

PIK Report

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CLIMATE POLICY IN THE COMING PHASES
OF THE KYOTO PROCESS:
TARGETS, INSTRUMENTS, AND THE ROLE OF
CAP AND TRADE SCHEMES

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edited by:

Martin Welp, Lutz Wicke, Carlo C. Jaeger



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Editors:

Prof. Dr. Martin Welp*
University of Applied Sciences Eberswalde, Faculty of Forestry
Alfred-Moeller-Str. 1, 16225 Eberswalde, Germany
Tel. +49-(3334) 65 483
Fax +49-(3334) 65 428
E-mail: martin.welp@fh-eberswalde.de
*(corresponding author)

Prof. Dr. Lutz Wicke
IfUM, European School of Management, Institute for Environmental Management, Germany

Prof. Dr. Carlo C. Jaeger
Potsdam Institute for Climate Impact Research
E-Mail: Carlo.Jaeger@pik-potsdam.de

Herausgeber:
Prof. Dr. F.-W. Gerstengarbe

Technische Ausführung:
U. Werner

POTSDAM-INSTITUT
FÜR KLIMAFOLGENFORSCHUNG
Telegrafenberg
Postfach 60 12 03, 14412 Potsdam
GERMANY
Tel.: +49 (331) 288-2500
Fax: +49 (331) 288-2600
E-mail-Adresse: pik@pik-potsdam.de

Preface

Over the past months and years, international climate policy has made significant progress despite huge resistances. But we are still far away from the turnaround in global greenhouse gas emissions that will be necessary to avoid dangerous climate change. There is broad agreement among climate scientists that the first Kyoto period cannot lead to major reductions of global emissions. The second commitment period may bring about improvements in this respect, depending on how serious nations are about climate protection. This raises the question of how to link whatever steps will be possible in the coming years to the prospect of a real turnaround in global emissions in the coming decades.

The Symposium, “Climate Policy in the Coming Phases of the Kyoto Process”, that took place on February 20-21, 2006 in Brussels brought together stakeholders from a broad range of institutions including research institutes, major energy providers, policy-makers on national and the EU level, including developing countries as well as representatives of NGOs (the full list of stakeholders can be found in Annex 2). The aim of the symposium was to identify options open to the international community to avoid dangerous climate change, as the legally binding goal of the UNFCCC is defined. These options ranged from incremental improvements of the commitment undertaken with the Kyoto protocol to a structural evolution of the current climate policy regime. At COP11 in Montreal parties agreed on a second commitment period. In Nairobi at COP12 some progress was made but how the mechanisms in the second commitment period will look like lies at the core of current international climate negotiations. In parallel many other activities, including, different variants of global cap and trade systems have been proposed, such as the Statement of the G8 Climate Change Roundtable convened by the World Economic Forum in collaboration with the UK government.

On the basis of multiple criteria developed in the scientific literature, the participants of the symposium discussed pros and cons of key options. These were looked at them from the point of view of climate protection potential, economic feasibility, and legal-administrative feasibility. Furthermore, stakeholder perspectives and different interests were identified – including those of nations, supranational institutions, business sectors, NGOs, and other constituencies. This exercise provided insights of the extent to which different strategies can be expected to avoid dangerous climate change without jeopardizing economic and social concerns or failing for legal-administrative reasons.

The following papers are based on the presentations either at the plenary sessions or the parallel break-out groups of the symposium. The full program of the event can be found in Annex 1.

The symposium was conducted as a joint effort of the Environmental Ministry of Baden-Württemberg, the European Climate Forum, the Institute for Environmental Management at the European School of Management (Berlin), and the Potsdam Institute for Climate Impact Research (PIK). The event built on past stakeholder dialogues and events organised by PIK with various partners. The mission of PIK, its research focus and structure have constituted a suitable environment within which science-based stakeholder dialogues have found a natural place. The stakeholders involved in PIK’s stakeholder activities have been diverse, ranging from interested individuals to international corporations. The group of people involved in this symposium represented a variety of organisations and viewpoints as well, thus triggering lively debates on long term policy options.

This is exactly the objective of PIK's active stakeholder approach, to bring together different views and exchange arguments on controversial issues related to climate change. We would like to thank all speakers, convenors and participants for the active support in making the event successful.

Prof. Dr. Martin Welp

Prof. Dr. Carlo Jaeger

Prof. Dr. Lutz Wicke

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1. Introduction by the Environment Minister of the State of Baden Württemberg, Tanja Gönner

1.1 Introduction: Importance of climate protection

Climate change is one of the greatest long-term problems facing the world today. Recent studies of climate and estimates of the costs to society of weather anomalies support the conclusion that the problem of climate change is not exaggerated; on the contrary: it is underestimated. National governments bear a joint responsibility for limiting greenhouse gas emissions such that any increase in the global average temperature by more than 2 °C above the pre-industrial level is avoided. This is necessary to protect the environment from very grave effects. Baden-Württemberg, in agreement with the Federal Government of Germany, takes its responsibilities as an industrial region seriously. There are several reasons for this:

- From an historical perspective the industrial nations have contributed very substantially to greenhouse gas emissions.
- In this era of globalized economic and trade relations we are dependent on international progress. It is not sufficient to consider only the consequences of climate change in our own countries.
- We are also responsible for giving those countries in Africa and Asia that are particularly affected by climate change further perspectives for development.

The President of the Maldives in the Indian Ocean - which lie no more than 1 metre above sea level - addressed industrial nations when he said: "Whatever our fate tomorrow, will be your fate the day after tomorrow."

1.2 Kyoto Protocol

2005 had more than its fair share of natural catastrophes, but it was also an important year for international climate protection:

- The Kyoto Protocol became legally binding in 2005.
- Agreement was reached at the World Climate Conference in Montreal on negotiations on the further development of climate policies for beyond 2012.

We know

- that ratification of the Kyoto Protocol took too long,
- that the USA and Australia reject the Kyoto Protocol
- the obligation under the treaty for industrial nations to reduce their greenhouse gas emissions by more than 5% below the 1990 level between 2008 and 2012 does not mean long-term success in climate protection.

Nevertheless, the ratification of the Kyoto Protocol is still of major importance. This is the first time that binding upper limits have been agreed for greenhouse gas emissions – even though important new industrialized and developing countries have not made commitments to reduce their emissions.

The signal given by the 156 signatories is clear: Climate protection is an important responsibility of governments. Citizens, communities and manufacturers must be more economical in their consumption of fossil fuels in the long term and thereby help reduce CO₂ emissions.

I therefore regard the Kyoto Protocol as the first milestone on the long road to successful climate protection in this Century. Despite its inadequacies, we need to build on this treaty with an eye to the future.

1.3 Future climate protection

The European Union considers emissions reductions of 15% to 30% to be necessary for industrial nations by the year 2020 and 60% to 80% by the year 2050 to limit global warming to a maximum of 2 °C. To achieve this it will be necessary to reduce global greenhouse gas emissions by between 15% and 50% from 1990 levels by the year 2050.

However,

- global CO₂ emissions increased by nearly 20% between 1990 and 2003, and
- if current policies are continued then the global CO₂ emissions in 2030 will be approximately 60% higher than present day values.

This illustrates the enormous challenge that faces us.

It is therefore of particular importance that agreement was reached at the climate conference in Montreal on developing international climate protection policies for the period after 2012. All nations that were party to the United Nations Framework Convention on Climate Change, including non-Kyoto states such as the USA and Australia, will participate in a new dialogue on long-term climate protection. I sincerely hope that the readiness of the USA to participate in this dialogue will make it easier for threshold countries to make their own commitment to climate protection.

In addition, a working group drawn from the Kyoto parties will put forward recommendations for further reduction obligations of industrial nations in a second obligation period after 2012. It is important that a level of planning certainty for investments in sectors that impact on the climate – such as the construction of new power stations or traffic infrastructure – be provided in good time before 2012. It is also important to give an early signal on the continuation of market mechanisms under the Kyoto Protocol – Emissions Trading, the Clean Development Mechanism (CDM) and Joint Implementation (JI).

I want to emphasize the following points with regard to the negotiations commencing this year:

- For the period after 2012 it is necessary for industrial nations to specify more ambitious reduction obligations than they have done to date.
- We need to succeed in motivating the USA and Australia to participate in a climate protection policy after 2012.

- The per capita emissions of greenhouse gases in industrial nations are still several times greater than those in threshold and developing countries. Nevertheless it is essential for effective long-term climate protection that threshold countries with comparatively high absolute emissions – such as China, Brazil or India – to commit themselves to their own reductions. This will be one of the topics for discussion today and tomorrow in Brussels.
- Sectors that have not been included in emissions reductions to-date, such as air traffic and shipping, should be included. The issue of deforestation, particularly in developing countries, must be tackled more effectively.
- The further development of flexible instruments in climate protection – such as Emissions Trading, as well as the project-specific mechanisms CDM and JI – need to be put on the Agenda.
- We need the development of new, clean technologies that are also available in threshold and developing countries. I therefore welcome the Asia-Pacific Partnership on Clean Development. This Partnership can provide a new impetus for the use of new technologies – additionally to the Kyoto Protocol.
- However, I am doubtful whether a system that is based exclusively on voluntary agreements without binding reduction aims would provide sufficient incentives for the use of technologies with a lower impact on the climate. Fixed reduction aims that are agreed are an important motive force for new technologies and provide a company with the necessary planning certainty over a longer period of time.

1.4 Climate change and the economy

Climate protection measures have been associated with increased costs. I wish to challenge the contention of opponents of the Kyoto Protocol that climate protection endangers the wealth of the population. The rise in energy prices in recent years has shown that there are good economic reasons for climate protection measures. The economic aims of reducing our dependence on imports, reducing costs and promoting innovation, employment and competition are increasingly gaining their own dynamics – which is benefiting the environment at the same time. The following examples show this:

- General Electric has announced that it will reduce its CO₂ emissions by 1% of the 2005 value by the year 2012. A trend scenario has shown that these emissions would rise by 40% if no action were taken. It will double its annual investment in technology to reduce emissions.
- The Siemens subsidiary PowerGeneration has taken over the 5th largest supplier of wind turbines in the world and plans considerable market growth.
- BP is now the 3rd largest solar company in the world and has announced that it will double its investment in alternative energies to 8 billion dollars by 2015.
- More and more investors are asking firms to provide them with information on the opportunities and risks that result from climate change. A total of 211

international investors with assets of US\$31 trillion dollars under management are participating in the Carbon Disclosure Project (CDP). The investors are requesting information from large companies on climate gas emissions and potential climate risks and the development of climate protection strategies.

- The G8 Climate Change Roundtable, which includes 24 global companies, emphasized last year the need to act on climate change and stressed the importance of a long term, market-based policy framework.

It is possible that this development will actually give "Grounds for hope on global warming" – as The Economist put it on its front cover last December.

1.5 Conclusion

I am delighted that we have representatives here today not just from the fields of politics, science and NGOs, but also from industry. This sets the scene for an open discussion, possibly with conflicting opinions, on the future of international climate protection.

The German weekly newspaper "Die Zeit" described the task facing us in the following terms: "It is about proving the ability of the human species to organise its survival through forward planning." I hope that we will be able to make a small contribution to this proof over the next 2 days.

2. Dinner Speech delivered by Malik Amin Aslam Khan, Minister of State for Environment, Government of Pakistan

Bismillah Al-rehman Al- raheem,

Distinguished ladies and Gentlemen,

I would like to thank the ECF and the State Government of Baden-Württemberg for allowing me this opportunity to speak to this select gathering of climate experts. It is said that the best dinner speech is a short speech so I shall try to be brief and not stand for too long between you and the succulent dinner that is waiting for us.

I was pleasantly surprised and really pleased as soon as I had lounged into my plane seat from Dubai because both of the leading gulf newspapers handed to me by the steward prominently carried articles related to Climate Change. One of the articles related to the need for internalising the growing climate risk for business while the other discussed the current state of Kyoto negotiations. What this showed was how intrinsically the issue of Climate Change has entered the mainstream global agenda and human conscience today. We are now living in a world of increasing acceptability and sensitivity to this particular environmental issue.

However, at the same time I have observed that a very deep divide exists between the climate experts and the political policy makers on this front. This, to me, is a weakness of the global climate negotiations process. Having adorned the hats of both a climate expert as well as one of a politician now, I can truly appreciate this stark shortcoming. To my mind it is severely constraining the development of a robust negotiations process. On one side we have the scientific climate expert community which is consistently churning out policy papers and statistics in typical climate jargon and on the other side of the divide we have the actual policy makers who, in most cases, remain ignorant of all the developments in the expert field. The two continue to work in separate silos with a very weak and unstructured interface. The result is that the most effective constituency surprisingly remains the least informed.

During the COP process, political negotiators arrive with pre-determined positions driven by defined national interests and literally cocoon themselves to new ideas. The plethora of meeting on the sidelines keeps on producing fresh and innovative thinking but the negotiations process hardly allows any of that to filter in when it really matters. Hence, the COP process is not at all akin to development of new thought processes. Yet fresh thinking is exactly what the nature of this daunting challenge demands.

The lack of an informal bridge for fostering open debate on new ideas is quite positively one of the main issues which is plaguing constructive progress on the issue of Climate Change. As mentioned, Climate Change is a truly science and economics driven issue which is searching for novel and creative avenues of global cooperation. Yet, the method for delivering these fresh ideas and debate to the relevant quarters at the global level has not been worked out. Blocked negotiations and a literally stalled policy process is a natural consequence.

I have noticed that the issue has also been raised in one of the papers being presented at this meeting where it is argued that the solution to the Climate issue needs to be found along three lines – finance, technology and policy. The paper rightfully argues that out of these two, finance and technology are easier to handle while the most complex issue remains the development of global policy.

I believe it is absolutely essential to bridge this information and communication divide if we are to make significant policy level progress on this issue.

Various factors can potentially feed into bridging this divide.

One of the most effective, and least focused, roles is one that informed parliamentarians could play on this front. Parliamentarians are the true representatives of civil society and effective agents of policy development in most countries. They need to be involved, integrated and included into the global climate negotiations process. The forum to carry out this dialogue can be found. There are a number of platforms with representation of global parliaments such as the IPU and the e-Parliament, which need to be tied in with a leading climate experts group to initiate an informal, yet constructive, dialogue process.

Secondly, the business community needs to be catalysed to take a lead on this issue. This, more than anything else, will force policy makers to be informed and involved. A most critical action to take in this respect is to both quantify and internalise the growing cost and risk of a changing climate. In this regards, I would like to welcome the “climate disclosure project” which was mentioned in an earlier presentation today. Such initiatives can bring out the true picture of working in a climate constrained economy as well as the risk of facing the impending impacts of climate change. This information, in an economically quantified and politically palatable manner, can truly spur policy action on the climate front. I would like to quote the example of India where the whole Government stance on the CDM changed after a business motivated study predicted an additional flow of \$1 billion through enhanced FDI due to the CDM !

