to such a global market oriented cap and trade scheme. Because most of the developing and newly industrialized countries would have economic benefits from such a GCCS/GCCS PLUS system they could – even much easier than industrialized – agree too.

Therefore: With the global cap and trade scheme (by way of a structural evolution of the KP) indeed there exists at least a chance to realize an international climate protection system that can be climate change effective!

XII.B.3. Political acceptability: Commitments versus global cap an trade

As shown above: There exists no chance at all, that the sum of all potential commitments of industrialized in a second or following commitment periods will ever lead to climate change effective amount of global emission reductions.

What is more: After the very disappointing first commitment period with a substantial overshooting of nearly all committed countries or regions (ref. to II.B.), with two important non-ratifying countries (USA and Australia with therefore Zero-Commitments) and with further non-committed important competitors on the world market (like China, India, Brazil and Argentina) there seem to be **nearly no chances at all, that Kyoto I** (commitment period 1990 to 2008-2012) **will have any (successful and substantial) successor commitment period**, **based on national commitments**.

Such a forecast is strongly backed by remarks of the British government in September and October 2005 (Der Tagesspiegel October 10th, 2005), a government always being very climate protection and Kyoto Protocol committed, that signals a deep scepticism about a Kyoto I successor regime based on binding (national) emission restrictions. The British environmental minister Margret Beckett said that she is pretty sure, that a second Kyoto-

agreement will not look like the first one, especially because such an agreement should and must include for instance China, India and Brazil. And: The British Prime Minister Tony Blair said – according to the protocol of conference organized by Bill Clinton nearly literally (re-translation from a German translation): "I want to say it with brutal honesty: No country will restrict its growth or its consumption because of environmental policy reasons. Some countries ratified Kyoto, some didn't. These differences will never be solved."

This remark of the Prime Minister and the above quoted remarks of his environment minister – at least – clearly show that UK as one of the most ambitious countries (being highly climate change endangered itself), that fought and fights intensively for an efficient climate change mitigation policy, is not willing at all to have binding national emission restrictions after 2012. If even such a country like Great Britain is rejecting binding national commitments than it is very easy to predict how the majority of much less climate policy committed countries will be positioned when it comes to negotiations and decisions of the follow up of Kyoto I (till 2012). The Montreal COP 11-success (Dec. 2006) of a mandate for further discussions about a Kyoto II – in the eyes of the author – is not all equivalent to be convinced, that in Kyoto II the same (by and large) climate nearly ineffective commitment strategy as Kyoto I will be implemented a second time.

Contrary to that – after a thorough discussion of the climate change mitigating and the economic effects of global cap and trade scheme – there should be a good chance that also industrialized countries would support a system like GCCS and not only developing and newly industrialized countries, that would have (important) economic benefits from a system like the GCCS. As already quoted in section II.A.: Worlds' economic leaders, being members of the so-called G8 Climate Change Roundtable of the World Economic Forum 'in collaboration with her majesty's government' (UK) urgently call for a drastic change of

- "the current 'patchwork' scheme of regulatory, financial, and technology' and 'the short term nature of the Kyoto Protocol and related policy mechanisms whose targets and timetables do not extend beyond 2012",

and urges other governments, primarily those of the G8

- to "establish a long term, market-based policy framework extending to 2030 …,
- to ensure that the policy framework is global in scope ..,
- define greenhouse gas emission rights through a cap-and-trade system, and to
- address climate change as part of an overall sustainable development agenda, putting in place mechanisms which address the challenges of poverty, energy, and economic growth in emerging markets while mitigating greenhouse gas emissions." (WEC 2005, p.3)

Because of those clear statements – implicit also of UK's government – the author is sure, that Tony Blair's above quoted remark about a restricting of growth and consumptions is not related to global CO_2- limits or cuts[142] (and resulting growth's and consumption's effects).

Therefore there exists a pretty good chance, that the United Kingdom – at the end of thorough discussions – could accept a global cap and trade scheme that comes close to the basic ideas within GCCS or GCCS PLUS. (This would be fully in line with the Kyoto PLUS-concept of the – after September 05-elections – leading German coalition party (CDU/CSU, 2004).

Summarizing: The above described 'theoretical' problems (global commons and the lack of a supranational authority) for implementing an efficient climate protection system could be overcome much easier by a global cap and trade scheme instead of an incremental evolution of the current commitment system of the KP.

In the following section it shall be shown in more 'practical' terms, that – if at all – there exists a chance, that (only) global cap trade schemes (whatever shape at the end they may have) have a relative good chance for an efficient international mitigation of the climate change problem.

[142] Sir Peter Torry, the British Ambassador in Germany, Berlin, firmly stated that a future climate protection framework will have its necessary effect, "if it gets global acceptance and real results in form of significant emission reductions". Great Britain doesn't retreat form the Kyoto Protocol. In: Der Tagesspiegel, October 16th 2005.

XII.C. Relatively good chances for the implementation and realization of GCCS/GCCS PLUS as a structural Kyoto I evolution - scheme

As quoted again in the last subsection: Most important progressive world's economic leaders in collaboration with the British government relentlessly describe the flaws of the current international climate protection system and call for an efficient structural evolution of it (for more quoted details ref. to II.A.).

In fact: Such an evolution is urgently needed. But on the other hand everybody knows: Whatever efficiency improvement of the 'Beyond Kyoto 2012'-global climate protection system should be aspired to, it will be extremely difficult to implement – mainly because of the 'unanimity principle' in international treaties. But: There exist several reasons for relatively good chances for the implementation of the GCCS and GCCS PLUS:

As described in section XII.A. and shown in Table 19 the GCCS / GCCS PLUS gets with altogether 84 respectively 81 points out of 100 an excellent score – especially because it fulfils as a special designed 'cap and trade' scheme all sub-criteria of climate effectiveness or sustainability nearly completely (refer to Table 19)[143].

For a fair and unbiased evaluation of the GCCS and for the prospect of a potential implementation of this 'Beyond Kyoto (2012) or structural evolution' – approach, the following remarks seem important too:

1. The international 'climate community' has got a clear agenda and has got to act according to the Kyoto Protocol:
   - Starting in 2005 there has to be 'the first review' of the KP 'in the light of … climate change and its impacts (art. 9 KP) and a consideration of the progress by achieving the (GHG emission reduction or limiting) commitments (art. 3.2 and 3.9 KP) under the auspices of the progress towards the objective of the UNFCCC (to avoid dangerous climate change) (art. 13.4.a. and b. KP). Such an unbiased review definitely will have the same sobering if not depressing results about the de facto climate inefficiency of the Kyoto I – commitment system as shown in sect. II.B..
   - Therefore: According to art. 9.1 KP there has to be taken 'appropriate action' in order to prevent dangerous climate change.
2. In order to fulfil this obligation the 'climate community' definitely can be sure, that the global cap and trade scheme GCCS / GCCS PLUS would be such an 'appropriate action' to prevent dangerous climate change. By these global cap and trade schemes both very ambitious EU climate change minimum targets (formulated in 1996: a concentration below 550 ppm CO_2 respectively (the current main target) a stabilization at +2°C, ref. to VIII.E.2.) can be reached and this could be done without dangerous interferences with the global economic system:
   - Moderate price increases in the beginning of the GCCS – no global scarcity: plus 0,5cts per litre gas or diesel (later gradual prices increases for the necessary climate efficiency), (Ref. to chapter VI., esp. VI.D.)
   - Still acceptable amounts of transfer payments to developing countries, financed by the fossil fuels users (not by the states or by the tax-payers!)
   - No overburdening of the users of fossil resources because of the 'price cap' at the free climate certificate – market.
3. The GCCS also includes an important development component: It has not only implemented the 'great' basic idea of equal distribution of emission rights 'born' in India (Agarwal and Narain, 1998, Agrarwal, 2000) and in Pakistan (Aslam, 2002), partly in the UK with C&C system too (Meyer 2000). The transmitting of the democratic 'one man – one vote'-principle to the use of the atmosphere by the 'one human – one climate emission right' distribution principle in a climate protection system for the first time would allow the active integration of developing countries into the global climate protection scheme. As a

[143] in Wicke (2005, p119 to 148) all main critical arguments against a global cap and trade scheme and most important criteria put forward in literature (i.g. by IEA/OECD, 2002, p106seq., Philibert and Pershing, p213seq., ECOFYS, 2002, p47seq.) are taken into consideration and discussed in depth.

function of their per-capita emissions which are far below average (thus contributing to a deceleration of climate change), developing countries can and should generate revenue not as 'foreign aid' but as a reward for this important contribution to a less worsened climate situation. But those countries should and must restrict the use of this revenue for 'sustainable development and elimination of poverty' (SDEP) measures in accordance with their national SDEP plans in a manner as climate-friendly as possible. Concurrent climate protection as well as sustainable development (including climate change adaptation policies and measures) and the elimination of poverty (SDEP) can and should be ensured by the concrete implementation of such plans with the GCCS.[144] What's more: Within the GCCS (sustainable and climate friendly) growth in developing countries is not just not obstructed but explicitly promoted – no 'eco-imperialism' as often feared within the Kyoto commitment system by DCs.

In order to overcome one problem within the GCCS that least developed countries – particularly vulnerable by the adverse effects of climate change – with a small population (and possibly higher per capita CO_2-emissions) would not get enough surplus transfer for a climate friendly development and especially for an adequate adaptation to dangerous climate change, 'special assistance' to those states can be provided within the GCCS. (ref. Wicke 2005, p175seq). The unavoidable price increase of fossil fuels also in developing countries could be mitigated in its social effects by compensation of purchasing power losses on an equal per capita distribution too (ref. to sub-section VI.D.4.d.).