Thirdly, it is said that the climate politics is actually waiting for a “climate catastrophe” to happen. I hope that this is not the route that is eventually taken and the world conscience and concern can be shaken without such an eventuality. However, today we see that the climate issue has already begun to physically manifest itself with the growing incidence of freak weather patterns across the globe. Hurricane Katrina and its disastrous effects showed the vulnerability of one of the world’s strongest economies in the face of this natural challenge. In our region, last year has brought about very uncertain weather with snowfalls near Islamabad and Dubai, where this never happens, flash floods in the Holy city of Mecca, where it hardly rains, and unprecedented rains in Mumbai which inundated the city in a matter of a few hours.

Not surprisingly, this growing physical presence of the climate issue is beginning to shift political paradigms. The previous year provides a lot of evidence of this shift.

To start with, the US Government finally accepted the scientific reality of the issue and also initiated the APEC agreement. This particular agreement got under a lot of

criticism and was termed as a “coal deal” and akin to being a “peace deal where use of guns is also allowed”. However, I strongly feel that it is not a threat but an opportunity for expanding the Kyoto process. It engages countries that are out of the Kyoto loop and also allows for a technology driven climate mitigation process to start in those countries. This parallel process carries the possibility of a later integration of the two tracks.

Last year also saw the landmark G8 summit as well as the Clinton global initiative put the issue of Climate Change as one of the highest priority agendas for global dialogue. Finally, the Kyoto process got a big boost at the Montreal COP with the decisions to extend the process into the second commitment period as well as the initiation of a dialogue with the non-entrants such as US and Australia.

All of the above may not be enough to start the reversal of the climate process but they do suggest that the signposts are now pointing in the right directions.

While there is certainly cause for some rejoice, the Climate Change issue still faces a host of challenges and a number of hurdles still remain to be overcome. The most important question is how to proceed further?

The Kyoto process is laden with a heavy “baggage” which severely constrains a repeat performance. The process of primary differentiation of Annex 1 targets under the Kyoto process was a totally unstructured process with neither any clear rules nor a solid moral or legal criterion. The final deal was achieved through a course of “negotiated justice” and primarily driven by the raw bargaining power of respective countries. In an unequal and inequitable world, replicating such an exercise is beset with insurmountable problems and issues.

At the same time the need to deepen the commitments of Annex 1 countries and widen the participation in Kyoto through new commitments from other emitting countries, is growing every day. The method to be adopted for the widening of this participation has been explored through various approaches but is yet an open and unanswered question. What we all agree is that the basic principles of the UNFCCC need to be respected which include the “equal but differentiated responsibility”, the “polluter pays principle” and the “right of future sustainable development” of developing countries. These are the formulating rules of the process which have to be respected.

One of the options that has been receiving a sustained global attention over the past years is a “global cap and trade” scheme. Different variants of this approach are also being discussed at this seminar. As the name shows it focuses on three main factors – it needs to be driven by a cap, managed through emissions trading and most importantly have a global participation. The selection of a global emissions cap is determined primarily by scientific evidence and is not a very contentious issue any more. Similarly, the efficacy and cost effectiveness of using the instrument of trading, especially in the form of “allowance trading”, is widely accepted today. The main complexity, however, arises on the quest for global participation. The need for this is also linked with the other two aspects. The mitigation process will not meet the cap and trading will not become truly effective until the participation becomes global. Thus, the imperative and complexity of the issue merit serious attention.

I would like to reinforce over here that this search for a globally participated scheme will remain elusive unless it is based on justice and equity. Justice and equity, to my mind, emanate from some variation of the principle of equal per capita entitlements. I will not delve too deeply into this, rather complex topic, as it will take dinner even further. However, I would like to state that some variations of this basic scheme are under discussion in this seminar also and all of them are trying to address the two main challenges of firstly controlling the resource transfer from developed to developing countries and secondly ensuring that the future growth of developing countries is neither compromised nor mortgaged. Let us hope that the debate we have will move us closer to our goal.

The earth's climate is already changing and it is not waiting for the political web to entangle, the economics to get ironed out or the technologies to be developed. We need a solution to this problem and we need it fast. In the end, it has to be an approach that is driven by environmental effectiveness, motivated by economic efficiency and ultimately packaged through political compromise.

I thank you all for your attention.

3. Curbing Climate Change by Global Trade - an outline from Vattenfall, by Dr. Lennart Billfalk¹

¹ Executive Vice President, VATTENFALLAB

(This is an excerpt of an article issued by Vattenfall's CEO Lars G. Josefsson in European Review on Energy Markets, 2006)

3.1 Executive Summary

The overriding environmental challenge of our time is climate change. There is no such thing as a handful of simple short-term solutions. Economy, energy and environment are closely interlinked, so it must be realized that measures to reduce the impact will need coordinated measures. Combating climate change must and will be a part of everyday life all over the globe and a long-term perspective must be applied stretching up to 100 years.

An adaptive burden-sharing model is presented. The model is based on the assumption that an overwhelming majority of all countries commit to participate in the system given that they will only face restrictions once the country is wealthy enough in relative terms. The long-term predictability and the flexibility needed for economic growth can thereby be sustained. Most important is that a burden-sharing model is built based on commitments to long-term reductions.

In order to find solutions, business and industry have to show leadership. Industry must more actively integrate climate issues into the world of markets and trade on a global scale.

The article deals with three aspects of climate change policy; global burden-sharing, the need for a global price on carbon dioxide emissions and implementation issues.

3.2 Vattenfall and climate change

Vattenfall is the fifth largest generator of electricity and the largest supplier of heat in the European Union. The Group's sales amounted to EUR 12.6 billion in 2004. Vattenfall's vision is to be a leading European energy company. The Group currently has operations in Sweden, Finland, Germany and Poland and is about to become a major player in the Danish energy market. Vattenfall acts in all parts of the electricity value chain — generation, transmission, distribution and sales. Vattenfall is also active in electricity trading and generates, distributes and sells heat. The total electricity generation in year 2004 was 174 TWh out of these 34.4 TWh was hydro and other renewables, 68 TWh from nuclear, 71.5 from fossil fuels. The total CO2 emissions were 77.5 million tones. The Group has about 33,000 employees and the parent company, Vattenfall AB, is wholly owned by the Swedish State.

Being a major European energy company, Vattenfall has a great responsibility for the environment. Fortunately, the size and resources of the Company also provide opportunities. We can make a difference in the process of reducing greenhouse gas

emissions and Vattenfall has a clear ambition; Vattenfall is to become the industry leader within environmental issues in the areas covered by our operations.

Today, almost half of our total electricity generation is basically emissions free and releases practically no greenhouse gases since it comes either from renewable energy sources, such as hydro, or from nuclear power generation.

Our lignite-fired generation plants in Germany are among the world's most modern. Which also means that there are limited possibilities to further attain significant reductions in greenhouse gases. An increased use of energy sources that do not add carbon dioxide emissions to the system, such as biofuel and other renewables will be made under commercial conditions.

Looking a few years ahead, we believe that capture of carbon dioxide from fossil fuel plants and permanent storage in geological formations will be a solution of major importance to reduce greenhouse gas emissions. However, further R&D is needed to make the carbon capture and storage technology commercially competitive. The construction of a 30 MW pilot plant for fossil carbon dioxide capture starting in 2006 in Schwarze Pumpe, Germany, is an important first step for Vattenfall's project on the carbon dioxide free power plant.

Although this is Vattenfall's own project, a major part of the research and development is carried out in cooperation with external partners. ENCAP, CASTOR, CO2SINK and CO2STORE are such projects partly financed with EU funds.

3.3 The Challenge

The climate change problem originates from the emission of greenhouse gases, primarily carbon dioxide, mainly from the transport, heavy industry and energy sectors.

Total global emissions of greenhouse gases in 2000 amounted to 37 billion tonnes of carbon dioxide equivalents, of which more than 23 billion tonnes carbon dioxide. The trend is towards a dramatic increase, especially in countries that are experiencing rapid growth such as China and India. Studies show that an acceptable temperature increase and long-term temperature stability could be achieved at a concentration of 550 ppm of carbon dioxide equivalents in the atmosphere. But, we have to respect that this is the current wisdom, it may very well be necessary to revise this target.

To reach the required reductions global emissions must be reduced by probably more than 50 per cent compared to today. During this period, the developing countries will increase their economic activity tremendously, so the presently industrialized countries will have to reduce their emissions by something in the range of 80 to 90 per cent. It is obvious, therefore, that we have a huge long-term problem on our hands.

The challenge is, however, not only long-term, it is urgent that we start acting now. The most pressing need is to create a credible, stable and predictable long-term framework defining how reductions will be achieved. Given efficient incentives, most parties in society can and will act in a rational and accountable way.

With the Kyoto Protocol, an agreement was reached to decrease the global emissions of greenhouse gases in the period 2008-2012 by at least 5 per cent below the 1990 levels. What will happen after the Kyoto period is still unclear, which makes long-term planning and investment decisions extremely difficult.

Against this background, three issues are of outstanding importance. First of all, it is necessary to continue reducing emissions after the Kyoto period ends. Secondly, we must establish a long-term global framework that will provide governments, citizens and corporations with a stable and predictable environment. Thirdly, since greenhouse gas emissions are a global problem, all countries in the world must, in due course, accept emission limits and contribute to the solution. Real long-term global governance is needed. Is such a common effort really possible? Three important aspects of this challenging need are discussed in the present paper:

- An outline of an adaptive global burden-sharing model
- A global price on carbon dioxide emissions and how markets can contribute
- What is needed to implement a global market for carbon dioxide.

3.4 An outline of an adaptive global burden-sharing model

An outline of a model for the global allocation of emissions is presented. The attitude is humble, the model including the calculations, has been developed with the intention of providing an illustration, and of inspiring further discussion.

The allocation to each country in the outline primarily depends on the country's share of global GDP. In addition, developing countries will be phased in to the system and face emission restrictions once they have reached a certain pre-determined GDP threshold.

Overriding principles of the proposed emission allocation model:

- All countries should participate – participation is a part of being a member of the global community
- No poor country shall be denied its right to economic development.
- No rich country shall have to go through disruptive change
- Richer countries pull a larger weight (emission caps do not embrace countries until they have reached a certain economic level; poorer countries with caps get higher allocations compared to richer countries)
- There shall be a level playing field. The proposed framework aims at minimising changes in relative competitiveness
- The system shall be robust. As new knowledge is accumulated parameters may change, but not the principles underlying the system
- Emission caps should be binding
- Emission allowances are allocated to each country in relation to its share of global GDP
- The final allocation to individual companies or facilities will be made at the national level
- The mechanism should be able to achieve wide acceptance as being fair and balanced

While the focus is on a long-term solution, the path as such is also important. It should be realised that enormous investments have already been made in carbon-emitting technologies. These investments often have a life span of several decades. Furthermore, technological development will probably mean that low-carbon technologies will gradually become available at a lower cost. This justifies not setting too severe requirements regarding early actions.

The allocation model allocates emission permits to each country in three steps:

- First a global target cap on a 550-ppm CO₂-equivalent in year 2100.
- Secondly, developing countries should not face restrictions on their emissions until they have reached a certain level of economic development. However, all countries should commit themselves from the start.
- Thirdly, the remaining scope for emissions is divided between all countries facing restrictions in a particular year in line with their share of total global GDP.

In the model, all Annex I countries face emission restrictions from the first year (2015), while the non-Annex I countries do not face any restrictions until the country reaches 50 per cent of the average GDP/capita in 2002 in the Annex I countries.

For the non-Annex I countries, an assumed business-as-usual emission scenario has been used. Eventually, all countries will face restrictions as their GDP/capita exceeds the determined threshold.

3.5 Adjustments

Countries facing restrictions but with a GDP/capita quota less than the world average are allocated up to 1.25 times extra emission allowances compared to a country at the average level. In a similar manner countries that are richer than the world average receives less allocation/GDP unit.

For the Annex I countries, two additional adjustment mechanisms have been applied. The first one sets a minimum level of reductions relative to the emissions in 2002, and the second one sets a maximum level of reductions relative to the emissions in 2002.

The maximum reduction level is imposed primarily to allow existing capital to serve its lifetime. The minimum level is there to guarantee a minimum level of action.

In the model, GDP in Annex I countries is assumed to increase by a factor of six between 2002 and 2100. This is in line with the average of the GDP projections presented by IPCC. For the remaining countries, growth depends on an assumed convergence in GDP/capita towards the Annex I average. In the model all countries are assumed to converge towards the average GDP/capita level in 2100. The population growth is based on the (unweighted) population assumption in the different IPCC scenarios.

Two scenarios

The mechanism is outlined with two different reduction path scenarios, labelled the early-peak and the late-peak scenario. Both these scenarios imply approximately the

same accumulated emissions (about 1 600 gigatonnes CO₂) over the entire period 2015-2100. In both scenarios, the path towards the long-term target means a gradual decrease in emissions for the industrialised countries, while developing countries are allowed to initially increase their emission levels. The early-peak scenario implies that the increase in total global emissions will be halted rather early, around 2025, while the late-peak scenario implies that emissions are allowed to increase for an additional 15 years.

Results

The early-peak scenario

The long-term target is set at emissions of 12 000 mega tonnes CO₂ in the year 2100, compared with approximately 24 000 mega tonnes in 2002. This long-term target, together with the reduction path, is intended to approximate to the emission path of a 550-ppm CO₂ equivalent target. The areas in Figure 3 represent the allocation between different regions, while the line is the global target cap.

Figure 3 shows that China would be allowed to increase its emissions substantially until 2015. By 2020, the GDP of China is assumed to have grown to a level where the country will face emission restrictions. After 2025, China would have to start reducing its emissions towards its long-term target. Since the developing countries do not face any restrictions before their GDP/capita exceeds the threshold, they are in practice allowed to increase their emissions to begin with.

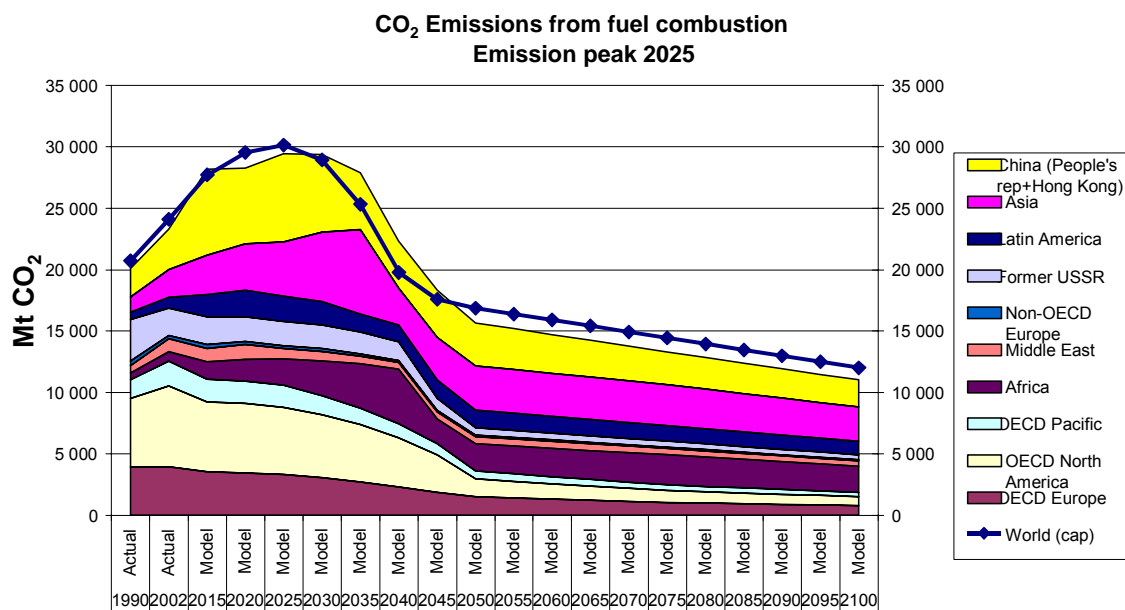


Figure 3. Allocation of emissions - early peak

Late-peak scenario

The late-peak scenario implies that all countries that face restrictions will be awarded a higher allocation up until 2060 and a lower allocation thereafter, compared with the early-peak scenario. The long-term target is consequently reduced to 8 000 mega tonnes in 2100. The fact that the reduction in the level of emissions comes later in

the late-peak scenario, i.e. that a larger share of the total emissions comes early, has some effect on the climate, although the difference is likely to be fairly limited since it is only a matter of a few decades.

A late peak will primarily benefit the countries that have relatively high emissions in the first half of the century, i.e. industrialised economies and fast growing economies (newly industrialised countries and some developing countries).

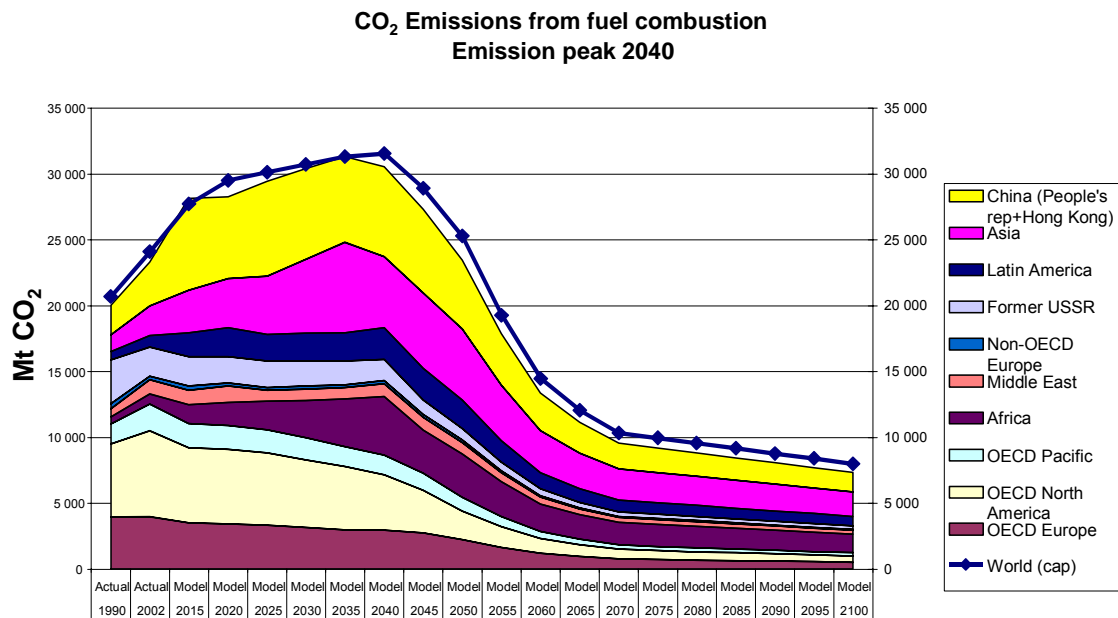


Figure 4. Allocation of emissions - late peak

A comparison between the early-peak and the late-peak scenario

The differences between the two scenarios hardly affect the USA at all. This is due to the fact that the restriction on the speed of adjustment protects the USA from too drastic reductions in the first half of the period. This restriction is not completely lifted until 2045, and determines the allocations for the USA up until then in both scenarios. The late-peak scenario gives the USA slightly higher allocations in the period 2050-60 relative to early-peak and a slightly lower allocation thereafter.

The late-peak scenario will, however, shift the reduction requirements quite substantially for a few developing countries. From the figure it is quite clear that China, India and Brazil will be allowed to continue with relatively high emissions for a longer period of time, but will have to make larger reductions in the future. A similar pattern will be the case for all countries facing restrictions fairly early in the century (i.e. Annex I countries, newly industrialised countries, and fast growing developing countries).

The speed of reductions does not only affect the timing, but also the total accumulated emissions over the entire period for individual countries. Fast growing developing countries and newly industrialised countries seems to gain most from the late peak, while these selected industrialised countries (Annex I) lose in the sense that their accumulated emissions over the period will be lower. The explanation is

that the fast growing developing countries and newly industrialised countries are allowed to increase their emissions for a longer period of time in the late peak scenario.

It is our belief that a GDP-based mechanism has a good chance of being accepted by different countries. For a given level of global emissions, it will not force the industrialised countries to commit to unreasonably large reduction, but at the same time it will give all countries similar opportunities to grow – especially since poor countries do not face restrictions at the start.

3.6 How can the need for a global price on carbon dioxide be met?

The implementation of a policy to reduce emissions of greenhouse gases touches upon two fundamental questions. The first relates to ways and means of achieving the goal of the policy in the most efficient way, i.e. an efficiency issue. The second is a distributional issue – how should the costs and the benefits of the policy be divided?

Economic instruments seem to provide the best means of achieving emission abatement at the lowest possible cost, i.e. of achieving a cost-efficient solution. Such instruments put a price on the emissions and create the same incentives for all parties to reduce emissions.

Curbing greenhouse gas emissions seems to be particularly well suited for emissions trading. The locations of the emissions are unimportant and an international trading system is therefore possible from an environmental point of view. The opportunities for cost savings are furthermore greater when the abatement costs differ. There are strong reasons for believing that the costs of reducing greenhouse gas emissions vary widely among sources (and countries) and the cost savings will thus be larger the wider the trading scheme is. International trade can thus provide the flexibility needed to achieve the lowest-cost abatement options. This is a very important argument in favour of forming a common system.

3.7 Implementation - What must be done?

The adaptive burden-sharing model is based on the assumption that an overwhelming majority of all countries can be convinced to commit themselves to participate in the system on the understanding that they will only face restrictions once the country is wealthy enough in relative terms. The long-term predictability and the flexibility needed for economic growth can thereby be sustained. Agreeing on and implementing a common global system will take time. The most important thing is, however, that we start now by forming a burden-sharing model built on commitments to long-term reductions.

The emissions trading system will not be sufficient on its own to solve the problem, but it is a tool for creating the incentives for actions that will result in solutions. Investments in research and development must be focused and significantly increased in order to produce new technology that can replace or radically improve current methods for transportation and the generation of energy. Prices are fundamental market signals and time will give results. The most important

technological development of the next few decades will probably be carbon capture and storage in connection with combustion of fossil fuels. Nuclear power, present and future, will also be a part of the solution as well as various forms of renewable energy. The transport sector will gradually complete the transition to low emissions or emission-free engines. Efficiency levels will increase as a consequence of clear market signals.

3.8 Summing up

Curbing climate change is about combining technology, finance and policy in a wise way. If that is done a worldwide carbon dioxide market will follow. Technology is not an unsolvable problem, given time and incentives, neither is financing. The real challenge is policy. Will it really be possible for policy makers to get their act together in due time? To be very short, there are no alternatives if humanity should be able to curb climate change.

Up to now, business leaders in general have made a strategic mistake by letting politicians and NGOs handle the challenge mainly on their own. It is high time for the international business community to rethink the entire climate change issue, we, as business leaders, must play a central and very active role in setting up the basic rules and regulations. The business community has unique knowledge that must be taken into account already when the rules and regulations are established. Handling climate change purely or mainly in terms of “red tape” will be extremely expensive – high costs and poor results are to be expected.

On the political level, Europe and the USA have diverged. This is not a sustainable situation and there is great need for a transatlantic dialogue. This responsibility lies primarily on the political system, but the business community has a vital role to play in contributing to such a dialogue.

Joint action on the part of business leaders can make a major contribution to breaking the deadlock between Europe and the USA and contribute to finding measures that have a chance to solve the problem.

4. Climate Policy Beyond Kyoto I by a Global Climate Certificate System – GCCS, by Prof. Dr. Lutz Wicke¹

¹ Institute for Environmental Management (IFUM), European School of Management

4.1 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, HSBC, 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)

- Taking the whole quoted paper, one can summarize the following 6 main demands of the World Economic Forum for an efficient Beyond Kyoto I – System as follows:
 1. A global cap-and-trade system which
 2. strictly limits greenhouse gas emission concentration in the atmosphere.
 3. Such a system should provide a long-term policy framework till 2030 and beyond thus defining emission rights for establishing
 4. a long-term value of clean, climate friendly investments.
 5. And: Such an efficient global climate policy should
 6. ensure and promote an overall sustainable development of emerging markets at the same time.

Concerning the last point more specific: The WEF-leaders are calling for an efficient climate policy with additionally integrated solutions for the elimination of poverty, an adequate energy supply and distribution system and for a policy that stimulates a sustainable, climate friendly economic growth at the same time.

In the following it will be shown, that those WEF-demands can be implemented completely by the Global Climate Certificate System. This can be done by the following four major elements of the GCCS explained later in more detail:

1. A global long term cap for reaching 450ppm CO₂ – nearly equivalent of reaching EU’s maximum plus 2°C – climate target.
2. A distribution of Climate Certificates (CCs) as emission rights according to an equal per capita distribution thus actively integrating developing countries into a world climate protection system.
3. Of course: In such a system there must be emission trading and emission trading regulations for an acceptability of the GCCS by industrialized countries and
4. CC-Transfer-payments from industrialized to developing countries must be strictly earmarked for Sustainable Development and Elimination of Poverty of developing countries.

4.2 The targets of the GCCS

Before defining targets and working elements one first of all has got to fully realize the following terrible situation: According to IEA-projections (IEA 2004) the world is heading towards a CO₂-concentration in the atmosphere of climate catastrophic 750ppm. (Refer to figure 1). At the bunch of the IPCC-emission scenarios for the stabilization at various CO₂-concentrations it is shown how much CO₂ can be emitted globally (as area under the emission curve over the course of time) in order to reach a stabilization at the various stabilization levels. At the steep dotted IEA’s emission projection (that includes all Kyoto I – effects till summer 2004) one can see, that in 2030 a yearly emission of 38 billion tons of CO₂ is pretty likely if no substantial change can be induced. This would be equivalent to a 90% increase of emissions over the 1990 level and a clear tendency towards a 750 ppm

concentration. And this indeed would imply a dangerous climate change with a temperature-stabilization far above 2 degrees Celsius by 2100, which is defined as non-dangerous climate change by the European Union. Contrary to this depressing projection the IEA in the same and other publications (IEA 2004, IEA 2005, Unander/Mattson/Gielen 2005) clearly shows, that a 450ppm CO₂-concentration and therefore (approximately) EU's climate target is still reachable. This is reachable by a global deployment of the CCS-(Carbon-dioxide capture and storage)–technology and at the same time and competing with CCS by the global deployment of the 'renewables'-technology. Based on those IEA-publications the GCCS PLUS strategy (to reach the 450 ppm) is the following – shown in Figure 2:

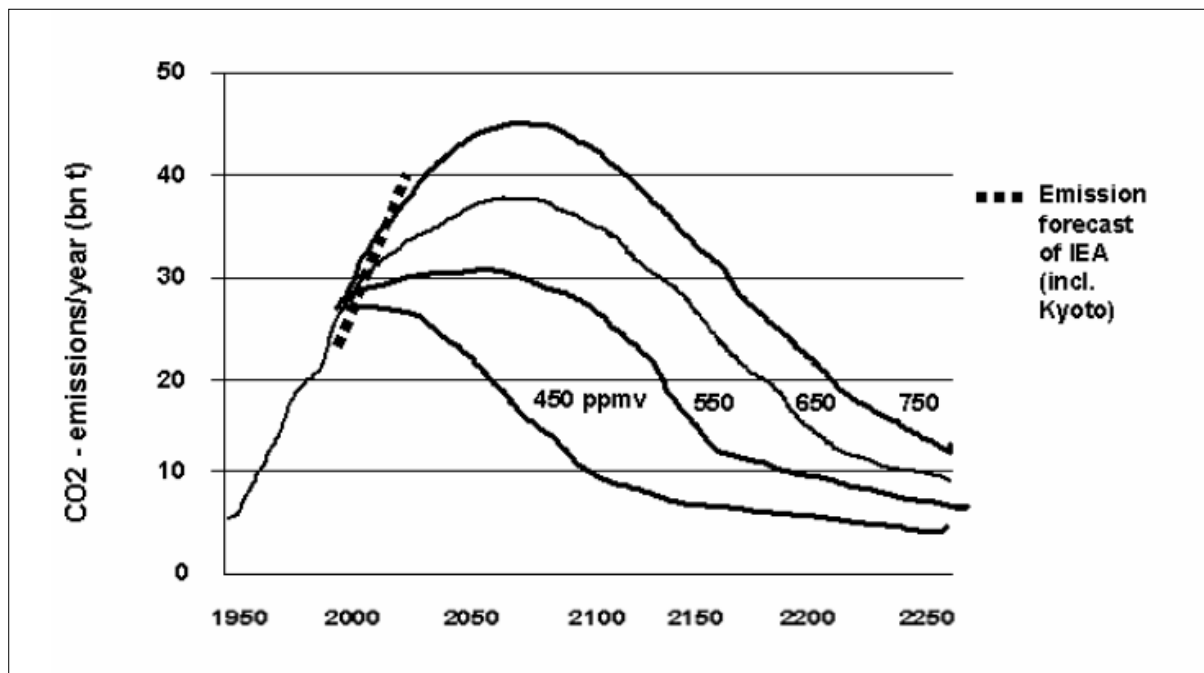


Figure 1: Global CO₂ emissions from 1990 until 2030 and emission scenarios of the IPCC – presented by WRI – for stabilizing at concentration levels between 450 and 750 ppm CO₂ and emission forecast of IEA till 2030

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 b1
- b) Energy-related CO₂ emissions: IEA (2004) p76 and p4332 3.
 - 2015 to 2030: Constant global cap of maximum global emissions of 30 billion ton of CO₂ and
 - - in the course of time – decreasing caps till the end of the century from 30 billion tons (2030) to 23 billion tons (2050) to around 10 billion tons per annum in 2100.