4. Therefore there should be a good chance for a PRO- GCCS–initiative by (some) developing countries (especially from South Asian states with a probably self designed global cap and trade scheme based on their (Indian and Pakistani an) equal per capita distribution proposals and incorporating their main objectives): The GCCS is based on fundamental principles, developed in countries, such as India and Pakistan (see above). This GCCS concept which was fully operationalised and instrumentalised (in Wicke (2005) and outlined in this report as urgently demanded by late Anil Agarwal (2000). That's why such a concept (of course after a revision by developing countries themselves!) certainly can be endorsed by many other countries. It should hence go without saying that developing countries in particular can and should launch an initiative for such a system or a modified form thereof.
5. Such an initiative by some developing countries and the backing of it by others could lead to a completely changed 'battle order' within the conferences of the parties (COPs): Instead of developing countries being (extremely) critical against the present international efforts against climate change up to now, those countries could become the driving and active force in the fight against dangerous climate change – because most of them would profit both economically and by the mitigation of the adverse effects of climate change. This in turn could lead – in the beginning of the negotiations process – to a 2/3 majority in the COPs for a 'structural evolution' of the Kyoto Protocol into a 'Global Cap and Trade Scheme' such as the GCCS. Other scientists support this presumption:
   > "A unifying crucial element within the G77 seems to be "equitiy" which develops into a cross-cutting issue in negotiations, allowing to form coalitions between EU, G77 and other countries – thus challenging the US position." (Ott, Klepper et. al (2004), p 15)
6. There even seems to be a pretty good chance that the United States – after intensive negotiations – could accept the GCCS:

   The GCCS has been developed under the following premise, that it is completely contra-productive (and, even worse, also arrogant) to negate the criticism of the Kyoto Protocol in the USA by members of the two dominant parties (with the 1997 95:0 Byrd-Hagel Senate Resolution (with a democratic majority in both houses of Congress during the Clinton administration)) and the 'official' refusal of the Kyoto Protocol in 2001 under the Bush administration based thereon. The two mainly criticized points of the KP by the US, i.e. that the strongly growing economies of developing countries might over-compensate potential efforts on the part of the US in the climate sector and that the US economy might suffer 'serious harm' in the case of sole efforts on the part of the US (and other industrial-

[144] For the reason for such SDEP plans ref. to element 7 in III.B.

ized nations) can not be dismissed as irrational – no matter whether one accepts the resulting the US climate change policy (or being critical as the author is).
This is why these points and other points of US political and scientific discussions are explicitly considered (to the largest possible extent) in the 'design' of the GCCS! There will be no 'inconsistent' 'exemption for Developing Countries Parties' and there will be no 'serious harm to the United States economy' (Byrd and Hagel, 1997) and there will be no 'skyrocketing prices' for Climate Certificates and a just moderate rise of the price of fossil fuels: A global cap and trade scheme (like the GCCS) in principle is the most efficient system to reach a fixed GHG concentration. And it has been designed in a manner to ensure maximum business compatibility as important US-American authors propose. (The price cap of 30$ per CC at the free CC-market has been directly taken from the Aldy/Orzag/Stiglitz (2001) proposal.)
Therefore the GCCS imposes upon the United States the weakest burdens possible whilst also demanding the smallest possible degree of change in order to achieve climate change stabilization. This is highly in the interest of the United States to avoid growing dangerous consequences of the accelerated climate change like the possible consequence of the cease of the gulf or North Atlantic stream (a potential non-fictive 'day after tomorrow')! Even the pretty much energy-consuming 'US-American way of life and business' will not all be 'forbidden' – but such a way will be more expensive and energy saving will be a good deal in the United States and in other parts of the world in a much higher degree than it is in the presence!

7. The Global Cap and Trade Scheme with all its various – illustrative (!) numerical – specifications (of course being open to scientific and political debate and to substantial modifications[145]) also has got relatively good chances for a (global) acceptance because – contrary to the Kyoto I commitment strategy – it imposes no specific (reduction) limits to single or groups of states. As Kyoto I has shown: Many Annex I states – like the USA, Australia and (nearly) all newly industrialized and developing countries – are not able and/or are not willing (very probably permanently!) to accept distinct 'individual (reduction or capping) commitments'. Above that: Many of the committed Annex I states are not able to comply even with their very limited commitments of the Kyoto I commitment period – as shown above and predicted by the IEA in the Kyoto I process (WEO 2004, p 433seq.). And most of those committed states (like UK) clearly signalize the rejection of future national commitments (ref. to XII.B.1.c). A global cap and trade system – contrary to this Kyoto I type 'national' commitment system – puts the reduction respectively the capping task to comply with the global cap not to the governments but to the market – by way of world wide incentives for climate friendly consumption and production patterns and for permanent investment in climate friendly of long existing technologies!
8. The GCCS implementation costs as welfare losses of an otherwise faster growing economy and losses of the GDP are globally (highly) worth while. This shows an excellent benefit/cost ratio of an efficient global cap and trade scheme: Such a mitigation policy 'produces' for every dollar/euro a benefit of reduced climate change costs in the range of 10 dollar or euro. Therefore the world and all nations can and should bear the cost burdens. Because of this high benefit by implementing the cap and trade scheme an economic compensation scheme for economically higher burdened and economically lesser strong economies should be reachable. To get the absolutely needed unanimous acceptance of the GCCS (PLUS) global cap and trade scheme, there can and should be a burden sharing between those economically burdened and climate change related benefited countries.
9. Last but not least: After some discussions there is a very good chance, that world's economic leaders could accept or even call for a system similar to GCCS or GCCS PLUS. In fact: They have already called for such a system as quoted twice up to now. The author is convinced, that the here presented global cap and trade schemes nearly exactly are in line with the following critic of the current Kyoto I system and that they fulfil nearly com-

[145] This has been done already in this report, because a lot helpful comments of colleague Christoph Boehringer have been integrated by some changes within the GCCS and by a modified wording.

pletely the criteria of the following urgent call of world's economic leaders, which finally – once again – is quoted as follows.

Worlds' economic leaders, being members of the so-called G8 Climate Change Roundtable of the World Economic Forum 'in collaboration with her majesty's government' (UK) urgently call for a drastic change of

- "the current 'patchwork' scheme of regulatory, financial, and technology' and 'the short term nature of the Kyoto Protocol and related policy mechanisms whose targets and timetables do not extend beyond 2012",

and urge other governments, primarily those of the G8

- to "establish a long term, market-based policy framework extending to 2030 …,
- to ensure that the policy framework is global in scope ..,
- define greenhouse gas emission rights through a cap-and-trade system, and to address climate change as part of an overall sustainable development agenda, putting in place mechanisms which address the challenges of poverty, energy, and economic growth in emerging markets while mitigating greenhouse gas emissions." (WEF 2005, p.3)

Following these nine arguments put forward above and the comparison of the GCCS with the most important proposals so far made for the incremental regime evolution of the Kyoto Protocol and of the two most important proposals for structural regime change on the basis of the above mentioned careful evaluation (Wicke, 2005, p109seq.) the author is convinced of the following conclusions:

Should it be possible at all – with the author being both sceptical and hopeful at the same time in this respect – to reduce global climate gas emissions to such an extent that the prevention of dangerous climate change is still possible,

- then this can only be achieved with the help of a global incentive system in the form of a 'cap and trade' emissions trading system where allocation is – at least – substantially based on the 'one human – one climate emission right' principle (of course being open to deviations by generally accepted correction factors[146]).
- The design of such a system must ensure that it offers developing countries sufficient incentives to join in on the one hand whilst also ensuring the highest possible degree of economic compatibility in order to avoid overburdening of any country and still giving world wide incentives for energy saving and for climate friendly consuming and producing patterns and for such a development.

From this perspective, the GCCS concept presented here does seem to be a practicable and promising and at the same time sufficiently operationalised approach towards resolving our planet's climate protection problems in an acceptable manner.

The author holds one main element of the GCCS, i.e. the distribution principle of 'one human – one climate emission right' as the crucial key to actively integrate developing and newly industrializing countries. Without such an integration there will be no chance at all to solve the global climate change problems to the benefit of the young and future generations living on that planet.

In the case that German policy (hopefully in cooperation with the United Kingdom) would succeed in putting a Kyoto PLUS or 'Beyond Kyoto' - global cap and trade scheme (based on some ideas presented in the GCCS / GCCS PLUS) on the relevant international agenda and, if possible, even on the agenda of international climate protection negotiations, the GCCS will trigger first, climate-relevant incentives even in the run-up to negotiations and resolutions.

The most optimistic scenario could be: Influential and important negotiation groups, such as the (developing country) Group 77 plus China, the European Union and, for example, the AOSIS (group of small island states) put this GCC system on the international agenda. Such a coordinated discussion start would make it evident that

- in fact around three quarters of all nations of the world with and over half [147] of present and far above 55% of future CO_2 emissions world-wide in 2005 are really determined

[146] Correction factors i.g. for arctic regions or for least developed and most vulnerable small island states, ref. to Wicke 2005, p244seq, 248seq, p175seq.

[147] According to US-EIA data and forecasts – an estimated well over 52.2% percent. These shares – and as a conservative and statistics-related approach – initially include 'western Europe and developing countries' only

to stabilize the climate, to mitigate climate change substantially and hence to limit climate gas emissions world-wide, and

- that these countries are planning a joint effort in order to enforce this limitation at the lowest cost level possible with the help of the rules of market economy and incentive systems.
- As shown elsewhere: There will remain a certain number of states (like the oil producing countries of the middle east, successor states of the former Soviet Union, the United States and Australia, Mexico and South Africa) that – at least at the beginning of negotiations – would try to oppose or even reject such a system.

But it seems conceivable that after a long negotiation period and by a linkage of that climate change mitigation matter with other international questions such as WTO and others, there could be an agreement may be around 2012 and therefore well before the end of the Kyoto I (commitment) period.

as supporter states. Refer to: Energy Information Adminstration (US Department of Energy): International Energy Outlook 2003. Washington D.C. May 2003, p. 195.