The technological and economical feasibility of EU's climate target is based on IEAs clear statements that a maximum price of US \$2 per ton of CO₂ (later 60\$) definitely would lead to the global breakthrough and the global implementation of CO₂-free fossil fuelled plants.

1 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 CO₂eq stabilization curve which comes closer to the EU's 550ppm CO₂ stabilization target, which is solely based on CO₂ 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.)

2 Since other CO₂ emissions from sources other than energy production and use (especially from other industrial processes and changes in land use and forest use) must be additionally considered, carbon dioxide emissions of around 30 billion tonnes must be expected in 2012-2014. 3 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 CO₂ emissions during the period from 1970 to 2030.

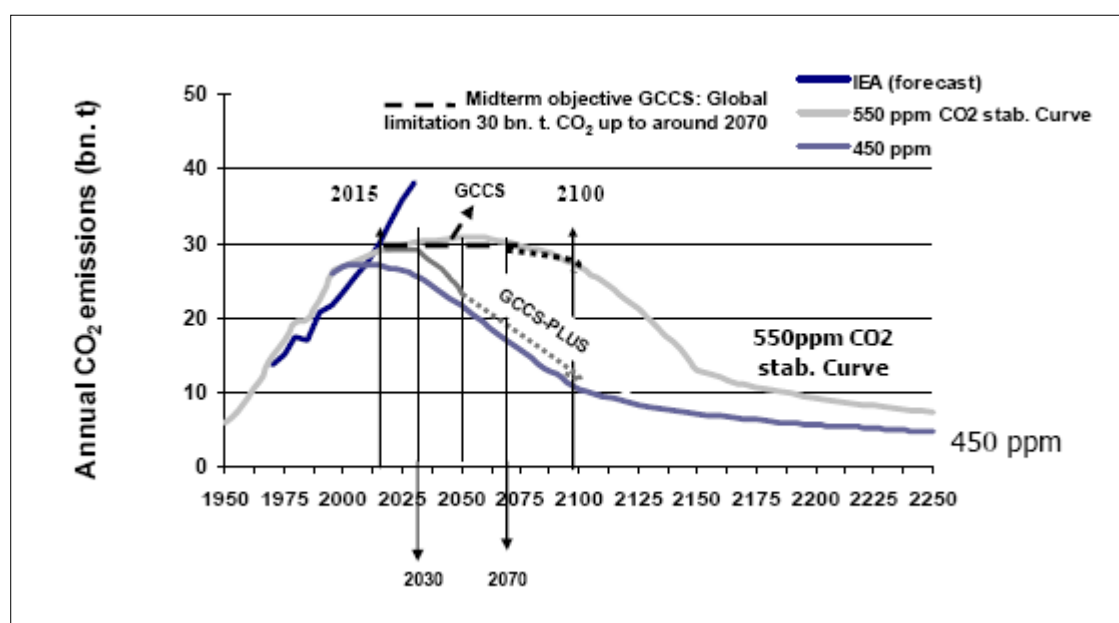


Figure 2: „GCCS PLUS“ versus „GCCS“- targets : Reaching EU's temperature and EU's (minimum) concentration target:

Sources for Figure (see also the footnotes to Figure 1

a) 550ppm CO₂ 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 CO₂ emissions: IEA 2002 a– International Energy Agency: World Energy Outlook 2002, p. 73 and p. 413. and IEA 2004

4.3 Elements and working principles of the GCCS

The Elements and working principles are shortly described as follows:

(Readers of the following should note: All the following figures are just illustrations in order to easily understand the GCC-system.)

1. As already explained: The maximum increase of global temperatures of plus 2°C till 2100 can be – according to the explanation in figure 2 – realized by a 30 billion ton CO₂-cap per year by an allocation of 30 billion climate certificates (CCs), starting in 2015 (staying at the same level till 2030). This would be a substantial reduction to the business as usual development of around yearly plus 1,7% CO₂-increase per annum (IEA 2004). 1 CC would be a permit to emit 1 t of CO₂ (respectively by including other greenhouse gases 1 ton of CO₂equiv.). These certificates will be allocated yearly and are valid for one year only. Starting with a 30 billion t or 30 billion CC-cap in 2015 would be equivalent to no global scarcity of CCs in 2015 and some following years, because global emission would be below this level by those years- This would imply only moderate price increases for fossil fuel and resources thus making it easier to accept this system.
2. The distribution key for CCs within the GCCS is disputable: For many people “One human – one climate emission right” seems to pretty radical. But note: The democratic ‘one man – one vote’-principle has been called radical in former times too. And above that: In any case “One human – one climate emission right” is much, much fairer than the current “cost free emission right” to the atmosphere as cost free waste disposal site. One could discuss fairness questions intensively for days and days (ref. Wicke 2005, p235seq.). But - besides of all fairness principles – a fair chance for climate protection for the world as a whole definitely exists only if developing and newly industrialized countries can be actively integrated in the international climate protection system. Many high ranking politicians of developing countries did make very clear statements in this respect – for instance the former Indian Prime Minister Vajpajee at the New Delhi climate conference in 2002. therefore: Also because of those ‘practical reasons’ the allocation respectively distribution key of emissions rights within the GCCS is the immediate equal per capita distribution! The population key of course must be based on a fixed year. In 2000 6.1 billion humans were living on earth. If everybody world wide would get the right of emitting 4.9 tons of CO₂ this would be equivalent to the described (in beginning years) just tolerable 30 billion tons of CO₂ emission. This could be ‘managed’ by the distribution of 4.9 climate certificates per head – altogether 30 billion CCs. These would be distributed yearly in the first allocation round to national governments – under strict rules.
3. Of course: The author not only being a conservative democrat but also a professor for (environmental) economics clearly knows: An immediate equal per capita distribution system without economic regulations would be ‘no serious proposal’. In case of a completely free climate certificate market this

equal per capita distribution would – because of a huge CC-surplus in developing countries – lead to unacceptable multi-billion Dollar/Eurotransfers. Therefore there must be clear transfer- and maximum price-limits. That is why two correction mechanisms were installed in the GCCS in the form of two separated Cmarkets as follows:

4. The correction mechanism 1 is realized by the transfer-market between countries: Developing countries get much more CCs than they need for their normal business as usual development, because their emissions are far below the cost free and 'allowed' 4.9 tons of CO₂ per person. Those "Surplus-CCs" must be redistributed for a fixed CC-transferprice of – for example – 2US\$ to industrialized countries via the World Climate Certificate Bank (WCCB). This means an additional 'low-cost' basic CC-supply in industrialized countries. The money of developing countries coming from their 'surplus CC-transfer' is strictly earmarked for the implementation of national SDEP Plans!
5. For specialists: Contrary to EU's emission trading system, the GCCS is a so-called 'upstream' ETS: Only traders of the first trading level with fossil fuels – called Fuel and Resources Providers (FRPs) – need tradable emission permits. Therefore the secondary allocation of CCs is done to those FRPs. They yearly get CCs by national climate certificate banks for 2US\$ or for a free CC-market-based allocation price. The amount of CCs being allocated according to last years' CC-demand. The compliance is done as following: All national FRP-sellers of coal, gas and oil (products) must have CCs equivalent to the CO₂-emission-potential of their sold fossil products. In case FRPs need additional CCs for additional 'fossil sales' they must purchase those CCs from other FRPs at the free CC-market. In the GCCS a low-cost CC-allocation to FRPs is possible (but not necessary) thus lowering the primary cost impact of the climate certificate system. The market-correction 2 is done by a price-cap of 30\$ per CC at the free CC-market by CC-sales by market intervention of the WCCB, if the CC-price rises above the 30\$. Therefore there can be no "skyrocketing CC-prices" and there can be no "serious harm" to any economy!
6. Industrialized countries would never accept transfer money to developing countries if the money gets 'out of control'. Therefore it must be very clear on the one hand: The transfer money to DCs is NO foreign aid but a reward for mitigating climate change by low greenhouse gas emissions. But once again and on the other hand: the money would be strictly earmarked for the definite implementation of SDEP-Plans for Climate friendly Sustainable Development and growth and Elimination of Poverty.
7. It is evident, that the SDEP-Plan-implementation meets vital interests of DCs. But it also meets vital interests of industrialized countries (ICs) by mitigating climate change for the sake of the whole world and for higher emission volumes of ICs under the global cap (respectively less tensions and a lower price at the free CC market). The supervision and the implementation of the GCCS is relatively easy: By help of the so called IPCC-reference-approach one mainly has got to control only the flows of national produced coal, oil and gas and their imports and exports. (Wicke 2005).

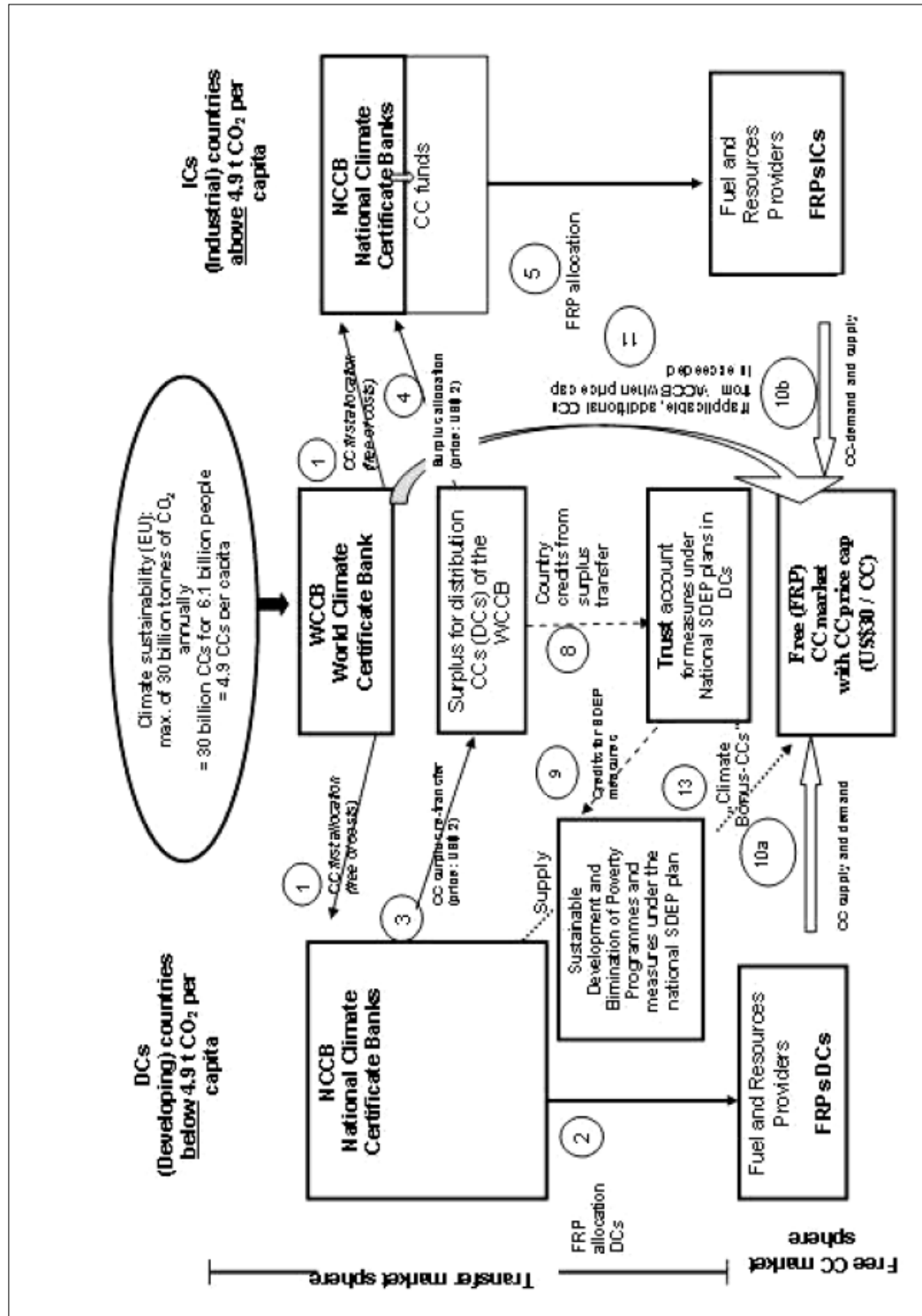


Figure 3: Operation of the GCCS as a climate-stabilizing and at the same time economically compatible 'cap and trade' emissions trading system (key functions) (Wicke, 2005, p211seq) sake of the whole world and for higher emission volumes of ICs under the global cap (respectively less tensions and a lower price at the free CC market). The supervision and the implementation of the GCCS is relatively easy: By help of the so called IPCC-reference-approach one mainly has got to control only the flows of national produced coal, oil and gas and their imports and exports. (Wicke 2005)

The functioning of the GCCS is shown in figure 3. It might – at first glance – look pretty complicated. But the reader definitely can be sure: The implementation of such a total global climate protection system is far less complicated than the current so called ‘clean development mechanism’ which in fact is a tiny little part of the current Kyoto I Protocol System.

4.4 Relatively good chances for the implementation of the GCCS

Some if not many readers, having read the foregoing explanations might think: An unfeasible and impossible to implement approach. Contrary to this – the author is convinced: The GCCS has got relatively good chances for its implementation. Everybody knows the extremely high hurdles for any adoption of any international treaty: The unanimity principle: Any efficient ‘Beyond Kyoto 2012’-system will have extreme difficulties to be accepted and implemented. After the Montreal-conference it seem evident: Even the climate mitigation-ineffective incremental evolution of the current Kyoto I-commitment strategy seems to me nearly impossible. Contrary to this, there exist eleven good reasons for a GCCS-Implementation:

1. The necessary ‘review of the protocol’ (art. 3.9/13.4.a KP) – if done unprejudiced – will have sobering if not depressing results about the climate inefficiency of the Kyoto I – Commitment System – both quantitatively and structurally. This has been shown clearly in Wicke’s Beyond Kyoto (2005).
2. On this depressing basis – according to art. 9.1. KP – there has to be taken ‘appropriate action’ to definitely prevent dangerous climate change.
3. Because the world community has to look for ‘appropriate action’ to tackle the climate crisis, one can be sure: The GCCS definitely is or would be such an ‘appropriate action’ for reaching EU’s 450ppm CO₂-target thus preventing dangerous climate change. And this could be done without dangerous interference with the global economic system:
 - There will be only moderate price increases of about 0.5 cents per litre of gas or diesel in the beginning years. Even the conceivable but not very likely maximum price increase will be bearable.
 - There will be acceptable transfer payments to developing countries, financed by the fossil fuels users – NOT by the states, nor by the taxpayers.
 - The ‘price gap’ at the free CC-market will provide, that there will be NO overburdening of the users of fossil resources.
4. Forth important reason for a conceivable implementation of the GCCS: Developing countries could become protagonist for the GCCS and – contrary tot their current understandable behaviour – protagonists for an active climate policy world wide:
 - With the GCCS there exists no longer climate unfairness with unfair proposals regarding the historical and the actual climate ‘guilt’ of industrialized countries.
 - With the GCCS there will be NO „Eco-Imperialism“ and NO grandfathering! Contrary to that: The GCCS would give an active support for development and growth of developing countries!