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Appendix: Results of the PACE – IAM – Calculations of 4 Scenarios

BAU

Radiative forcing since pre-Industrial (Wm^2)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	2,38	2,68	2,98	3,26	3,54	3,81	4,08	4,32	4,55	4,77	4,99	5,21	5,44	5,66	5,88	6,04	6,21	6,34	6,48	6,60	6,71

Global mean temperature (degrees Celsius)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	0,43	0,61	0,79	0,97	1,14	1,31	1,47	1,63	1,79	1,94	2,08	2,22	2,36	2,49	2,62	2,75	2,88	2,99	3,11	3,21	3,31

Carbon Dioxide Emissions from Fossil Fuels and Cement (Tg of Carbon Equivale

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	2,85	3,00	3,11	3,29	3,43	3,56	3,63	3,78	3,87	4,01	4,11	4,19	4,35	4,43	4,58	4,71	4,74	4,85	4,90	4,99	5,06
GER	0,28	0,29	0,29	0,29	0,28	0,28	0,26	0,26	0,25	0,25	0,24	0,23	0,21	0,19	0,17	0,16	0,14	0,13	0,12	0,10	0,09
EUR	1,05	1,09	1,12	1,13	1,12	1,13	1,12	1,14	1,14	1,15	1,16	1,09	1,00	0,93	0,84	0,79	0,71	0,65	0,58	0,52	0,45
LAM	0,38	0,44	0,49	0,56	0,62	0,70	0,77	0,87	0,95	1,05	1,13	1,26	1,35	1,47	1,57	1,65	1,68	1,74	1,78	1,84	1,89
IND	0,31	0,36	0,41	0,46	0,50	0,58	0,65	0,74	0,73	0,79	0,81	0,88	0,97	1,09	1,14	1,30	1,34	1,47	1,55	1,66	1,75
CHN	1,02	1,25	1,37	1,64	1,76	2,04	2,14	2,35	2,40	2,57	2,66	2,80	2,84	2,96	3,03	2,94	2,69	2,57	2,35	2,21	2,02
ROW	1,03	1,28	1,49	1,76	1,99	2,34	2,62	2,96	3,19	3,51	3,77	4,16	4,49	4,86	5,21	5,45	5,38	5,54	5,55	5,66	5,71
OECD	4,18	4,38	4,51	4,71	4,84	4,97	5,01	5,17	5,26	5,41	5,51	5,51	5,55	5,55	5,60	5,65	5,60	5,63	5,60	5,61	5,60
Non-OECD	2,74	3,33	3,76	4,42	4,87	5,66	6,18	6,92	7,27	7,91	8,37	9,20	9,66	10,38	10,95	11,33	11,09	11,32	11,23	11,36	11,37
World	6,92	7,71	8,27	9,13	9,72	10,63	11,18	12,09	12,53	13,32	13,87	14,71	15,21	15,94	16,55	16,99	16,69	16,95	16,83	16,97	16,97

Carbon Dioxide Concentrations (ppmv)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	372	383	394	406	419	433	446	461	476	492	508	524,9178609	541,7830981	559,5634344	577,3437727	593,1184768	608,8931809	623,5861773	638,2791738	652,2052443	666,1313148

Methane Emissions (Gigagrams of methane)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	0,34	0,34	0,34	0,35	0,36	0,37	0,37	0,36	0,34	0,33	0,31	0,34	0,36	0,38	0,40	0,43	0,46	0,50	0,53	0,56	0,59
GER	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
EUR	0,09	0,09	0,08	0,09	0,09	0,09	0,09	0,08	0,08	0,07	0,07	0,07	0,07	0,07	0,07	0,06	0,06	0,06	0,05	0,05	0,05
LAM	0,16	0,18	0,19	0,22	0,26	0,28	0,31	0,33	0,35	0,38	0,40	0,39	0,39	0,38	0,38	0,38	0,38	0,37	0,37	0,37	0,36	0,36
IND	0,12	0,14	0,16	0,18	0,20	0,23	0,26	0,26	0,26	0,26	0,26	0,27	0,28	0,30	0,31	0,32	0,33	0,33	0,34	0,35	0,36
CHN	0,21	0,25	0,28	0,31	0,35	0,37	0,39	0,39	0,39	0,39	0,40	0,38	0,37	0,36	0,35	0,33	0,31	0,29	0,27	0,24	0,22
ROW	0,30	0,36	0,41	0,47	0,52	0,58	0,64	0,69	0,73	0,78	0,82	0,88	0,94	1,00	1,06	1,03	0,99	0,94	0,90	0,86	0,82
OECD	0,44	0,44	0,44	0,46	0,47	0,47	0,47	0,45	0,43	0,41	0,39	0,41	0,43	0,45	0,47	0,50	0,53	0,56	0,59	0,62	0,65
Non-OECD	0,79	0,92	1,04	1,18	1,33	1,47	1,61	1,67	1,74	1,80	1,87	1,93	1,99	2,05	2,11	2,05	1,99	1,93	1,88	1,82	1,76
World	1,23	1,36	1,48	1,64	1,80	1,94	2,08	2,12	2,17	2,21	2,26	2,34	2,42	2,50	2,58	2,55	2,52	2,50	2,47	2,44	2,41

Methane Concentrations (ppbv

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	5569,91	6829,57	8089,24	9179,09	10268,95	11237,55	12206,15	12773,01	13339,87	13737,82	14135,78	14594,81	15053,84	15538,54	16023,24	16125,59	16227,94	16166,47	16104,99	15977,70	15850,41

Welfare Change (in % HEV of lifetime income

	OOE	GER	EUR	LAM	IND	CHN	ROW	OECD	Non-OECD	World
Welfare										

GDP (Total in billions of 2000 U

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	15946,37	17886,15	19853,58	22096,04	24396,71	27124,82	29928,62	33240,24	36638,29	40142,89	43723,78	48107,64	52582,15	57172,74	61890,63	67920,78	73792,96	80031,82	86342,00	92478,29	98953,73
GER	1850,03	2088,11	2318,72	2568,00	2815,26	3095,65	3377,71	3685,55	4003,64	4335,54	4674,03	5052,18	5437,44	5837,59	6242,28	6765,76	7276,50	7820,01	8370,63	8908,52	9474,91
EUR	6974,50	7838,36	8718,92	9713,14	10705,57	11858,77	13032,88	14388,67	15783,78	17237,90	18743,09	20465,76	22212,99	24027,51	25865,00	28202,84	30480,41	32903,10	35355,36	37754,10	40282,75
LAM	1993,89	2317,49	2652,17	3103,70	3562,40	4163,62	4820,75	5682,44	6947,34	8040,49	9244,42	11281,05	13309,94	15368,02	17468,53	20041,68	22517,41	25146,67	27791,58	30351,03	33077,34
IND	484,00	589,49	705,60	870,67	1046,12	1310,48	1623,52	2254,64	2883,85	3564,56	4445,21	5624,75	8741,29	10905,22	13295,97	17161,55	20811,32	24658,08	28517,93	32280,70	36372,54
CHN	1351,88	1895,09	2498,88	3412,17	4422,58	5914,01	7481,34	9374,55	11304,37	13306,94	15414,77	17964,63	20540,10	23220,93	26088,08	29778,79	33358,14	37150,00	40992,17	44794,26	48846,07
ROW	2761,76	3551,22	4376,00	5457,09	6602,06	8210,42	9913,56	12249,01	14609,95	17040,56	19583,36	23658,21	27660,48	31762,09	36217,70	42987,31	49493,51	56376,79	63293,74	70025,01	77215,76
OECD	24760,90	27812,62	30891,22	34377,18	37917,54	42079,25	46339,19	51314,47	56425,71	61716,34	67140,90	73625,58	80232,58	87037,85	93997,91	102889,36	111549,87	120754,93	130067,99	139140,90	148711,38
Non-OECD	6591,53	8353,29	10232,64	12843,63	15633,16	19598,74	23839,16	29760,64	35745,52	41952,55	48787,76	59528,63	70251,80	81256,25	93070,28	109969,33	126180,39	143331,55	160595,41	177451,00	195511,71
World	31372,43	36165,91	41123,86	47220,81	53550,70	61677,98	70178,35	81075,12	92171,22	103668,88	115928,66	133154,21	150484,38	168294,11	187088,19	212858,71	237730,27	264086,47	290663,41	316591,91	344223,09

KYOTO

Radiative forcing since pre-industrial (Wm^{-2})

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	2,38	2,64	2,90	3,14	3,39	3,63	3,87	4,08	4,29	4,48	4,68	4,88	5,09	5,29	5,50	5,69	5,91	5,95	6,08	6,20	6,31

Global mean temperature (degrees Celsius

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	0,43	0,61	0,79	0,96	1,12	1,28	1,43	1,57	1,72	1,85	1,98	2,10	2,22	2,34	2,46	2,58	2,70	2,81	2,91	3,01	3,10

Change in macroeconomic consumption (in billions of 2000 USD)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	-0,11	0,24	-8,85	-14,23	-18,94	-22,54	-25,46	-29,35	-33,40	-37,49	-41,43	-44,09	-46,24	-50,82	-54,41	-58,12	-60,37	-62,75	-64,51	-66,02	-67,59
GER	0,37	0,42	-0,67	-1,26	-1,71	-2,00	-2,21	-2,49	-2,76	-3,03	-3,28	-3,38	-3,51	-3,56	-3,63	-3,79	-3,84	-3,89	-3,99	-3,97	-3,95
EUR	-0,50	-0,57	-4,82	-7,47	-9,52	-11,15	-12,43	-14,08	-15,79	-17,50	-19,11	-20,16	-21,30	-22,14	-23,04	-24,48	-25,48	-26,59	-27,32	-28,02	-28,72
LAM	0,72	0,94	-0,49	-1,33	-2,07	-2,69	-3,18	-4,02	-4,89	-5,83	-6,80	-7,81	-9,05	-9,91	-10,95	-11,85	-12,19	-12,57	-12,66	-12,72	-12,69
IND	0,51	0,66	-0,05	-0,41	-0,63	-0,79	-0,90	-1,11	-1,15	-1,30	-1,42	-1,38	-0,55	0,14	0,88	2,02	3,72	5,52	7,56	9,76	12,05
CHN	1,41	2,20	0,98	0,78	0,76	1,03	1,64	2,14	2,71	3,11	3,48	4,77	5,78	7,25	9,36	10,77	13,88	17,19	20,81	24,35	28,25
ROW	0,58	1,07	-1,38	-3,09	-4,57	-6,09	-7,35	-9,31	-11,32	-13,51	-15,76	-17,98	-20,83	-22,84	-25,36	-28,76	-30,66	-32,90	-34,44	-35,81	-36,94
OECD	-0,02	0,01	-1,43	-2,30	-3,02	-3,57	-4,01	-4,59	-5,19	-5,80	-6,38	-6,76	-7,31	-7,85	-8,11	-8,64	-8,97	-9,31	-9,57	-9,78	-10,01
Non-OECD	0,32	0,49	-0,69	-0,41	-0,65	-0,85	-0,96	-1,23	-1,46	-1,75	-2,05	-2,24	-2,46	-2,54	-2,71	-2,79	-2,52	-2,29	-1,97	-1,44	-0,93
World	2,98	4,99	-15,27	-27,02	-36,69	-44,22	-49,90	-58,23	-68,59	-75,55	-84,32	-90,04	-97,70	-101,89	-108,13	-114,21	-114,93	-116,09	-114,37	-112,33	-109,36

Change in GDP (in billions of 2000 USD)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	-5,26	-7,32	-548,38	-643,62	-725,15	-754,21	-771,32	-846,18	-931,37	-1019,24	-1111,90	-1095,33	-1202,57	-1201,70	-1269,99	-1323,93	-1315,65	-1333,63	-1325,63	-1333,14	-1333,94
GER	1,21	5,02	-45,66	-51,56	-56,00	-55,99	-54,51	-58,35	-62,83	-67,44	-72,70	-65,33	-66,28	-60,99	-60,28	-58,63	-53,82	-50,64	-45,82	-41,93	-37,39
EUR	-2,30	10,93	-200,33	-227,24	-249,38	-256,80	-258,30	-262,73	-310,78	-339,74	-371,91	-338,76	-343,48	-320,56	-318,04	-312,86	-292,51	-280,48	-259,49	-244,74	-226,05
LAM	3,38	0,93	-88,93	-110,25	-130,02	-144,34	-157,72	-180,13	-224,91	-263,27	-299,76	-316,84	-359,49	-376,85	-419,35	-441,83	-445,72	-460,82	-464,85	-474,39	-481,72
IND	3,29	1,27	-54,37	-62,19	-68,27	-74,97	-78,32	-89,90	-92,18	-104,15	-108,33	-109,33	-121,27	-124,99	-135,99	-145,76	-130,64	-129,61	-113,69	-102,53	-92,81
CHN	0,89	-16,02	-209,82	-271,29	-314,52	-367,25	-389,12	-472,88	-541,91	-624,92	-689,26	-722,11	-780,11	-810,19	-855,13	-825,39	-747,91	-686,38	-618,55	-563,46	-494,60
ROW	1,44	-23,44	-297,78	-379,94	-455,18	-524,39	-585,97	-705,37	-830,73	-972,07	-1105,05	-1159,24	-1327,39	-1398,32	-1535,97	-1609,11	-1593,75	-1637,44	-1630,33	-1652,96	-1692,21
OECD	-6,35	6,63	-794,37	-922,42	-1030,53	-1067,00	-1084,14	-1197,25	-1304,99	-1426,42	-1555,60	-1499,41	-1612,32	-1593,25	-1668,30	-1695,43	-1661,97	-1664,75	-1630,74	-1619,80	-1597,38
Non-OECD	9,10	-37,27	-650,89	-823,67	-957,99	-1110,94	-1221,13	-1458,28	-1688,84	-1964,31	-2212,42	-2317,52	-2586,27	-2712,15	-2946,34	-3022,09	-2917,13	-2924,25	-2826,81	-2789,24	-2721,34
World	2,75	-26,64	-1445,26	-1746,09	-1998,52	-2177,94	-2305,27	-2645,53	-2993,83	-3390,73	-3768,03	-3816,94	-4208,59	-4295,40	-4614,64	-4717,52	-4579,11	-4588,99	-4457,55	-4410,05	-4318,72

Incremental Value of Carbon Permit/Carbon Tax (2000 US$/metric to

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	0	0	15	16	17	17	17	18	19	21	22	21,04647797	22,36413362	21,76444004	22,5049722	22,54899813	22,35833615	22,40225162	22,22256119	22,21555676	22,15412411

Carbon Dioxide Emissions from Fossil Fuels and Cement (Tg of Carbon Equival

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	2,85	3,00	2,87	3,02	3,13	3,25	3,31	3,42	3,47	3,56	3,62	3,71	3,84	3,93	4,06	4,14	4,15	4,21	4,24	4,29	4,33
GER	0,28	0,29	0,27	0,27	0,27	0,26	0,25	0,25	0,24	0,24	0,23	0,22	0,20	0,18	0,16	0,15	0,13	0,12	0,11	0,09	0,08
EUR	1,05	1,09	1,06	1,07	1,06	1,07	1,06	1,08	1,08	1,09	1,09	1,03	0,94	0,87	0,78	0,73	0,66	0,60	0,53	0,48	0,41
LAM	0,39	0,44	0,47	0,53	0,58	0,66	0,75	0,82	0,89	0,97	1,04	1,17	1,25	1,36	1,45	1,52	1,56	1,62	1,66	1,72	1,77
IND	0,31	0,35	0,35	0,39	0,41	0,47	0,52	0,58	0,57	0,61	0,62	0,76	0,77	0,86	0,91	1,04	1,09	1,19	1,25	1,36	1,43
CHN	1,02	1,25	0,92	1,08	1,15	1,35	1,46	1,62	1,69	1,92	1,93	2,10	2,17	2,32	2,43	2,35	2,15	2,05	1,87	1,75	1,59
ROW	1,03	1,28	1,39	1,64	1,85	2,17	2,45	2,73	2,93	3,20	3,42	3,80	4,08	4,43	4,75	4,68	4,94	5,11	5,14	5,26	5,34
OECD	4,19	4,38	4,21	4,36	4,46	4,59	4,62	4,74	4,78	4,89	4,94	4,96	4,97	4,98	5,00	5,02	4,94	4,94	4,88	4,87	4,83
Non-OECD	2,74	3,33	3,13	3,64	3,99	4,66	5,13	5,76	6,07	6,60	7,01	7,92	8,27	8,99	9,53	9,69	9,73	9,95	9,93	10,09	10,13
World	6,92	7,71	7,34	8,00	8,45	9,24	9,75	10,50	10,85	11,49	11,95	12,78	13,24	13,86	14,53	14,91	14,67	14,90	14,81	14,94	14,95

Carbon Dioxide Concentrations (ppmv)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	372	380	389	399	410	421	433	446	458	472	485	499,496894	514,086619	529,726733	545,367276	559,197305	573,007395	585,876499	598,746501	610,956358	623,167116

Methane Emissions (Gigagrams of methan

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	0,34	0,34	0,33	0,34	0,35	0,35	0,36	0,34	0,33	0,31	0,29	0,32	0,33	0,36	0,39	0,40	0,43	0,46	0,49	0,52	0,55
GER	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,10	0,10	0,10	0,10
EUR	0,09	0,09	0,08	0,09	0,09	0,09	0,08	0,08	0,07	0,07	0,06	0,06	0,06	0,06	0,06	0,06	0,06	0,05	0,05	0,05	0,04
LAM	0,16	0,18	0,19	0,22	0,25	0,28	0,31	0,33	0,35	0,37	0,39	0,39	0,38	0,38	0,37	0,37	0,37	0,36	0,36	0,35	0,35
IND	0,12	0,14	0,15	0,18	0,20	0,23	0,25	0,25	0,25	0,25	0,25	0,27	0,28	0,29	0,31	0,31	0,32	0,33	0,34	0,34	0,35
CHN	0,21	0,25	0,25	0,28	0,31	0,33	0,36	0,36	0,35	0,35	0,35	0,35	0,33	0,33	0,32	0,30	0,28	0,26	0,24	0,22	0,20
ROW	0,30	0,36	0,41	0,46	0,51	0,57	0,63	0,68	0,72	0,76	0,80	0,86	0,92	0,98	1,04	1,01	0,97	0,93	0,89	0,85	0,81
OECD	0,44	0,44	0,42	0,44	0,45	0,45	0,45	0,43	0,41	0,39	0,37	0,39	0,41	0,43	0,44	0,47	0,50	0,62	0,65	0,67	0,70
Non-OECD	0,79	0,92	1,01	1,14	1,28	1,41	1,55	1,61	1,68	1,74	1,80	1,86	1,92	1,98	2,04	1,98	1,93	1,97	1,92	1,77	1,71
World	1,23	1,36	1,43	1,58	1,73	1,87	2,00	2,04	2,08	2,12	2,16	2,25	2,32	2,40	2,48	2,45	2,43	2,50	2,47	2,44	2,41

Methane Concentrations (ppbv

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	5569,80	6740,36	7910,93	8932,54	9954,15	10879,62	11805,09	12337,84	12870,58	13238,73	13606,87	14047,69	14469,91	14959,85	15430,39	15529,33	15629,27	15740,57	15852,87	15798,64	15744,41

Welfare Change (in % HEV of lifetime incom

	OOE	GER	EUR	LAM	IND	CHN	ROW	OECD	Non-OECD	World
Welfare	-0,07	-0,05	-0,08	-0,05	0,06	-0,07	-0,07	-0,03	-0,06	

GDP (Total in billions of 2000 U

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	15945,84	17885,42	19788,74	22031,69	24324,19	27049,40	29851,49	33155,63	36545,15	40040,97	43612,58	47898,11	52461,90	57052,57	61761,63	67768,39	73661,40	79696,45	86209,44	92344,97	98820,33
GER	1860,15	2068,61	2314,16	2562,84	2809,66	3089,05	3372,26	3679,72	3987,35	4328,78	4686,76	5045,64	5430,81	5831,49	6236,26	6759,90	7271,12	7814,94	8366,07	8894,32	9471,17
EUR	6974,27	7939,45	8658,89	9493,42	10680,63	11833,09	13067,63	14360,40	15752,70	17203,93	18705,98	20421,69	22178,64	23995,46	25833,19	28171,55	30451,16	32875,06	35329,41	37729,63	40260,14
LAM	1994,22	2317,58	2643,27	3082,68	3549,40	4149,39	4804,98	5663,43	6624,85	7614,17	9214,44	11249,35	13273,59	15330,16	17426,60	19357,49	22472,84	25190,59	27745,10	30303,69	33029,17
IND	464,33	589,62	700,16	864,45	1039,29	1302,99	1615,69	2245,65	2874,63	3554,14	4434,38	6613,81	8729,19	10892,72	13282,37	17146,08	20798,26	24645,12	28508,62	32270,45	36364,26
CHN	1351,98	1693,48	2477,69	3385,04	4391,12	5677,28	7441,43	9327,26	11250,27	13244,46	15344,84	17892,42	20461,29	23139,91	26002,56	29896,25	33283,44	37080,36	40930,31	44736,22	48796,61
ROW	2761,91	3548,98	4346,22	5419,10	6556,55	8157,96	9854,96	12178,48	14526,98	16943,35	19572,85	23541,29	27527,74	31622,25	36064,12	42826,40	49334,14	56213,05	63130,70	69859,72	77049,54
OECD	24780,27	27813,48	30611,78	34284,94	37814,49	41972,55	46230,77	51195,75	56295,21	61573,69	66985,34	73476,64	80071,35	86879,53	93831,08	102719,84	111383,68	120588,45	129804,92	138976,92	148551,84
Non-OECD	6592,43	8349,56	10167,55	12761,26	15536,36	19487,64	23717,05	29614,62	35576,63	41756,11	49566,51	59296,89	69992,19	80985,04	92775,65	109667,12	125886,68	143039,12	160312,73	177171,98	196239,57
World	31372,70	36163,04	40979,33	47046,20	53350,85	61460,19	69947,82	80810,66	91871,84	103329,81	116551,86	132772,52	150063,52	167864,57	186606,73	212386,96	237272,36	263627,57	290217,65	316150,90	343791,22

KYOTO_PLUS

Radiative forcing since pre-industrial (Wm^{-2})