- GCCS is a fair ‚equal per capita‘-system according to the democratic ‚one man – one vote‘-principle.
 - The origin of GCCS’ basic ideas about equal per capita distribution lies in India and Pakistan (partly in GB).
 - And once again: Only by an ‚equal per capita distribution‘ an active integration of developing countries into global climate policy is conceivable.
5. Therefore fifth: By help of the GCCS there can and could be a completely changed ‚battle order‘: The conceivable support of the GCCS by developing countries could lead to a 2/3 majority at Climate Conferences!
 6. Very important too: The GCCS integrates justified US-objections:
 - There will be an active integration of developing countries!
 - NO ‚serious harm‘ to the US-economy has to be feared! And there will NO ‚sky-rocketing‘ CC-prices: ‚Price cap‘ according to a proposal by US noble-prize winner Stiglitz!
 - The main cap and trade – ideas have been directly taken from US-proofed successful examples.
 7. The author is pretty sure: Beyond Kyoto 2012 there will be no longer a system of national commitments that has got any relevant climate impact. The GCCS is very realistic in this respect too. Therefore the GCCS has NO national commitments nor national cuts – BUT an easier to accept and more efficient GLOBAL cap: The climate-intensive ‚way of life and of business‘ will still be possible but considerably more expensive; and: The climate friendly sustainable development will become globally much more desirable!
 8. And one has to recall: The International community has got 6 years for the 2012-negotiations. There can be a linkage with non-climate matters (for instance of the WTO) and of course: There can and would be many conceivable modifications of the GCCS and compromises for an efficient and implementable ‚Global Cap and Trade‘ Scheme!
 9. By the help of the GCCS an extremely important climate alliance between the climate change mitigation committed international policy and world’s economic leaders can be built. The reason for this: The GCCS exactly meets the elements of the Urgent Call of world’s economic leaders already quoted:
 - ▶ A global cap-and-trade system,
 - ▶ defining greenhouse gas emission rights.
 - ▶ a long-term policy framework till 2030 resp. till 2050 for
 - ▶ a long-term value for clean investments. And it represents
 - ▶ an efficient global climate policy that
 - ▶ stimulates the sustainable development of emerging economies at the same time.
 10. An additional very important economic argument for GCCS’ implementation is the following: According to model calculations of the two leading German Institutes for Economic climate impacts’ Research (DIW and ZEW) there exists a very, very good benefit/cost – ratio of implementing GCCS (PLUS): 10 : 1! In these calculations the ‚benefits‘ of an efficient climate policy are defined as reduced climate change damage in monetary value.

11. Eleventh and last good reason for pretty good implementation chances of the GCCS: The GCCS could be a good compromise between opponents and supporters of the Kyoto Protocol: GCCS is a STRUCTURAL EVOLUTION of the KP. On the one hand it is a global expansion of the 'US - based' emission trading between states (Art. 17 KP) and on the other hand a modified and expanded EU emission trading system! Therefore: The GCCS is a BEYOND KYOTO CAP AND TRADE SCHEME!

4.5 Outlook

The author is deeply convinced: There exists still a chance for the prevention of dangerous climate change. But – to be honest – the author is both skeptical and hopeful at the same time about this chance. But one point seems absolutely clear: If mankind can reach this vital climate target at all, it ONLY can be reached by a 'global cap and trade'-system! The reason for this conviction is the following: Contrary to a "Beyond Kyoto" based on the Kyoto I – commitment - approach the "GCCS – Beyond Kyoto" is "good for" 5 essential Basics

1. It has a clear-cut climate target by a clearly defined global CO₂-cap!
2. GCCS can actively integrate developing countries by favouring their sustainable development and growth!
3. GCCS provides permanent worldwide incentives for climate gas reductions and for companies and private household and it provides fair competition rules!
4. This implies: Changing Consuming Patterns, long term Energy Safety by clean fossil CCS power generation and by renewable energies!
5. Last but not least and very simple: There definitely exists is no cheaper way for climate protection than an efficient global cap and trade - scheme!
Therefore the essence of this article can be summarized in one sentence as follows: For the sake of mankind – let us do OUR Job!

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5. Evaluation methods for screening global climate policy approaches, by Dr. Asbjørn Torvanger¹

¹ CICERO: Center for International Climate and Environmental Research, Oslo, Norway

5.1 Introduction

Negotiating post 2012 climate policy agreements is costly in terms of time and money. Furthermore the capacity of negotiators to handle policy proposals is limited. Therefore it makes sense to develop methods for screening proposed approaches before they are presented to negotiators. Through such an evaluation process a proposal may get sufficiently high score to be presented for the negotiators. However, some proposals may be discarded because they fail to meet important criteria, or, if they show more promise, they could be improved through revision before re-submission, see figure 1.

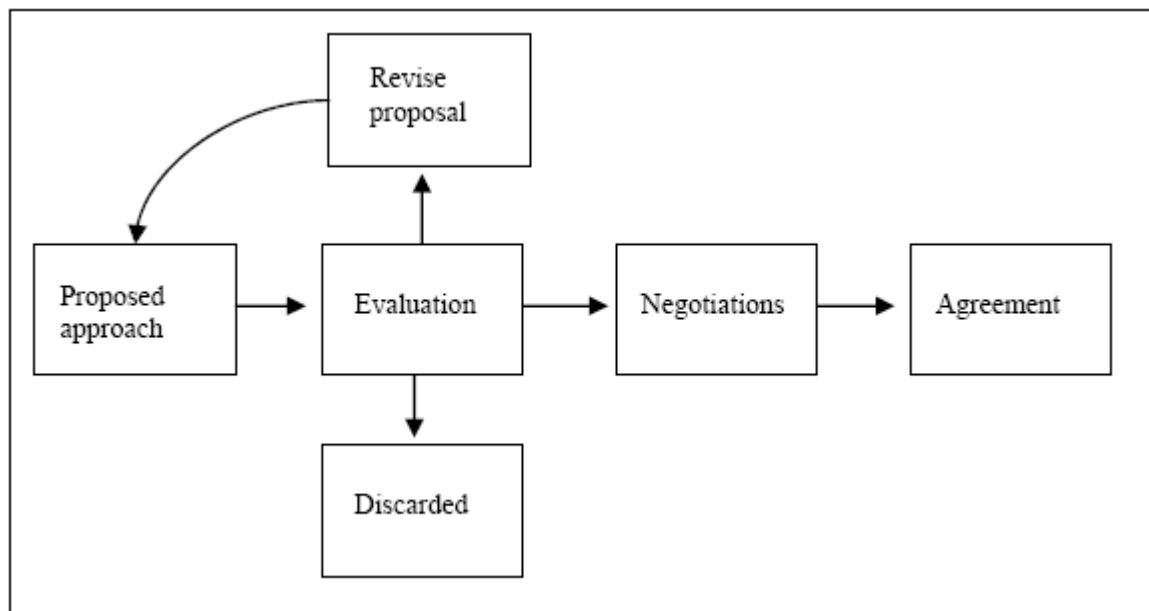


Figure 1. The role of evaluation schemes.

On this background the aim of this paper is to develop a helpful evaluation method for screening proposed approaches for future climate policy agreements at global level. Rather than picking the ‘best’ proposal the ambition should be to identify and discard the least promising proposals through the screening process, and thus save negotiation capacity.

Evaluation methods

The scope for evaluation methods chosen is wider than in most of the literature on criteria for assessing global climate policy agreements and evaluation schemes, which is indicated by referring to evaluation ‘methods’ in stead of evaluation ‘schemes’. There are four categories of evaluation methods considered in this paper:

- a. Criteria-based;
- b. Expert panel;
- c. Model studies; and
- d. Experiment.

The first two categories are qualitative in the sense that they are based on qualitative criteria. The last two categories are quantitative in the sense that these methods can provide numerical estimates of consequences of policy proposals for participating countries (and possibly other stakeholders such as firms). Overviews of climate policy approaches and relevant requirements with regard to efficiency and feasibility are given by Blok et al. (2005), Höhne (2005), Torvanger et al. (2004), Storey (2002), and Ringius et al. (2002). The dominating method in literature is type a, where a set of evaluation criteria is chosen, and agreement proposals compared with regard to how well they do on the criteria, see Höhne (2005), Torvanger and Ringius (2004), Aldy and Stavins (2003), Höhne et al. (2003), Storey (2002), and Philibert and Pershing (2001) for examples. In some references the criteria are weighted and added up to find the total score for each climate policy or agreement proposal submitted to evaluation; for examples see Wicke (2005), and Torvanger and Ringius (2002). Another option is to use expert panels to assess the qualities of candidates for global climate policy agreements. The Delphi technique is a well-known method, whereby questionnaires are sent to a panel of experts for some rounds. There is a potential for more use of expert panels in the area of climate policy. The third option of numerical modeling is widely used in the form of economic models applied to calculate the implementation costs for regions and countries of climate policy scenarios. The last IPCC (2001) report provides a useful overview of studies on costs of implementing the Kyoto Protocol and also on costs of stabilizing atmospheric concentration of greenhouse gases at various levels by 2100. The major advantage of economic models is the stringency in assumptions and the precise results that are generated. However, in our context a weakness is the requirement to measure linkages and effects along one dimension, namely money. The last category of experiments has so far not been employed to assess climate policy agreement proposals to my knowledge. Experiments have been used in economics for many years to simulate markets and interactions between agents to test the effect on prices etc. of changing variables one by one. However, in our context the idea is to employ experiments to test and compare the outcomes of candidates for climate agreements, or potentially to simulate negotiations to come up with possible compromises.

Value judgments and usefulness of evaluation

A main difficulty of employing specific methods to evaluate agreement proposals is the subjectivity or value judgments that are required to come up with 'precise' results. This is particularly the case for the criteria-based approach. There are at least three steps that involve value judgments: first the selection of criteria, then the weighting of each criterion, and finally giving a score on a criterion for a specific agreement proposal. The alternative is to aim at more general evaluation approaches, for instance only ranking proposals instead of giving specific scores, or limit the evaluation effort to the more limited scope of economic consequences given a specific numerical model. Another possibility is to limit the assessment to consequences in terms of e.g. per capita emission allowances at country level. In all

these cases the price of fewer value judgments is a less 'precise' evaluation outcome, where less direction is given for the screening process. Such a limited assessment will likely lead to more proposals being submitted to the negotiators, and thus also leave more work for negotiators and politicians. In any case we should be aware of these difficulties tied to evaluation methods, and be careful with the interpretation of the screening results. In the best case such screening efforts can be useful preparatory work for increasing the efficiency of negotiations, but at the end of the day only the outcome of negotiations will show what turns out to be feasible agreement compromises among countries of the world. Countries have substantial differences in national circumstances with respect to potential for and cost of abatement, resource base, economic development level, expected costs of impacts of climate change and adaptation to this change, and economic capacity to take on commitments to abate greenhouse gas emissions. The next section of the paper discusses the steps involved in criteria-based evaluation schemes. Section three briefly discusses three alternative evaluation methods, namely expert panels, economic models, and experiments. This is followed by a presentation of an evaluation method proposed by the author, which thereafter is applied to evaluate and compare two proposals for global cap&trade systems. Finally, in section six conclusions and policy recommendations are offered.

5.2 Criteria-based evaluation

Selection, weighting and aggregation

Given a criteria-based evaluation approach the first step is to select criteria to include. The literature refers to the following main criteria types: fairness, environmental efficiency, economic efficiency, operational efficiency, and feasibility. In the following these criteria categories are discussed, but first we need to give some attention to the process of weighting and aggregation of scores. Comparison across criteria can take place at three levels, cardinal, ordinal, and 'minimum value', where the latter works like a 'filter'. The most ambitious is the cardinal level, whereby each criterion is given a numerical weight and score, and the weighted scores are summed to calculate the total score. At the ordinal level agreement proposals can only be compared criterion-by-criterion, where each criterion meets one of two or more minimum values, for instance indicated by high, medium, and low value. Ranking of agreement proposals is then only possible if e.g. proposal A is doing as good as or better than proposal B on all criteria. A clear ranking is not possible if A scores better on some criteria than B, and vice versa. In the latter case of 'minimum value', a criterion is either satisfied or not. In this case agreement proposals are only "approved" if they reach the required minimum value on all criteria. Table 1 summarizes the value judgments involved in the cardinal, ordinal and 'minimum value' cases.

Level	Select criteria	Single thresholds	Multiple thresholds	Weight	Numerical score
Cardinal level	√			√	√
Ordinal level	√		√		
Minimum value	√	√			

Table 1. Comparison of value judgments required for evaluation schemes building on cardinal, ordinal, or 'minimum value' levels.

Fairness principles

Several authors argue that climate agreement proposals should be supported by one or more fairness principles. The most frequently mentioned principles are *need* (e.g. interpreted as equal per capita emissions), *capacity* (e.g. measured as GDP per capita), and *responsibility* for global warming (e.g. interpreted as a country's share of past greenhouse gas emissions), see e.g. Ringius et al. (2002).

Environmental efficiency

The main purpose of a climate policy agreement is to reduce man-made global warming through abatement of greenhouse gases. Therefore the ability of the proposed agreement to achieve reductions of greenhouse gas emissions is essential, e.g. in terms of reaching a target for maximum greenhouse gas concentration in the atmosphere by year 2100. This ability is commonly referred to as environmental efficiency.

Economic efficiency

Economic efficiency refers to the ability of the proposed climate policy agreement to achieve the greenhouse gas reduction in a cost-effective manner, meaning that abatement is carried out where the cost per ton is lowest. Studies show that the cost varies substantially across countries due to different economic structure, resource base, economic development level, economic policy, technology, abatement already undertaken, and environmental policy. However, if flexible (market-based) policy instruments are available under the proposed agreement and have a wide-spread and efficient use emission reductions will be allocated to the lower cost measures, sectors, sources and countries no matter how the agreement allocates abatement targets across countries. Obvious examples are emissions trading, the clean development mechanism, and joint implementation under the Kyoto Protocol, and EU's emission trading system. In this way there can be a perfect decoupling of equity and efficiency in theory, but in practice there is likely to be some trade-off between them. Thus there is still some point in allocating abatement targets across countries with some view to marginal cost of reducing emissions of greenhouse gases.