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	2,38	2,64	2,90	3,14	3,39	3,61	3,84	4,03	4,22	4,39	4,56	4,76	4,94	5,13	5,33	5,48	5,62	5,76	5,89	6,00	6,12

Global mean temperature (degrees Celsius)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	0,43	0,61	0,79	0,96	1,12	1,28	1,43	1,57	1,71	1,83	1,96	2,07	2,19	2,30	2,41	2,52	2,63	2,73	2,83	2,92	3,01

Change in macroeconomic consumption (in billions of 20

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	-2,73	-2,78	-12,37	-18,35	-23,75	-30,53	-37,82	-47,37	-58,36	-69,85	-81,48	-88,46	-97,23	-102,73	-109,32	-116,30	-121,31	-126,13	-130,25	-133,67	-137,23
GER	0,39	0,41	-0,70	-1,31	-1,81	-2,41	-3,04	-3,85	-4,75	-5,69	-6,69	-7,91	-7,38	-7,56	-7,73	-8,05	-8,22	-8,37	-8,45	-8,49	-8,53
EUR	-1,14	-1,33	-5,73	-8,59	-10,93	-13,84	-16,95	-20,94	-25,44	-30,15	-34,79	-37,47	-39,91	-41,56	-43,11	-45,80	-47,42	-49,21	-50,73	-51,98	-53,28
LAM	1,26	1,56	0,20	-0,55	-1,19	-2,17	-3,32	-5,07	-7,24	-9,73	-12,61	-14,72	-17,12	-18,74	-20,48	-21,91	-22,61	-23,19	-23,43	-23,45	-23,40
IND	0,94	1,20	0,55	0,32	0,21	-0,03	-0,36	-0,75	-1,08	-1,65	-2,27	-2,23	-0,68	0,65	2,20	4,58	7,85	11,43	15,64	19,66	24,08
CHN	2,42	3,64	2,83	3,33	4,02	4,90	5,77	6,44	6,72	6,47	5,78	7,33	8,73	11,05	13,05	17,35	22,65	28,34	34,75	40,94	47,73
ROW	1,39	2,11	-0,14	-1,69	-2,77	-4,78	-7,18	-10,79	-15,18	-20,26	-25,02	-30,27	-35,16	-39,36	-42,04	-46,81	-49,42	-52,21	-53,58	-55,33	-56,32
OECD	-0,35	-0,37	-1,88	-2,83	-3,65	-4,68	-5,78	-7,22	-8,86	-10,57	-12,29	-13,29	-14,45	-15,18	-16,02	-16,99	-17,69	-18,37	-18,94	-19,41	-19,91
Non-OECD	0,60	0,85	0,34	0,15	0,03	-0,21	-0,51	-1,02	-1,68	-2,52	-3,50	-3,99	-4,42	-4,54	-4,73	-4,68	-4,15	-3,56	-2,71	-1,92	-0,79
World	2,51	4,79	-15,35	-26,75	-36,21	-48,86	-62,91	-82,33	-105,34	-130,86	-157,89	-172,84	-189,76	-197,25	-207,42	-216,73	-218,48	-219,34	-216,68	-212,33	-206,96

Change in GDP (in billions of 2000 USD)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	-8,05	-10,01	-551,17	-646,74	-726,42	-879,48	-1026,63	-1238,15	-1492,85	-1743,18	-2032,09	-1993,44	-2161,04	-2145,70	-2286,19	-2293,04	-2295,16	-2305,28	-2296,92	-2297,76	-2296,05
GER	2,85	6,94	-43,45	-49,01	-51,88	-61,26	-69,17	-82,71	-99,64	-115,91	-136,36	-122,05	-122,01	-111,83	-109,25	-103,25	-95,72	-88,85	-80,25	-73,07	-64,89
EUR	1,58	15,60	-194,84	-220,73	-237,30	-286,65	-331,96	-403,23	-492,05	-579,35	-685,59	-620,13	-618,36	-571,40	-555,50	-535,48	-502,93	-474,59	-437,51	-407,19	-372,07
LAM	7,79	6,12	-82,82	-103,23	-122,83	-162,56	-208,11	-276,54	-361,76	-454,53	-552,73	-577,36	-642,77	-669,52	-726,44	-762,79	-764,87	-781,54	-769,54	-769,75	-809,96
IND	7,33	6,21	-48,37	-54,62	-58,64	-76,28	-91,17	-114,19	-127,90	-155,77	-177,32	-174,29	-188,17	-169,33	-157,15	-157,39	-169,22	-152,37	-117,54	-89,64	-42,35
CHN	5,86	-9,65	-199,88	-259,25	-301,39	-404,64	-498,08	-650,49	-818,47	-1014,17	-1211,05	-1248,99	-1351,92	-1381,80	-1438,39	-1567,25	-1741,68	-1941,40	-1999,34	-1961,41	-1785,10
ROW	6,95	-16,07	-268,43	-368,15	-447,47	-608,29	-781,65	-1039,60	-1343,08	-1677,99	-2021,46	-2109,41	-2348,93	-2443,80	-2631,63	-2715,81	-2705,47	-2749,45	-2739,28	-2755,84	-2763,97
OECD	-3,62	12,53	-789,46	-916,48	-1015,61	-1227,39	-1427,76	-1724,08	-2084,54	-2438,35	-2854,03	-2735,62	-2901,42	-2828,73	-2929,94	-2931,77	-2893,80	-2899,71	-2814,68	-2779,02	-2733,01
Non-OECD	26,03	-12,39	-619,60	-764,25	-930,30	-1251,68	-1577,02	-2080,81	-2651,19	-3302,46	-3962,26	-4110,05	-4531,79	-4664,54	-4993,82	-5033,25	-4881,24	-4824,77	-4655,70	-4544,63	-4401,38
World	24,40	0,15	-1409,07	-1700,73	-1945,90	-2479,07	-3004,78	-3804,89	-4735,72	-5740,81	-6816,29	-6845,67	-7433,21	-7513,28	-7923,56	-7966,02	-7775,05	-7693,48	-7470,38	-7322,66	-7134,39

Incremental Value of Carbon Permit/Carbon Tax (2000 US$/metric ton

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	0	0	15	16	17	20	23	28	33	38	43	40,4956866	42,0762691	40,2746095	40,8821126	40,3018917	40,3849628	40,0637791	39,9280317	39,7037899	39,5847112

Carbon Dioxide Emissions from Fossil Fuels and Cement (Tg of Carbon Equivale

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	2,65	3,00	2,87	3,02	3,13	3,20	3,21	3,26	3,25	3,29	3,28	3,38	3,52	3,61	3,74	3,82	3,80	3,86	3,87	3,91	3,93
GER	0,28	0,29	0,27	0,27	0,27	0,26	0,25	0,24	0,23	0,23	0,22	0,21	0,19	0,17	0,15	0,14	0,13	0,12	0,10	0,09	0,08
EUR	1,05	1,09	1,06	1,07	1,06	1,06	1,04	1,05	1,04	1,05	1,04	0,98	0,90	0,83	0,75	0,70	0,63	0,58	0,51	0,45	0,39
LAM	0,38	0,44	0,47	0,53	0,58	0,65	0,71	0,80	0,85	0,92	0,98	1,10	1,17	1,29	1,37	1,44	1,47	1,54	1,58	1,63	1,68
IND	0,31	0,36	0,35	0,39	0,41	0,46	0,49	0,53	0,50	0,52	0,52	0,65	0,67	0,76	0,80	0,92	0,96	1,05	1,12	1,20	1,28
CHN	1,02	1,25	0,92	1,08	1,15	1,30	1,34	1,45	1,49	1,60	1,67	1,84	1,94	2,09	2,21	2,15	1,98	1,87	1,70	1,59	1,45
ROW	1,03	1,28	1,39	1,64	1,85	2,14	2,38	2,63	2,77	2,99	3,16	3,52	3,79	4,14	4,44	4,67	4,65	4,62	4,66	4,99	5,07
OECD	4,18	4,38	4,21	4,36	4,46	4,52	4,59	4,56	4,52	4,56	4,55	4,58	4,00	4,62	4,64	4,66	4,55	4,65	4,48	4,46	4,39
Non-OECD	2,74	3,33	3,13	3,64	3,99	4,55	4,90	5,41	5,61	6,03	6,33	7,12	7,57	8,27	8,81	9,18	9,04	9,27	9,26	9,42	9,48
World	6,92	7,71	7,34	8,00	8,45	9,06	9,49	9,96	10,13	10,60	10,87	11,70	12,16	12,89	13,46	13,84	13,69	13,92	13,74	13,87	13,88

Carbon Dioxide Concentrations (ppmv)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	372	380	389	399	410	420	431	443	454	465	477	489,692932	502,841991	517,239043	531,636095	544,321943	557,007791	568,820208	580,632625	591,851145	603,069665

Methane Emissions (Gigagrams of methane

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	0,34	0,34	0,33	0,34	0,35	0,35	0,35	0,33	0,32	0,30	0,29	0,30	0,32	0,34	0,36	0,39	0,42	0,51	0,54	0,57	0,60
GER	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
EUR	0,09	0,09	0,08	0,09	0,09	0,09	0,08	0,08	0,07	0,07	0,06	0,06	0,06	0,06	0,06	0,06	0,05	0,05	0,05	0,05	0,04
LAM	0,16	0,18	0,19	0,22	0,25	0,28	0,31	0,33	0,35	0,37	0,38	0,38	0,38	0,37	0,37	0,36	0,36	0,36	0,35	0,35	0,35
IND	0,12	0,14	0,15	0,18	0,20	0,23	0,25	0,25	0,25	0,25	0,25	0,26	0,28	0,29	0,30	0,31	0,32	0,33	0,33	0,34	0,35
CHN	0,21	0,25	0,25	0,28	0,31	0,33	0,35	0,35	0,34	0,34	0,34	0,33	0,32	0,31	0,30	0,29	0,27	0,30	0,27	0,25	0,23
ROW	0,30	0,36	0,41	0,46	0,51	0,57	0,63	0,67	0,71	0,75	0,79	0,85	0,91	0,97	1,03	0,99	0,95	0,96	0,91	0,87	0,83
OECD	0,44	0,44	0,42	0,44	0,45	0,45	0,45	0,42	0,40	0,37	0,35	0,37	0,39	0,41	0,43	0,45	0,48	0,56	0,59	0,62	0,65
Non-OECD	0,79	0,92	1,01	1,14	1,28	1,41	1,54	1,60	1,65	1,71	1,76	1,83	1,88	1,85	2,00	1,95	1,90	1,93	1,87	1,82	1,76
World	1,23	1,36	1,43	1,58	1,73	1,86	1,99	2,02	2,05	2,08	2,11	2,20	2,27	2,35	2,43	2,40	2,38	2,50	2,47	2,44	2,41