Operational efficiency

Operational efficiency refers to simplicity both in technical terms and with regard to being easily accessible for negotiators. Furthermore the proposed agreement must be realistic with regard to availability of data. Related sub-criteria are flexibility regarding global applicability and flexibility for future amendments due to new knowledge and changes in political, economic and technological conditions across the world.

Feasibility

Feasibility refers to acceptability for as many countries as possible. Often this is referred to as political feasibility. Acceptability has an absolute part and a conditional part. The absolute acceptability is defined by the greenhouse gas abatement target acceptable to a country no matter what the other countries accept or do. The conditional part, which is likely to be more important due to the public good nature of greenhouse gas emission abatement, is defined by how much a country is willing to abate given information on what other countries are willing to abate. Given the conditional and strategic (gaming) aspects of this type of information, it can foremost be revealed through negotiations.

5.3 Alternative evaluation methods

Expert panel

In stead of selecting a set of criteria and constructing a weighting and scoring system, which is subjective to a number of value (political) choices, the idea of an expert panel is to ask the opinion of members of a group of competent people or experts. The proposed agreement or agreements are mailed to the panel. The comments can be provided according a strict scheme, or have a more open format. Furthermore this exercise can be repeated in two or more rounds where the group results from the previous round are given to members of the panel, confer the Delphi methods (see Gamon 1991). Such a process could lead to convergence of results from members of the panel, leading to interesting results from the panel as a whole.

Model studies

Model studies are an example of outcome-based evaluation, whereby consequences of a proposed climate policy agreement is in focus and basis for the evaluation process. This is a widely used evaluation approach. In its simplest version one can calculate emission abatement consequences for instance at per capita basis compared to present situation or compared to business as usual in some future year. A more common approach is to implement the climate agreement scenario in an economic model to calculate the cost of involved countries, see e.g. the survey of studies in IPCC (2001). The costs can be national costs, annual costs as percentage of GDP, annual per capita costs, or marginal costs at some point in time. In the latter case the figure indicates the cost of abating the last ton of greenhouse gases, which should be reflected in the allowance price in associated emission trading markets.

Experiments

To my knowledge experiments have so far not been directly used to evaluate candidates for climate policy agreements. In the last decade experiments have been a growing branch of economics. One climate-related example is trading of greenhouse gases; see e.g. Carlén (2003). Experiments can simulate the workings of a market through computer based interactions between people in a group. Each person plays the role of a market participant, being a firm or a country. A major advantage compared to observing ordinary markets is the ability to vary one variable at the time to study its effect, which of course is impossible in an ordinary market setting due to simultaneous changes in many variables and due to noise. I believe there is role for experiments as an evaluation tool in climate policy. This role should be further explored. The simplest version could be outcome-based and encompass the implementation of an agreement candidate and emissions trading to study abatement and cost consequences for the involved countries. A more challenging setting would be to let people in the experiment play the role of negotiators that each represent a country or region to try to identify possible agreeable solutions. To make such experiments realistic at the level aimed at the designers would need to put a lot of work in describing the circumstances of the countries and the broad policy setting of the negotiations simulated by the experiment.

5.4 A proposed evaluation method

In this study I develop a criteria-based evaluation scheme that tries to strike a sober balance between specificity and required value judgments on the one hand and less specific outcome and objectivity on the other hand. Experiments, expert panels, and model studies are interesting evaluation methods but outside the scope of this study. Referring to the discussion of weighting and aggregation in section 2 I choose an ordinal comparison level comprising the three thresholds Low (L), Medium (M), and High (H) fulfillment of a criterion. The selected criteria are based on the discussion in section 2 and presented in the left-hand column of table 2. The aim of this evaluation scheme is to identify agreement candidates that should be discarded or revised due to important weaknesses. Thus the satisfaction of minimum requirements is tested, and there is a possibility to rank the remaining candidates. Thus there is no ambition to make a detailed score on each criteria or giving a precise overall score. Rather the overall evaluation in table 2 is limited to counting the number of L-s, M-s and H-s for each proposal. Since fairness has three and operational efficiency five sub-criteria and the remaining criteria no sub-criteria the overall evaluation is only based on the five main criteria (shown in bold in table 2). For fairness and operational efficiency this means the “average” of scores across the sub-criteria.

Criterion	Proposal	Proposal a	Proposal b
Fairness			
	Need		
	Capacity		
	Responsibility		
Environmental efficiency			
Economic efficiency			
Operational efficiency			
	Technical simplicity		
	Data requirement		
	Global applicability		
	Future flexibility		
	Negotiation simplicity		
Feasibility			
Overall evaluation			

Table 2. An evaluation scheme for testing minimum requirements and ranking proposed climate policy agreements. In the next section this evaluation scheme is put to use by assessing two proposals for global cap&trade schemes.

5.5 Evaluation of global cap & trade proposals

As an illustration of the evaluation scheme presented in section 4 the scheme is applied to evaluate two global cap&trade proposals. The first proposal is usually referred to as “Contraction and Convergence” (C&C), see e.g. Meyer (2000). The C&C approach implies that a global emission limit is specified over some time horizon; i.e. to reach a stabilization target for atmospheric greenhouse gas concentration. Then a convergence period is specified for national per capita emissions, which implies that per capita emission allowances gradually are reduced from the present high level in industrialized countries to the global average level in the convergence year, say 2070, consistent with the global emission limit (target). Since developing countries have much lower per capita emissions most of them are allowed to increase their per capita emissions in the convergence period. However, the emission allowances for developing countries are sensitive to the overall stringency of the global target. Given a stringent target most developing countries will not be able to increase their per capita emissions much, except maybe for an early transition period where the pressure is on industrialized countries. Subsequently countries are allowed to trade allowances in a global market so that the least expensive measures are carried out first to minimize global costs. Since the industrialized countries can save a lot by buying allowances from developing countries, which have a large surplus, C&C implies a substantial transfer of money from North to South. The second proposal evaluated is a newer and elaborated sibling of CC called the “Global Climate Certificate System” (GCCS) proposed in Wicke (2005). GCCS puts a specific cap on global emissions which will take effect and consequently constrain global emissions from 2015. The annual allowance is 30 billion tons of CO₂, which are turned into the same number of Climate Certificates

(CC). Importers and domestic producers of fossil fuels and fossil fuel products receive enough CC to cover emissions due to combustion of their products. Globally the CC are distributed at an equal per capita basis. This basic amount of CC is transferred to National Climate Certificate Banks (NCCBs), which thereafter supply the CC for free to fossil fuel producers and importers. Developing countries can then sell their surplus CC to industrialized countries, leading to an enormous transfer of money to developing countries. To make the proposal more realistic surplus CC are sold to industrialized countries via a World Climate Certificate Bank (WCCB) for a fixed price at USD 2 per CC. There is a free market of CC between the fossil fuel producers and importers. If a fossil fuel producer has a higher production than his stock of basic CC he has to buy additional CC at the market. Similar to a hybrid system with price cap the WCCB intervenes in the market with increased supply to prevent the price from climbing above USD 30. Developing countries can only use income from CC sale for climate-friendly plans and for the purpose of sustainable development and elimination of poverty.

Criterion	Proposal	Contraction and Convergence (C&C)	Global Climate Certificate System (GCCS)
Fairness		<i>M</i>	<i>M</i>
	Need	<i>H</i>	<i>H</i>
	Capacity	<i>M</i>	<i>M</i>
	Responsibility	<i>L</i>	<i>L</i>
Environmental efficiency		<i>H</i>	<i>H</i>
Economic efficiency		<i>H</i>	<i>H</i>
Operational efficiency		<i>H</i>	<i>M</i>
	Technical simplicity	<i>H</i>	<i>M</i>
	Data requirement	<i>H</i>	<i>M</i>
	Global applicability	<i>H</i>	<i>H</i>
	Future flexibility	<i>M</i>	<i>M</i>
	Negotiation simplicity	<i>H</i>	<i>M</i>
Feasibility		<i>L</i>	<i>L</i>
Overall evaluation		<i>3H, 1M, 1L</i>	<i>2H, 2M, 1L</i>

Table 3. An evaluation scheme for testing minimum requirements and ranking proposed climate policy agreements. The scores are based on fulfillment of criteria at the main criterion level: High (H), Medium (M), and Low (L). Overall evaluation is the sum of H; M and L score on the main criteria.

In table 3 the two proposals for global cap&trade systems are evaluated and compared. Both proposals are doing quite well on fairness, environmental efficiency, and economic efficiency. With regard to operational efficiency C&C is doing better than GCCS due to the added complexity of the latter proposal. Both have a low score in terms of feasibility. The feasibility score must be seen on the background of the enormous difficulty of constructing climate policy agreements that are broad in terms of participation, deep in terms of emission reductions, and involving a consistent long-term global strategy required to meet an ambitious future target. A corresponding aspect of this immense challenge is the wide discrepancies in views and interests between many countries and other stakeholders in terms of perceived

interests, views on how the ideal climate policy should be - including the long-term climate target, and the fair allocation of efforts to reach such a target.

5.6 Conclusions and policy recommendations

This paper has argued that evaluation methods for climate agreement candidates have important weaknesses. In particular criteria-based schemes are prone to valuation at several levels. The usefulness for evaluation methods is foremost to screen proposed agreements so that proposals with deficiencies are discarded or possibly revised before they are forwarded to international negotiations and thus allowed to constrain the limited capacity of negotiators. After all only the outcome of negotiations can show what agreement design that turned out to be feasible. Due to the limitations of criteria-based methods and the complexity of the task at hand it seems wise to supplement evaluations with alternative methods such as expert panels, model calculations, and experiments. There seems to be an under-utilized potential for exploring experiments and expert panels in the context of designing climate policy. Given the limitations of criteria-based methods with respect to valuation a simplified evaluation scheme suitable for testing fulfillment of minimum criteria and for ranking of agreement proposals is proposed. The evaluation scheme contains five main criteria that each can be given a low, medium or high score. I believe that evaluation schemes with such a sober ambition level are more helpful than elaborate schemes with a lot of numerical weights and scores, which are dependent on the author's subjective valuation. Employing the proposed evaluation scheme on the global cap&trade proposals 'Contraction and Convergence' and 'Global Climate Certificate System' shows that both fare well with exception of the most demanding criterion, namely feasibility.

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6. Comparison of approaches for international climate policy post 2012, by Niklas Höhne¹

¹ Ecofys energy and environment GmbH

6.1 Introduction

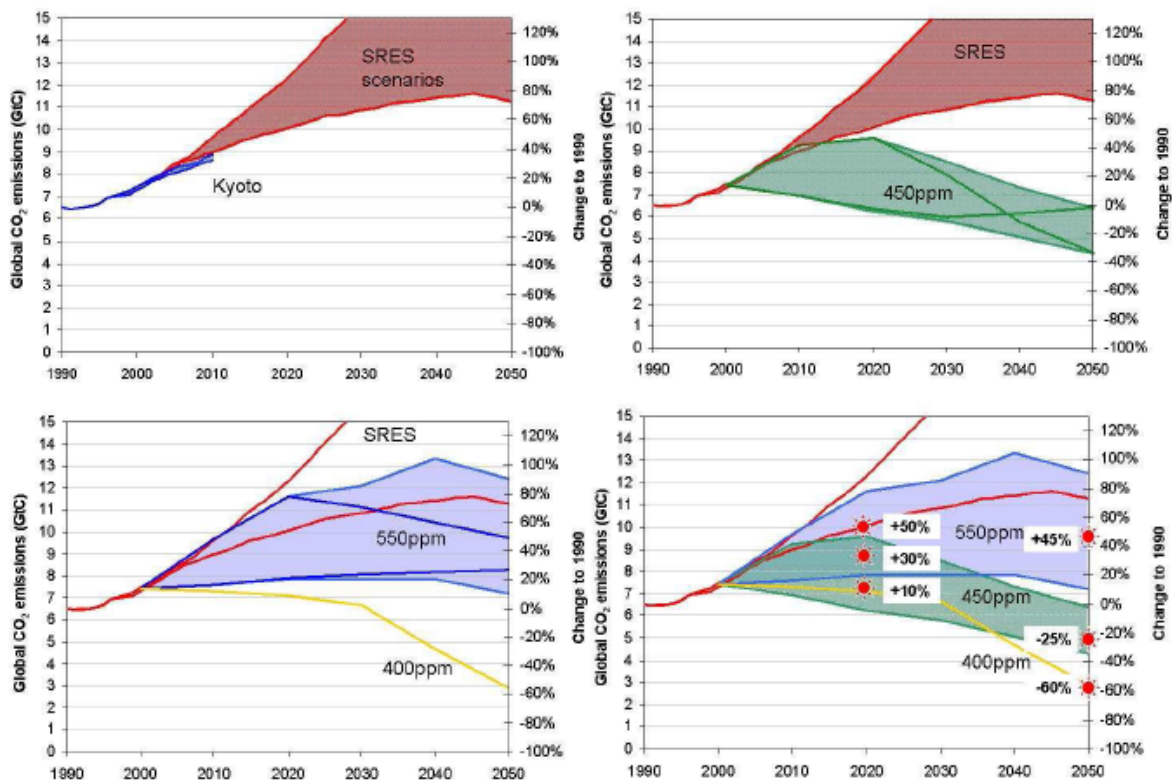
With the entry into force of the Kyoto Protocol, the second round of commitments moved to the center stage of the international negotiating agenda on climate change under the United Nations Framework Convention on Climate Change (UNFCCC). For the first commitment period from 2008-2012 OECD countries and economies in transition, the so-called Annex I countries, have accepted binding greenhouse gases (GHG) emission targets. Developing countries (non-Annex I countries) have no such commitments but may host emission reduction projects through the Clean Development Mechanism (CDM). Nevertheless, reaching the ultimate objective of the UNFCCC, "to achieve ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC 1992) will only be possible, if emission reductions are intensified and participation in those reductions is broadened. This paper presents an overview of approaches for international climate policy after 2012. First, it addresses the requirement for stabilization of greenhouse gas concentrations in general and related global emission and concentration levels (Section 2). Then, it describes and assesses various approaches to further develop the Kyoto Protocol (Section 3). Final conclusions are presented in section 4.