Methane Concentrations (ppbv)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	5569,87	6740,51	7911,14	9032,74	9954,33	10946,07	11737,81	12226,28	12714,75	13037,84	13360,94	13782,52	14204,10	14666,04	15127,98	15224,27	15320,56	15522,03	15723,50	15706,76	15690,02

Welfare Change (in % HEV of lifetime Income

	OOE	GER	EUR	LAM	IND	CHN	ROW	OECD	Non-OECD	World
Welfare	-0,12	-0,07	-0,12	-0,06	0,04	0,14	-0,09	-0,12	-0,01	-0,08

GDP (Total in billions of 2000 U

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	15945,56	17885,15	19798,46	22031,37	24324,07	27036,89	29925,95	33116,43	36489,01	39968,58	43620,57	47908,30	52366,05	56958,17	61664,01	67691,48	73563,45	79801,29	86112,31	92246,51	98724,12
GER	1060,32	2088,60	2314,38	2563,10	2810,07	3069,52	3370,80	3677,29	3993,67	4323,96	4660,40	5039,97	5425,23	5826,43	6231,46	6755,44	7266,93	7811,12	8362,61	8901,21	9468,42
EUR	6974,66	7839,92	8599,44	9591,07	10681,84	11930,11	12999,66	14348,35	15734,57	17179,97	18674,53	20403,76	22151,16	23670,37	25809,45	28149,29	30439,12	32855,65	35311,61	37713,38	40245,54
LAM	1964,67	2318,10	2643,97	3083,39	3550,12	4147,56	4800,14	5854,79	6911,16	7995,04	9189,14	11223,31	13245,66	15301,07	17395,69	19988,40	22440,92	25068,52	27712,63	30271,06	32896,34
IND	484,75	580,11	760,76	865,21	1040,26	1302,86	1614,40	2243,23	2871,06	3549,96	4427,51	6607,32	8722,47	10896,29	13276,26	17141,81	20794,40	24642,84	28506,19	32272,64	36368,30
CHN	1352,47	1894,22	2479,89	3386,34	4392,44	5873,55	7431,53	9309,50	11222,53	13205,52	15293,66	17639,73	20404,91	23682,74	25844,24	29642,06	33233,98	37035,88	40891,23	44764,12	48787,56
ROW	2762,46	3649,62	4347,16	5420,29	6557,32	8149,80	9935,39	12145,05	14475,65	16872,78	19481,21	23447,27	27425,58	31517,71	35854,54	42715,73	49222,97	56161,85	63019,81	69749,32	76939,37
OECD	24760,54	27813,87	30912,28	34285,54	37815,99	41956,51	46159,41	51142,08	56217,25	61472,50	66855,50	73352,02	79942,44	86754,59	93704,92	102586,20	111260,49	120468,05	129786,52	138863,10	148439,08
Non-OECD	6584,33	8352,05	10170,68	12765,21	15540,13	19473,57	23581,46	28552,56	35480,40	41622,30	48391,53	59117,83	69768,62	80787,89	92570,92	108466,00	125692,27	141849,07	160129,84	176996,54	195071,57
World	31374,87	36165,92	40982,95	47050,74	53356,11	61430,08	69677,87	80694,63	91697,65	103094,80	115247,03	132469,84	149741,06	167542,78	186275,64	212062,21	236952,76	261917,13	289916,37	315859,64	343509,65

Radiative forcing since pre-industrial (W

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	2,39	2,64	2,90	3,13	3,36	3,55	3,73	3,86	4,00	4,11	4,23	4,35	4,45	4,57	4,68	4,75	4,82	4,89	4,97	5,02	5,07

Global mean temperature (degrees Cels

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	0,43	0,61	0,79	0,96	1,12	1,27	1,42	1,55	1,68	1,79	1,89	1,98	2,07	2,15	2,23	2,31	2,38	2,44	2,50	2,56	2,61

Change in macroeconomic consumption (in billions of 2000 U

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	-10,57	-11,72	-22,42	-27,61	-40,15	-62,75	-88,63	-127,42	-159,02	-165,07	-174,85	-179,71	-190,02	-194,62	-196,35	-209,35	-234,59	-240,83	-255,98	-269,83	-267,99
GER	0,90	1,09	-0,05	-0,39	-1,52	-3,63	-6,04	-9,56	-12,21	-11,99	-12,11	-11,28	-10,75	-9,75	-8,50	-8,14	-9,67	-9,03	-9,45	-8,72	-8,43
EUR	5,97	6,69	3,17	2,08	-1,84	-9,75	-19,14	-33,27	-44,40	-44,39	-45,77	-43,24	-41,77	-38,50	-34,12	-33,16	-39,25	-36,29	-38,28	-35,19	-33,77
LAM	0,81	1,62	-0,45	-0,89	-2,66	-6,55	-11,49	-20,13	-27,93	-32,22	-36,67	-44,65	-52,64	-60,40	-67,32	-75,62	-83,61	-89,52	-95,53	-99,34	-103,52
IND	5,43	6,71	7,02	8,40	9,11	9,58	9,69	11,39	14,33	18,11	21,67	33,93	49,72	64,71	80,24	107,67	136,17	168,12	201,70	234,61	269,47
CHN	4,23	6,23	6,17	8,54	9,48	9,44	8,65	4,61	0,79	-1,41	-3,56	-5,22	-6,52	-7,55	-8,02	-8,03	-1,68	4,22	11,68	20,01	29,38
ROW	-4,16	-5,13	-9,13	-11,98	-17,16	-27,94	-40,59	-62,26	-82,65	-98,82	-114,30	-128,33	-143,01	-157,13	-209,88	-247,50	-291,12	-313,45	-344,71	-371,47	-398,77
OECD	-0,37	-0,49	-1,93	-2,58	-4,35	-7,81	-11,36	-17,02	-21,56	-22,14	-23,27	-23,42	-24,25	-24,31	-24,10	-25,06	-28,35	-28,67	-30,37	-30,37	-31,02
Non-OECD	0,63	0,88	0,36	0,41	-0,12	-1,56	-3,37	-6,64	-9,57	-11,41	-13,30	-15,43	-17,25	-19,04	-20,50	-22,16	-23,06	-23,66	-22,69	-21,52	-20,34
World	2,60	4,81	-15,69	-21,86	-44,68	-91,69	-147,55	-236,64	-311,30	-335,60	-365,77	-398,51	-415,00	-433,44	-445,93	-472,22	-514,15	-517,29	-530,57	-519,93	-513,64

Change in GDP (in billions of 2000 USD)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	-18,06	-21,58	-564,70	-524,84	-916,94	-1622,49	-2146,80	-3065,89	-3507,67	-3636,95	-3757,70	-3883,05	-4091,95	-4220,36	-4458,41	-4623,20	-4653,51	-4703,68	-4695,97	-4705,57	-4710,67
GER	14,12	19,37	-30,62	-19,09	-44,67	-98,56	-132,35	-206,80	-230,61	-241,05	-241,69	-227,25	-213,08	-200,76	-191,15	-187,69	-173,06	-158,01	-138,28	-120,76	-101,69
EUR	61,18	81,88	-124,40	-77,56	-190,22	-433,48	-601,29	-950,71	-1114,67	-1148,21	-1171,00	-1103,17	-1029,22	-971,54	-921,71	-903,37	-829,07	-758,14	-662,16	-578,76	-496,17
LAM	10,52	9,26	-78,72	-77,62	-162,10	-324,47	-472,62	-745,91	-914,00	-1016,66	-1108,40	-1246,85	-1363,91	-1503,68	-1643,84	-1767,39	-1828,15	-1907,59	-1959,53	-2016,06	-2089,36
IND	46,90	54,69	10,61	33,33	13,17	-34,37	-52,40	-59,38	-73,88	-45,50	27,35	146,03	259,15	336,90	449,60	548,68	906,09	1150,29	1440,18	1716,82	2056,55
CHN	16,62	7,02	-177,41	-193,31	-357,66	-581,15	-858,67	-1468,39	-1777,43	-2007,66	-2210,67	-2422,89	-2604,10	-2803,26	-2983,10	-2922,48	-2722,56	-2577,70	-2351,78	-2170,36	-1883,44
ROW	-1,69	-27,69	-296,76	-324,62	-536,23	-1235,94	-1804,02	-2756,92	-3333,63	-3697,63	-4024,22	-4475,05	-4891,73	-5333,86	-5766,54	-6153,02	-6244,15	-6494,64	-6584,48	-6743,82	-6870,24
OECD	57,23	79,68	-719,71	-621,59	-1151,82	-2154,53	-2880,44	-4223,40	-4861,36	-5026,22	-5179,38	-5213,47	-5334,25	-5392,76	-5571,27	-5714,26	-5655,63	-5620,03	-5486,41	-5405,18	-5296,53
Non-OECD	72,34	43,28	-542,31	-562,45	-1142,82	-2275,93	-3288,00	-5060,60	-6099,83	-6767,47	-7315,95	-7998,75	-8600,59	-9303,90	-9923,89	-10193,98	-9888,77	-9819,64	-9455,61	-9211,10	-8846,49
World	129,58	122,97	-1262,02	-1184,04	-2294,64	-4430,47	-6188,44	-9284,00	-10961,18	-11793,69	-12488,33	-13212,23	-13934,84	-14696,66	-15495,16	-15909,24	-15544,41	-15439,67	-14952,03	-14616,28	-14145,02

Incremental Value of Carbon Permit/Carbon Tax (2000 US$/metric ton C E

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	0	0	15	13	23	41	56	80	92	92	92	91,5555527	91,4680898	91,3828884	91,3454913	91,3053982	91,2314157	91,1517859	91,0983613	91,048949	91,0147435

Carbon Dioxide Emissions from Fossil Fuels and Cement (Tg of Carbon Equivalent)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	2,85	3,00	2,87	3,07	3,05	2,92	2,82	2,69	2,65	2,72	2,78	2,83	2,97	3,03	3,16	3,20	3,17	3,19	3,17	3,18	3,17
GER	0,28	0,29	0,27	0,28	0,28	0,25	0,23	0,22	0,21	0,21	0,20	0,19	0,17	0,16	0,14	0,13	0,12	0,10	0,09	0,08	0,07
EUR	1,05	1,09	1,06	1,08	1,04	1,01	0,97	0,95	0,94	0,96	0,96	0,91	0,92	0,76	0,68	0,63	0,57	0,52	0,45	0,40	0,34
LAM	0,38	0,44	0,47	0,53	0,57	0,61	0,65	0,69	0,72	0,80	0,86	0,96	1,02	1,12	1,19	1,26	1,28	1,34	1,38	1,43	1,48
IND	0,32	0,37	0,35	0,40	0,39	0,39	0,38	0,36	0,36	0,39	0,41	0,51	0,53	0,60	0,64	0,73	0,77	0,85	0,90	0,97	1,03
CHN	1,02	1,25	0,92	1,16	1,06	1,04	1,03	1,06	1,11	1,25	1,36	1,59	1,66	1,72	1,84	1,78	1,63	1,55	1,41	1,32	1,20
ROW	1,03	1,27	1,39	1,66	1,81	1,97	2,10	2,20	2,29	2,52	2,71	3,09	3,25	3,52	3,79	4,00	4,00	4,15	4,21	4,34	4,42
OECD	4,18	4,38	4,21	4,43	4,35	4,17	4,02	3,86	3,79	3,89	3,94	3,93	3,97	3,95	3,98	3,98	3,85	3,81	3,71	3,64	3,58
Non-OECD	2,74	3,33	3,13	3,75	3,83	4,01	4,16	4,32	4,49	4,85	5,34	5,96	6,40	6,96	7,46	7,77	7,68	7,69	7,90	8,05	8,12
World	6,92	7,71	7,34	8,18	8,18	8,18	8,18	8,18	8,18	8,18	8,18	8,18	8,18	8,18	8,18	8,05	7,91	7,77	7,64	7,50	7,36

Carbon Dioxide Concentrations (ppmv)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	372	380	389	398	408	416	425	432	440	447	454	460,209077	466,767676	472,948817	479,129956	484,336579	489,487202	493,995271	498,323339	502,086696	505,850053

Methane Emissions (Gigagrams of methane)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	0,34	0,34	0,33	0,34	0,34	0,34	0,33	0,31	0,29	0,28	0,28	0,28	0,30	0,31	0,33	0,36	0,39	0,41	0,56	0,61	0,62
GER	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
EUR	0,09	0,09	0,08	0,09	0,09	0,08	0,08	0,07	0,07	0,06	0,06	0,06	0,06	0,06	0,06	0,05	0,05	0,05	0,05	0,04	0,04
LAM	0,16	0,19	0,19	0,22	0,25	0,28	0,30	0,32	0,33	0,35	0,37	0,37	0,37	0,36	0,36	0,35	0,35	0,35	0,34	0,34	0,34
IND	0,12	0,14	0,16	0,18	0,20	0,22	0,25	0,25	0,25	0,25	0,25	0,26	0,27	0,28	0,30	0,31	0,31	0,32	0,33	0,34	0,34
CHN	0,21	0,25	0,25	0,29	0,31	0,32	0,33	0,32	0,32	0,32	0,32	0,31	0,30	0,30	0,29	0,27	0,25	0,23	0,22	0,20	0,18
ROW	0,30	0,36	0,41	0,46	0,51	0,56	0,62	0,65	0,69	0,73	0,77	0,83	0,89	0,95	1,00	0,97	0,93	0,89	0,96	0,91	0,88
OECD	0,44	0,44	0,42	0,44	0,45	0,43	0,42	0,39	0,37	0,35	0,33	0,34	0,36	0,38	0,39	0,42	0,44	0,46	0,62	0,66	0,67
Non-OECD	0,79	0,92	1,01	1,15	1,27	1,38	1,50	1,54	1,59	1,65	1,71	1,77	1,83	1,89	1,95	1,90	1,85	1,79	1,85	1,78	1,74
World	1,23	1,36	1,43	1,59	1,71	1,81	1,92	1,93	1,96	2,00	2,04	2,12	2,19	2,27	2,34	2,31	2,28	2,25	2,47	2,44	2,41

Methane Concentrations (ppt

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	5569,89	6740,73	7911,56	6907,85	9804,13	10595,17	11486,21	11885,04	12283,88	12602,35	12920,82	13324,39	13727,96	14165,01	14602,05	14683,91	14765,76	15129,00	15490,24	15541,10	15591,96

Welfare Change (in % HEV of lifetime income)

	COE	GER	EUR	LAM	IND	CHN	ROW	OECD	Non-OECC	World
Welfare	-0,31	-0,15	-0,11	-0,27	0,97	0,16	-0,58	-0,24	-0,18	-0,22

GDP (Total in billions of 2000

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	15944,56	17883,99	19797,11	22043,55	24305,02	26962,58	29713,94	32933,66	36287,50	38779,20	43348,01	47718,34	52172,96	56750,71	61444,79	67458,46	73327,61	79561,43	85872,40	92007,72	98462,86
GER	1861,44	2090,04	2315,66	2566,09	2810,78	3065,79	3364,48	3664,07	3979,78	4311,43	4649,66	5028,45	5416,13	5817,52	6223,17	6746,99	7259,20	7804,20	8356,80	8898,44	9464,74
EUR	6980,62	7846,55	8706,48	9705,39	10686,55	11815,43	12972,73	14293,60	15672,29	17123,08	18625,98	20355,44	22110,97	23930,35	25772,83	28112,50	30397,50	32827,28	35269,14	37698,23	40234,13
LAM	1994,94	2319,42	2644,29	3005,94	3546,19	4131,37	4773,49	5867,85	6855,85	7938,93	9133,58	11156,36	13173,55	15217,66	17304,15	19884,94	22334,60	24955,91	27595,63	30149,43	32870,40
IND	486,69	594,95	706,66	874,00	1047,44	1307,05	1618,28	2244,71	2876,46	3569,01	4447,95	6639,35	8767,21	10938,91	13340,93	17226,44	20901,93	24773,11	28661,95	32452,58	36578,19
CHN	1353,54	1895,79	2481,14	3392,84	4386,91	5845,89	7395,44	9228,71	11126,63	13108,17	15193,70	17722,34	20279,69	22940,60	25781,77	29486,54	33095,89	36892,23	40756,99	44577,23	48649,72
ROW	2761,59	3549,46	4346,32	5424,81	6536,44	8086,63	9733,16	11973,32	14276,59	16670,79	19280,94	23210,71	27171,30	31228,79	35641,96	42372,01	48869,10	55728,33	62635,29	69350,64	76528,74
OECD	24786,62	27620,58	30819,25	34315,02	37892,36	41863,79	46051,14	50992,13	55939,57	61213,71	66623,97	73104,23	79599,15	86496,58	93440,78	102317,96	110994,31	120192,92	129518,35	138606,39	148181,53
Non-OECD	6598,76	8357,62	10178,41	12787,39	15516,68	19371,14	23510,36	29254,59	35135,53	41275,80	48056,16	58728,76	69391,74	80325,86	92077,86	108949,93	125191,52	142349,56	159649,95	176529,89	194627,06
World	31385,38	35976,20	40997,66	47102,41	53321,24	61234,94	69561,51	80246,71	91075,11	102489,51	114680,03	131832,99	149090,90	166824,44	185518,68	211267,89	236175,63	262542,51	289168,20	315136,28	342809,59

GCCS_PLUS

Radiative forcing since pre-industrial (W

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	2.38	2.64	2.90	3.13	3.36	3.55	3.73	3.83	3.94	4.00	4.07	4.13	4.19	4.23	4.28	4.29	4.30	4.31	4.33	4.31	4.29

Global mean temperature (degrees Celsi

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	0.43	0.61	0.79	0.96	1.12	1.27	1.42	1.55	1.69	1.79	1.88	1.95	2.03	2.09	2.15	2.19	2.24	2.27	2.30	2.32	2.35

Change in macroeconomic consumption (in billions of 2000 US

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	-7.93	-8.70	-19.05	-23.96	-36.59	-60.12	-89.19	-131.27	-134.63	-130.17	-126.91	-128.93	-133.90	-130.12	-123.86	-131.67	-151.29	-151.14	-159.09	-154.91	-154.74
GER	1.29	1.45	0.45	0.16	-0.96	-3.15	-5.89	-9.01	-9.05	-7.45	-6.15	-4.51	-3.03	-0.92	1.64	2.63	1.95	3.53	4.12	5.93	7.30
EUR	6.39	7.19	3.74	2.88	-1.35	-9.74	-20.65	-35.95	-35.12	-30.29	-26.71	-21.78	-17.29	-10.36	-1.48	1.23	-2.13	3.39	5.29	12.14	17.33
LAM	0.47	0.53	-0.89	-1.43	-3.34	-7.95	-13.11	-23.75	-29.47	-32.61	-37.20	-46.83	-56.54	-65.76	-73.65	-84.01	-93.44	-100.18	-106.90	-110.99	-115.43
IND	4.86	6.01	6.20	7.39	7.90	8.02	7.66	7.78	10.82	13.70	16.37	24.65	36.20	46.96	58.61	78.53	100.43	126.56	152.62	179.76	208.76
CHN	3.45	5.11	4.71	6.50	6.81	5.58	3.26	-4.71	-9.09	-14.03	-19.16	-25.10	-30.50	-35.29	-39.92	-41.95	-41.70	-39.46	-35.51	-30.98	-23.69
ROW	-5.61	-6.98	-11.39	-14.84	-20.64	-32.70	-47.05	-74.34	-92.62	-110.54	-128.77	-169.58	-198.82	-217.97	-244.74	-290.95	-331.42	-370.29	-407.36	-436.77	-476.76
OECD	-0.03	-0.01	-1.49	-2.11	-3.89	-7.36	-11.57	-17.68	-17.88	-16.79	-16.18	-15.52	-15.33	-14.14	-12.38	-12.78	-15.15	-14.42	-14.97	-13.57	-13.01
Non-OECD	0.32	0.48	-0.14	-0.24	-0.93	-2.87	-4.92	-9.59	-11.84	-14.35	-16.88	-23.58	-23.97	-27.21	-29.87	-33.83	-36.91	-38.44	-39.72	-40.91	-40.11
World	2.91	4.69	-16.24	-23.50	-48.16	-99.75	-164.97	-271.67	-298.16	-311.39	-330.53	-361.08	-392.86	-413.45	-422.51	-466.09	-517.59	-526.69	-546.83	-536.81	-531.24