6.2 Necessary efforts to meet the EU's 2°C target

Stabilization of atmospheric concentrations in the 21st century at any level requires a significant departure from current emission levels. Global emissions will need to decline significantly compared to today's level. They will have to drop below the 1990 level and decline to almost zero over time. The earlier the emissions peak and decline, the lower the stabilized concentration level as well as the absolute level of climate change and the earlier climate change is attenuated. In order to achieve stabilization of greenhouse gas concentrations, CO₂ and other greenhouse gases have to be included. Historically, emissions have increased the CO₂ concentration from 280 ppmv to the level of 360 ppmv in the mid 1990s. CO₂, CH₄ and N₂O together produced an amount of radiative forcing equivalent to the forcing of CO₂ alone at roughly 400 ppmv (400 ppmv CO₂eq.). Stabilizing the CO₂ concentration at 450 ppmv and reducing emissions of the other gases at similar rates would lead to a radioactive forcing of CO₂ plus the other gases that is equivalent to the radioactive forcing of 550 ppmv CO₂ only. Hence, stabilization of CO₂ concentration at 450 ppmv would lead to stabilization at 550 ppmv CO₂ equivalent, when accounting for the other greenhouse gases (Eickhout et al. 2003). The translation of greenhouse gas concentrations to temperature increase involves the relatively large uncertainty in the climate sensitivity: the temperature increase for a doubling of the CO₂ concentration lies between 1.5°C and 4.5°C. Kerr (2004) suggests a higher range for the climate sensitivity of 2.0 to 5.1°C. According to Azar & Rhode (1997), the scenario for a concentration of 350 ppmv CO₂ leads to an equilibrium temperature increase of 1.5°C above pre-industrial levels at a mean climate sensitivity. The CO₂ concentration of 450 ppmv leads to an equilibrium temperature increase above 2°C

at a mean climate sensitivity (IPCC 2001). Due to the delay between the increase in concentrations and the rise of temperature the temperature increase will not yet occur to its full extent until 2100. The council of ministers of the European union agreed in June 1996 that “global average temperatures should not exceed 2 degrees Celsius above pre-industrial level and that therefore concentration levels lower than 550 ppmv CO₂ should guide global limitation and reduction efforts” (EC 1996). The European Union and several European ministers repeatedly committed to the 2°C temperature target. In light of the latest analyses described above, the 2°C target would, however, mean that the EU has to aim for a CO₂ concentration below 450 ppmv (at average climate sensitivity). Using various probability distributions of the climate sensitivity, Hare and Meinshausen (2004) conclude that it is “likely” that the 2°C will not be met with stabilization of at 550 ppmv CO₂eq. (450 ppmv CO₂ only). Furthermore, they assume that there is roughly a 50% change that it is met at 450 ppmv CO₂eq. (400 ppmv CO₂ only) and that it is roughly “likely” to be met at 400 ppmv CO₂eq. Figure 1 (top left) provides an overview of the range of future global CO₂ emissions as adapted from the Special Report on Emission Scenarios (SRES, Nacicenovic et al. 2000) of the IPCC in comparison to historical emissions: We applied the emission growth rates of the six “SRES marker scenarios” as implemented in the IMAGE model (IMAGE-team 2001) to the absolute emissions estimated for the year 2000 by source. The spread of future emissions is quite substantial already in the next few decades. The figure also shows the possible range of global CO₂ emissions under the assumption that the Kyoto targets are reached by all Annex I Parties (including the USA). Even assuming the emissions of Annex I countries are constrained to the levels provided in the Kyoto Protocol, the range of the global emission level is still wide, since the future emissions of the developing countries are uncertain. Figure 1 (top right and bottom left) shows the resulting range of possible global CO₂ emission pathways leading to different stabilization levels that we adapted from the post-SRES mitigation scenarios (Morita et al. 2001) as follows: Since the post SRES scenarios were not harmonized, absolute global emissions of the scenarios in 1990 and 2000 are not the same for all scenarios. We therefore applied the emission growth rates of the scenarios to the absolute emissions estimated for the year 2000. Included are all post-SRES scenarios except two, whose emissions in 1990 and 2000 deviated completely from these values. The result is only an approximation and further research is needed on the required emission corridors to a certain stabilization level.

(Source of emission corridors: Adapted from Morita et al. 2001 as presented in Höhne et al. 2005)



(Source of emission corridors: Adapted from Morita et al. 2001 as presented in Höhne et al. 2005)

Figure 1. Possible global CO₂ emission pathways until 2050: Reference emissions and emissions with the implementation of the Kyoto Protocol (top left), reference emissions and corridor towards stabilization at 450 ppmv CO₂ (top right), corridor towards 550 ppmv CO₂ and path towards 400 ppmv CO₂ (bottom left) and selected global emission levels for this analysis (bottom right).

The spread of paths that lead to the same concentration levels is large. With up to some 100 years CO₂ has a very long residence time in the atmosphere. Due to this, it is approximately the aggregated emissions irrespective of the time of emission that define the concentration level. Significant differences in the timing of required emission reductions under various stabilization scenarios permit many alternative pathways. Two example pathways are shown in the corridor of 450 ppmv CO₂ or 550 ppmv CO₂ eq. (top right). Global emissions could increase rapidly now, peak and then decrease rapidly (by 3% per year over a period of 20 years until 2040). Or, they could decrease moderately until 2030 and then increase moderately. Both paths will lead to the same concentration level by the end of the century. Paths to concentration levels lower than 450 ppmv CO₂ need to involve very rapid emission reductions or global removal, i.e. negative emissions. The lowest path included in Figure 1 is the only post SRES pathway that leads to a CO₂ concentration below 450 ppmv, namely 350 ppmv. It assumes that emissions are negative in the latter half of the century. We take this pathway here until 2050 as example path for 400 ppmv CO₂, assuming that global emissions would not be negative in the latter half of the century. This is consistent with stabilization pathways of other analyses. We conclude from the figure that the increasing global emission trend has to reverse

within the next 20 years to achieve a stabilization at 450 ppmv CO₂. For stabilization at lower levels, the reverse of the trend has to occur even earlier. Current business as usual projections are well outside of the necessary range within a few years. For parts of this analysis, we selected reference points of global emission levels in 2020 and 2050 which have to be met by all approaches for the following quantification of emission allowances. These are taken from Figure 1 (bottom right) as rounded percentages from the middle of the ranges to be in line with 550 ppmv CO₂ (roughly 650 ppmv CO₂eq.), 450 ppmv CO₂ (roughly 550 ppmv CO₂eq.) and towards 400 ppmv CO₂ (roughly 450 ppmv CO₂eq.). We assumed for the case towards 550 ppmv CO₂ that *global greenhouse gas emissions*, weighted with global warming potentials, can be 50% above the 1990 level in 2020 and 45% above the 1990 level in 2050 (following the middle of the possible emission band). For the 450 ppmv CO₂ case, it would be +30% in 2020 and -25% in 2050. This is high in the emission band for 2020 and low in 2050, assuming that such is a more likely pathway. For the 400 ppmv CO₂ case the global emissions would be +10% in 2020 and -60% in 2050.

These global targets are only based on considerations of the most important greenhouse gas CO₂. Stabilization scenarios considering all greenhouse gases are rare in the literature (e.g. Eickhout et al. 2003, Wigley et al. 2005, Meinshausen et al. 2005). In assessing emission pathways to stabilize the climate system, however, other greenhouse gases are also important. Non-CO₂ emissions are a significant part of the Kyoto basket, especially for Non-Annex I countries. In addition, non-CO₂ gases provide some low cost reduction options. For simplicity, we assume that for a given concentration level emissions of the non-CO₂ gases need to be reduced with the same percentage as the CO₂ emissions. A delay of only a few years has considerable consequences on the ability to keep CO₂ concentrations below 450 ppmv. We used the EVOC tool to demonstrate this (Höhne et al. 2005a).

Figure 2 shows global CO₂ emissions until 2020 under four cases:

Reference: A reference case with no climate action based on IPCC SRES scenario A1B

- **Delayed 2020:** A delayed case where the countries that ratified the Kyoto Protocol achieve their Kyoto targets and stay on that level. All other countries follow their reference. Global reductions start as of 2020
- **Delayed 2015:** A delayed case where the countries that ratified the Kyoto Protocol achieve their Kyoto targets and stay on that level. All other countries follow their reference. Global reductions start as of 2015
- **Multistage:** The multistage agreement as described in section 3.5 below. After 2020, we choose the emission paths to ensure that the CO₂ concentration will stay below 450 ppmv. We assume that global emission reductions start as of 2020 except for 'delayed 2015' where they begin in 2015. As global emission trends are unlikely to change drastically from one year to the next, we represented this inertia in a simplified manner: the global emission trend cannot change more than 0.5 percentage points per year. For a detailed description of this methodology see Höhne and Blok (2005). Figure 2 shows that following the reference case or the delay until 2020 would make it virtually impossible to stay below 450 ppmv CO₂. Only global reduction rates higher than 10% per year after 2020 would make this achievable. Already the delay of 5 years increases the global reduction rate per year after 2020 considerably (here from 2.2% to 3.6%). If a concentration of 550 ppmv

CO₂ was aimed at, the difference between the cases would be less pronounced. This is because to stay below 550 ppmv the peak in global emissions may occur later in the century but still before 2040/2050.

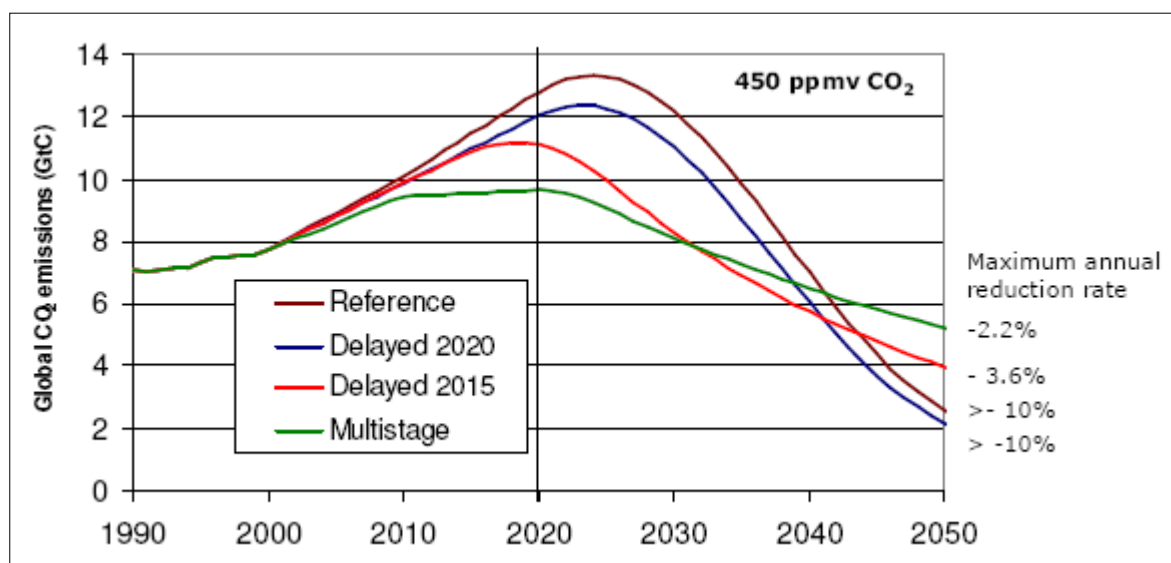


Figure 2. Global CO₂ emissions under several scenarios until 2020 and emission pathways towards stabilization of CO₂ concentration at 450 ppmv

We conclude from Figure 2 that a delay reducing emissions for 5 to 10 years after the first commitment period of the Kyoto Protocol (2008 to 20012) has significant implications on subsequently necessary emission reductions to meet the same goal. Therefore, approaches that only focus on long term technology development and not on short-term emission reductions are not compatible with the goal to keep global temperature increase below 2°C.

6.3 Comparison of post 2012 approaches

In this chapter, we describe and assess some approaches for international climate policy post 2012 that could be compatible with the 2°C limit (Figure 3). These approaches strongly vary in their degree of complexity. Some are based on only a few principles and structured differently compared to the Kyoto Protocol, such as contraction and convergence, common but differentiated convergence and the global climate certificate system. The Triptych approach provides a more sophisticated allocation method. A more complex framework is the multistage approach, which could evolve gradually from the current system. These approaches are described in the following sections.

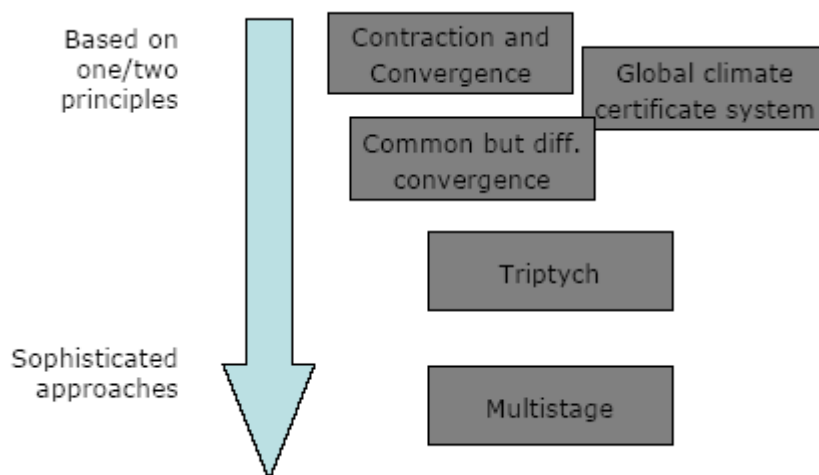


Figure 3. Overview of some post 2012 approaches.

6.3.1 Contraction and Convergence (C&C)

Contraction and convergence was proposed by the Global Commons Institute (Meyer 2000, GCI 2005). Under this approach, all countries participate in the regime with quantified emission targets. As a first step, all countries agree on a path of future global emissions that leads to an agreed long-term stabilization level for greenhouse gas concentrations ('Contraction'). As a second step, the targets for individual countries are set in such a way that per capita emissions converge from the countries' current levels to a level equal for all countries within a convergence period ('Convergence'). The convergence is calculated that resulting global emissions follow the agreed global emission path. Indicative convergence levels are given in Table 1. Global emission trading would be allowed to level off differences between allowances and actual emissions. Current per capita emissions differ greatly between countries. Some developing countries could be allocated more emission allowances than necessary to cover their emissions ("hot air"). This would generate a flow of resources from developed to developing countries.

Under relatively strict long-term targets (e.g. 450 ppmv CO₂) and convergence by, e.g., 2050, not all developing countries would benefit from this approach. As the per capita emissions have to converge to a level below current average of developing countries, those developing countries above or close to the average (e.g. Argentina, Brazil, Venezuela, Mexico, South Africa, South Korea, Namibia, Thailand, China) will soon (e.g. 2020) be constrained and will not receive excess allowances. More excess allowances would be available under a higher concentration target, e.g. 550 ppmv CO₂, or under earlier convergence, e.g. by 2030. Reaching a fixed global emission level is easier for Annex I countries, if all Non-Annex I countries participate immediately, as in C&C. Because only then relatively cost-effective mitigation options in some developing countries can be accessed and traded within the system. It would be more difficult for Annex I countries in a staged approach, such as Multistage, where developing countries gradually phase-in to receive commitments. Some more strengths and weaknesses of the approach are given in Table 5 in section 3.6.