Change in GDP (in billions of 2000 USD)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	-14.89	-17.55	-558.71	-514.34	-896.41	-1579.17	-2045.27	-3258.82	-3306.49	-3432.40	-3572.09	-3723.92	-3850.50	-4095.87	-4382.53	-4553.45	-4591.42	-4638.89	-4619.99	-4615.96	-4606.16
GER	13.98	19.23	-36.84	-18.73	-43.37	-95.03	-120.77	-224.75	-219.57	-222.66	-226.97	-215.05	-203.18	-192.84	-186.72	-185.59	-173.58	-159.07	-139.08	-120.98	-101.38
EUR	56.57	76.76	-129.61	-91.87	-191.40	-426.14	-563.61	-1047.67	-1051.51	-1091.86	-1131.04	-1082.99	-1024.79	-982.56	-953.83	-956.66	-895.14	-832.80	-741.90	-661.98	-573.27
LAM	7.21	5.46	-82.85	-92.21	-166.50	-327.81	-473.79	-925.67	-910.95	-1024.57	-1134.46	-1303.22	-1445.99	-1615.19	-1787.50	-1945.22	-2034.95	-2139.43	-2214.49	-2291.48	-2365.60
IND	41.43	47.86	2.65	23.52	1.77	-47.49	-65.45	-161.52	-109.61	-101.04	-58.01	-2.10	46.92	61.65	100.35	169.91	351.93	501.58	701.04	894.28	1140.35
CHN	12.45	1.03	-186.11	-202.78	-367.10	-689.13	-962.46	-1691.00	-1781.55	-2038.61	-2291.50	-2545.48	-2791.06	-3038.05	-3260.28	-3289.54	-3148.29	-3056.61	-2981.17	-2743.15	-2579.43
ROW	-9.28	-37.51	-306.85	-339.13	-651.38	-1249.36	-1828.46	-3051.60	-3352.92	-3753.38	-4130.91	-4849.54	-5135.36	-5650.87	-6169.05	-6664.55	-6850.08	-7181.23	-7365.08	-7691.51	-7937.83
OECD	55.67	78.44	-716.95	-614.84	-1131.16	-2100.34	-2729.65	-4531.44	-4577.56	-4746.95	-4929.20	-5021.96	-5178.49	-5271.38	-5603.08	-5696.80	-5686.14	-5630.75	-5550.97	-5398.91	-5292.91
Non-OECD	51.82	16.94	-574.26	-600.80	-1183.21	-2312.59	-3330.16	-5631.39	-6155.03	-6917.60	-7604.78	-8497.34	-9313.20	-10242.46	-11116.48	-11709.51	-11681.50	-11977.67	-11759.68	-11741.96	-11612.32
World	107.49	95.38	-1293.21	-1215.54	-2314.39	-4412.93	-6059.81	-10162.83	-10732.60	-11664.56	-12533.97	-13518.30	-14491.69	-15513.84	-16619.56	-17406.41	-17341.64	-17608.42	-17260.64	-17140.87	-16896.13

Incremental Value of Carbon Permit/Carbon Tax (2000 US$/metric ton C Ei

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	0	0	15	13	23	41	56	82	92	91	92	91.5351676	91.4460895	91.359577	91.3211605	91.2804284	91.2060226	91.1360765	91.0724063	91.0207119	90.9885118

Carbon Dioxide Emissions from Fossil Fuels and Cement (Tg of Carbon E

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	2.85	3.00	2.87	3.07	3.05	2.92	2.82	2.61	2.65	2.73	2.78	2.83	2.99	3.04	3.17	3.20	3.17	3.19	3.17	3.18	3.18
GER	0.28	0.29	0.27	0.28	0.26	0.25	0.23	0.21	0.21	0.21	0.20	0.19	0.17	0.16	0.14	0.13	0.12	0.10	0.09	0.08	0.07
EUR	1.05	1.10	1.06	1.08	1.04	1.01	0.97	0.93	0.94	0.96	0.97	0.91	0.82	0.76	0.68	0.63	0.57	0.52	0.45	0.40	0.34
LAM	0.39	0.44	0.47	0.53	0.57	0.61	0.65	0.67	0.72	0.80	0.86	0.96	1.02	1.12	1.19	1.26	1.28	1.34	1.39	1.43	1.47
IND	0.32	0.37	0.35	0.40	0.39	0.39	0.38	0.36	0.36	0.39	0.41	0.51	0.53	0.60	0.64	0.73	0.77	0.85	0.89	0.97	1.03
CHN	1.02	1.25	0.92	1.15	1.06	1.04	1.03	1.01	1.11	1.25	1.36	1.58	1.60	1.72	1.83	1.78	1.62	1.54	1.41	1.32	1.19
ROW	1.03	1.27	1.39	1.66	1.81	1.97	2.10	2.13	2.29	2.52	2.71	2.99	3.25	3.52	3.79	4.00	3.99	4.15	4.21	4.33	4.42
OECD	4.18	4.38	4.21	4.43	4.36	4.17	4.02	3.76	3.80	3.95	3.96	3.93	3.97	3.95	3.96	3.96	3.95	3.91	3.71	3.66	3.58
Non-OECD	2.74	3.33	3.13	3.75	3.63	4.01	4.16	4.17	4.49	4.96	5.34	5.96	6.40	6.96	7.46	7.77	7.67	7.89	7.89	8.04	8.12
World	6.92	7.71	7.34	8.18	8.18	8.18	8.18	7.90	7.23	6.75	6.27	5.93	5.58	5.25	4.91	4.57	4.23	3.89	3.55	3.20	2.86

Carbon Dioxide Concentrations (ppmv)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	372	380	389	399	408	416	425	430	436	436	441	443.602969	445.771322	446.911112	446.950926	448.192144	448.333363	447.524331	446.715299	445.008098	443.300898

Methane Emissions (Gigagrams of meth

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	0.34	0.34	0.33	0.34	0.34	0.34	0.33	0.30	0.29	0.28	0.26	0.29	0.30	0.31	0.33	0.36	0.38	0.41	0.54	0.62	0.63
GER	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
EUR	0.09	0.09	0.08	0.09	0.09	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04
LAM	0.16	0.18	0.19	0.22	0.25	0.28	0.30	0.31	0.33	0.35	0.37	0.37	0.37	0.36	0.36	0.35	0.35	0.35	0.34	0.34	0.34
IND	0.12	0.14	0.16	0.18	0.20	0.22	0.25	0.26	0.25	0.25	0.25	0.26	0.27	0.28	0.30	0.31	0.31	0.32	0.33	0.34	0.34
CHN	0.21	0.25	0.25	0.29	0.31	0.32	0.33	0.32	0.32	0.32	0.32	0.31	0.30	0.30	0.29	0.27	0.25	0.23	0.22	0.20	0.18
ROW	0.30	0.36	0.41	0.46	0.51	0.56	0.62	0.65	0.69	0.73	0.77	0.83	0.89	0.95	1.00	0.97	0.93	0.89	0.89	0.88	0.87
OECD	0.44	0.44	0.42	0.44	0.45	0.43	0.42	0.39	0.37	0.35	0.33	0.34	0.36	0.38	0.39	0.42	0.44	0.46	0.69	0.67	0.68
Non-OECD	0.79	0.92	1.01	1.15	1.27	1.38	1.50	1.53	1.59	1.66	1.71	1.77	1.83	1.89	1.95	1.90	1.85	1.79	1.87	1.77	1.73
World	1.23	1.36	1.43	1.59	1.71	1.81	1.92	1.92	1.96	2.00	2.04	2.12	2.19	2.27	2.34	2.31	2.28	2.25	2.47	2.44	2.41

Methane Concentrations (ppb

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
World	5569.79	6740.58	7911.37	8907.75	9904.13	10695.71	11487.29	11986.65	12286.40	12604.79	12923.19	13328.00	13728.92	14165.02	14601.22	14582.47	14763.71	15126.54	15489.38	15540.49	15591.59

Welfare Change (in % HEV of lifetime inc

	OOE	GER	EUR	LAM	IND	CHN	ROW	OECD	Non-OECD	World
Welfare	-0.33	-0.17	-0.15	-0.35	0.74	-0.01	-0.71	-0.27	-0.32	-0.29

GDP (Total in billions of 2000

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
OOE	15944.80	17884.39	19797.71	22044.61	24307.07	26968.91	29724.09	32914.36	35307.64	39799.65	45386.57	47735.25	52187.10	56763.16	61454.38	67465.43	73333.62	79567.93	85880.69	92016.68	98492.91
GER	1861.43	2090.03	2315.86	2566.13	2810.92	3085.15	3365.63	3683.09	3991.68	4313.27	4651.42	5030.67	5417.12	5819.30	6223.61	6747.09	7258.15	7804.10	8355.72	8896.42	9464.77
EUR	6990.16	7846.04	8705.96	9704.96	10668.43	11915.16	13276.59	14293.89	15678.83	17128.72	18625.99	20357.48	22110.61	23929.26	25766.51	28107.17	30390.66	32819.83	35281.17	37697.90	40225.42
LAM	1994.61	2318.04	2643.97	3095.48	3545.75	4131.06	4773.37	5799.75	6856.24	7938.04	9130.97	11151.02	13165.37	15206.51	17299.76	19947.15	22314.01	24932.73	27570.13	30121.68	32840.78
IND	488.14	594.29	705.86	873.02	1046.30	1305.74	1616.97	2239.45	2872.89	3564.46	4439.41	6024.54	8746.16	10911.38	13306.01	17180.53	20846.62	24708.24	28568.03	32370.13	36498.57
CHN	1353.12	1895.19	2480.37	3391.89	4365.97	5845.19	7385.09	9215.45	11126.22	13103.06	15186.62	17710.09	20261.09	22917.12	25782.05	29449.83	33343.22	38844.14	44734.05	44519.95	48588.12
ROW	2760.93	3547.47	4345.11	5423.18	6538.93	8085.49	9730.71	11943.85	14274.66	16665.22	19270.26	23193.26	27146.94	31197.00	35600.80	42320.84	48908.51	55698.67	62557.23	69264.64	76435.00
OECD	24766.47	27920.46	30819.33	34315.69	37804.42	41869.21	46066.22	50881.33	55967.95	61241.64	66647.96	73123.38	79714.73	86510.71	93447.60	102319.70	110983.86	120191.85	129517.90	138601.01	148183.10
Non-OECD	6596.71	8554.89	10175.21	12783.57	15514.84	19367.48	23506.15	29197.51	35130.01	41260.78	48027.28	58679.90	69320.48	80232.01	91958.63	108798.37	125012.24	142143.78	159419.45	176275.81	194350.47
World	31363.17	36175.44	40994.54	47099.26	53319.27	61236.69	69572.37	80056.83	91097.96	102502.43	114675.26	131802.29	149035.21	166742.72	185406.24	211118.07	235996.10	262335.63	288937.34	314877.82	342533.57