	A1B	A1FI	A1T	A2	B1	B2
400 ppmv	1.4	1.4	1.4	1.1	1.4	1.3
450 ppmv	2.7	2.7	2.7	2.1	2.7	2.5
550 ppmv	5.2	5.2	5.2	4.0	5.2	4.8

Table 1. Indicative convergence level of per capita emissions in 2050 in tCO₂eq./cap for different scenarios (Source: Höhne et al. 2005a)

We can conclude that the concept of eventually converging per capita emissions in the long term could be part of a future regime. But classic Contraction and Convergence is too simple to accommodate the concerns of all countries. A decision that all countries participate at once would be unrealistic.

6.3.2 Global Climate Certificate System (GCCS)

The Global Climate Certificate System (GCCS) was proposed by Wicke (2005). Under this system all countries would participate. Emission allowances would be distributed to governments based on equal per capita levels. This would result in a very large shortage of emission allowances in developed countries and excess allowances for some developing countries. In a first level emission trading system, countries may level this imbalance by trading at a fixed price (e.g. 2 US\$/tCO₂) through a world climate certificate bank. Developing countries can use the revenues only for sustainable development projects. In a second level emission trading system, governments give the earlier traded emission allowances to their fossil fuel providers. They can then trade these allowances on the free international market with other fossil fuel providers. The first level of emission trading is a support mechanism to developing countries. Since developed countries emit much more than their per capita allocation would be, it is essentially a fixed tax on CO₂ for developed countries with the revenue distributed to the developing countries with the lowest emissions. The second level is then an emission trading system among the fossil fuel providers. This is essentially a tax on all fossil fuels, where its height depends on carbon content of the fuels and the overall shortage. But it is unclear how the two-level market would work. Since global emissions have to decline, emission allowances would be scarce and the price on the open second level market might be higher than the proposed 2 US\$/tCO₂. In such a case, countries with excess allowances will not sell them to the world climate certificate bank, as they could achieve higher prices at the open second level market. Also developed countries would ask for more allowances than available from the global certificate bank. It is unclear according to which criteria the available allowances would be redistributed. This essential feature of a future framework is not solved in this approach. In conclusion: The Global Climate Certificate System aims to combine a support mechanism for developing countries with a global emission trading system. This combination makes the approach complicated and its functioning not easy to understand. For several reasons the approach seems politically infeasible: A very strong support mechanism through an intergovernmental institution seems unacceptable for developed countries. Many allowances will be redistributed in the first level emission trading system, but the approach does not explain, which

countries receive the scarce allowances. And finally it seems uncertain whether the market would function as proposed. While equal per capita allowances could be viewed as a fair system, the GCCS is even more difficult to be accepted than converging per capita emissions.

6.3.3 Common but Differentiated Convergence (CDC)

Common but differentiated convergence (CDC) is a new approach presented by Höhne et al. (2005b). Annex I countries' per capita emission allowances converge within, e.g., 40 years (2010 to 2050) to an equal level for all countries. Individual Non-Annex I countries' per capita emissions also converge within the same period to the same level but convergence starts from the date, when their per capita emissions reach a certain percentage threshold of the (gradually declining) global average. Non-Annex I countries that do not pass this percentage threshold do not have binding emission reduction requirements. Either they take part in the Clean Development Mechanism or they voluntarily take on "positively binding" emission reduction targets. Under the latter, emission allowances may be sold if the target is overachieved, but no emission allowances have to be bought if the target is not reached. The CDC approach, similarly to C&C, aims at equal per capita allowances in the long run. In contrast to C&C it considers more the historical responsibility of countries. Annex I countries would have to reduce emissions similarly to C&C, but many Non-Annex I countries are likely to have more time to develop until they need to reduce emissions. Non-Annex I country participation is conditional to Annex I action through the gradually declining world average threshold. No excess emission allowances ("hot air") would be granted to least developed countries. Illustrative parameters of the convergence time, the threshold for participation and the convergence level used are provided in Table 2. Some strengths and weaknesses of the approach are given in Table 4.

Concentration level	Convergence time (years)	Threshold (% above or below world average)	Convergence level (tCO ₂ eq./cap)
400 ppmv	40	-45%	1.1
450 ppmv	40	-10%	2.1
550 ppmv	40	30%	4.5

Table 2. Illustrative parameters used for the Common but Differentiated Convergence approach (Source: Höhne et al. 2005a)

In conclusion: The "Common but Differentiated Convergence" approach is likely to also meet resistance of some developed countries due to the element of per capita convergence. But even if is not implemented in its entirety, future decisions could be guided by the principles provided in the approach: that developed countries' per capita emissions converge in the long term and that developing countries do the same but delayed and conditional to developed country action.

6.3.4 Triptych

The Triptych approach is a method to share emission allowances among a group of countries. It takes into account main differences in national circumstances between

countries that are relevant to emissions and emission reduction potentials. The Triptych approach as such does not define, which countries should participate. This approach was originally developed at the University of Utrecht (Blok, Phylipsen, Bode 1997) to share the emission allowances of the first commitment period within the European Union. It has been updated and revised subsequently (Phylipsen et al. 1998, Groenenberg 2002, Den Elzen and Lucas 2003, Höhne et al. 2003, Phylipsen et al. 2004, Höhne et al. 2005a, Höhne 2005). The Triptych methodology calculates emission allowances for the various sectors which are added to obtain a national target. Not individual sectoral targets but only the national targets are binding. This shall allow countries the flexibility to pursue any cost-effective emission reduction strategy. The emissions of the sectors are treated differently: For 'electricity production' and 'industrial production', a growth in the physical production is assumed together with an improvement in production efficiency. This takes into account the need for economic development but constant improvement of efficiency. For the 'domestic' sectors, convergence of per capita emissions is assumed. This takes into account the converging living standard of the countries. For the remaining sectors, fossil fuel production, agriculture and waste, similar reduction and convergence rules are applied. If the approach is applied globally, substantial reductions for the industrialized countries, esp. those with carbon intensive industries (Eastern Europe and Russian Federation), are required. Substantial emission increases are allowed for most developing countries. But for lower concentration targets (e.g. 450 ppmv CO₂) these are rarely above BAU-emissions. Table 3 provides the illustrative parameters that have been chosen for the calculations shown in the next section. They are chosen with the intent to be balanced in stringency over the sectors. The parameters for the 550 case are relatively moderate: 40% share of renewable and emission-free fossil electricity in 2050, 40% reduction in electricity generation based on coal and oil and convergence a conversion of industrial energy efficiency to a level that is 20% better than today's best available technology. The parameters for the 400 ppmv case stretch the methodology to the limit: 70% renewable and emission-free fossil electricity in 2050, 80% reduction in electricity generation from coal and oil, convergence to an industrial energy efficiency that is 60% better than today's best available technology. Some strengths and weaknesses of the approach are given in Table 5.

Sector	Quantity	400 ppmv	450 ppmv	550 ppmv
Electricity	Maximum deviation of total power production at the country level in 2050	45%	45%	45%
	Maximum deviation of total power production at the global level in 2050	10%	10%	10%
	Share of renewables and emission-free fossil generation in 2050	70%	60%	40%
	Share of CHP in 2050	10%	35%	20%
	Reduction of solid fuels in 2050 compared to base year	80%	75%	40%
	Reduction of liquid fuels in 2050 compared to base year	80%	75%	40%
	Total efficiency of CHP	90%	90%	80%
	Convergence of power generation efficiency of solid fuels in 2050	55%	50%	45%
	Convergence of power generation efficiency of liquid fuels in 2050	55%	50%	45%
Convergence of power generation efficiency of gas in 2050	65%	65%	60%	
Industry	Maximum deviation of total industrial production at the country level in 2050	45%	45%	45%
	Maximum deviation of total industrial production at the global level in 2050	10%	10%	10%
	Structural change factor	0.3	0.3	0.7
	Convergence of Energy Efficiency Indicator in 2050	0.4	0.5	0.8
Domestic sector	Domestic convergence level – per capita emissions in tCO ₂ /cap/yr in 2050	0.4	0.7	1.3
Fossil fuel production	Fossil fuel emission level – % total emissions below base year in 2050	95%	90%	95%
Agriculture	Reduction below reference scenario emissions in 2050 – low GDP/cap	70%	50%	20%
	Reduction below reference scenario emissions in 2050 – high GDP/cap	90%	70%	40%
Waste	Waste convergence level – per capita emissions	0	0	0

Table 3. Parameter choices for 2050 for the Triptych cases aiming at 400, 450 and 550 ppmv CO₂ concentration (Source: Höhne et al. 2005a)

In conclusion: The Triptych approach is a very sophisticated approach to share emission allowances within any group of countries. It, hence, has high data requirements. Especially the assumed future production growth rates are critical. The approach could be applied globally but best on any subset of countries (e.g. in the group of reducing countries in a staged approach) where sectoral data are available. The approach can accommodate concerns of many countries.

6.3.5 Multistage

In a Multistage setting, countries participate in several stages with differentiated types and levels of commitments (Gupta 1998, 2003, Berk and den Elzen 2001, den Elzen et al. 2003, Höhne et al. 2003, 2005a, Michaelowa et al. 2003, Criqui et al. 2003, Ott et al. 2004, Höhne 2005, Blok et al. 2005). Each stage has its stage-specific commitments. Countries graduate into next stages when they exceed certain thresholds (e.g. emissions per capita or GDP per capita). All countries agree to have commitments at a later point in time. The different stages could be the following (Höhne et al. 2005a):

- **Stage 1 – No commitments:** Countries with a low level of development do not have climate commitments. At least all least developed countries (LDCs) would be in this stage.

- **Stage 2 – Enhanced sustainable development:** At the next stage, countries commit in a clear way to sustainable development. The environmental objectives are built into the development policies. Such a first ‘soft’ stage would make it easier for new countries to join the regime. Requirements for such a sustainable pathway could be defined, e.g. inefficient equipment is phased out and requirements and certain standards are met for any new equipment or a clear deviation from the current policies depending on the countries.
- **Stage 3 – Moderate absolute target:** In this stage, countries commit to a moderate target on absolute emissions. The emission level may be higher than the starting year, but it should be below a reference scenario. The target could also be positively binding, meaning that allowances can be sold, if the target is exceeded. No allowances have to be bought, if the target is not achieved. An incentive to accept such a target would be the possibility to participate in emissions trading.
- **Stage 4 – Absolute reduction target:** Countries in stage 4 receive absolute emission reduction targets and have to reduce their absolute emissions substantially until they reach a low per capita level (essentially a fifth stage). How much each individual country has to reduce its emissions can be defined in different ways, e.g. converging per capita emissions, based on the Triptych approach or based purely on negotiations. As time progresses, more and more countries enter stage 4. Example parameters for reductions and participation thresholds are given in Table 4. In order to reach stringent long term goals (such as maximum increase of 2°C), additional countries, especially newly industrialized countries, need to participate relatively early, best soon after 2012, major regions (East Asia and South Asia) before the middle of the century. Such start would be at significantly lower per capita emissions and GDP levels than Annex I countries. Model outcomes also critically depend on the time when large countries such as China and India enter the system. The parameters in the 550 ppmv case could have a realistic chance of being acceptable to many countries: Participation in stage 4 (substantial reductions) would be at current Annex I average, Non-Annex I countries participate, when they reach the development (emission levels) of developed countries. The second stage (pledge for sustainable development) would require 5% reduction below the reference scenario, the third stage (moderate reductions) would require emission to be 10% to 15% below reference. The final stage would still be ambitious with 1.5% to 4% reduction per year. The parameters for the 450 ppmv case are already much more stringent and likely to be less agreeable: Participation in stage 4 (substantial reductions) would be at current world average. The second stage (pledge for sustainable development) would already require emissions to be reduced by 10% to 15% below reference, the third stage (moderate reductions) would require reductions of 30% to 35% below reference. The final stage would be ambitious with a 4.5% to 5.2% reduction per year. The parameters needed for the 400 ppmv case stretch the Multistage approach to its limits: Participation in stages 2 and 3 has to occur almost immediately for most developing countries. Already in stages 2 and 3 reductions of 20% and 30% to 35%, respectively, have to occur and countries at stage 4 have to reduce emissions drastically with 7.5% to 9% per year. Some strengths and weaknesses of the approach are given in Table 4.

Parameter	Unit	400 ppmv		450 ppmv		550 ppmv	
		Only until 2020	Long term	Only until 2020	Long term	Only until 2020	Long term
Threshold to enter stage 2	tCO ₂ eq./cap	3	3	3-4	3	5 - not entering	4-8
Threshold to enter stage 3	tCO ₂ eq./cap	4-6	3.5	5-8	3.5-4	8 - not entering	6-10
Threshold to enter stage 4 in 2010	tCO ₂ eq./cap		4		5-5.5		9-12
Threshold to enter stage 4 in 2100	tCO ₂ eq./cap		1.5		2-3		3
Threshold for no further reduction in stage 4	tCO ₂ eq./cap		1.5		1.5		2
Stage 2 (enhanced sustainable development) reduction below reference scenario in 10 years	%	20	20	10	15	5-10	5
Stage 3 (Moderate absolute target) reduction below reference scenario in 10 years	%	30-35	30-35	20-25	30-35	10-15	10-15
Stage 4 (Absolute reduction) reduction per year*	%	4-6.7	7.5-9	1.5-4.2	4.5-5.2	0-2.2	1.5-4

* The reduction percentages per year are applied to the absolute emissions in the previous year and therefore lead to an exponential decline in absolute emissions. Other slopes (e.g. linear) are possible.

Table 4. Parameters used for the Multistage approach. Ranges are due to the use of different reference scenarios (Source: Höhne et al. 2005a)

In conclusion: It seems likely that any future regime will be staged in some form. Countries are very diverse. Hence, several types of targets are likely to exist in parallel. A staged or parallel setting is the most likely outcome of the sequential decision-making that is currently applied. The critical element of the approach is that additional countries participate early enough so that stringent environmental goals can be reached. Incentives for such participation (not just thresholds) have to be included into the system.

6.3.6 Overview of all considered approaches

In the following table the major strengths and weaknesses of the above-mentioned approaches are summarized.

	Strengths	Weaknesses
Contraction & Convergence	<ul style="list-style-type: none"> • Participation of all countries • Certainty about global emissions • Simple, clear concept • Includes cost-effective reduction options in developing countries through full international emissions trading • Support for least developed countries through excess emission rights • Compatible with Kyoto Protocol (reporting and mechanisms, CDM not necessary) 	<ul style="list-style-type: none"> • National circumstances (incl. historical responsibility) not accommodated (optionally countries within one region can redistribute allowances to accommodate national concerns) • Substantial reduction for countries with high per capita emissions, also such developing countries • Also least developed countries need to be capable to participate in emissions trading (national greenhouse gas inventories and emission trading authorities) • Excess emission rights for least developed countries need to be compensated by more stringent reduction targets for developed countries.
Global Climate Certificate System	<ul style="list-style-type: none"> • Participation of all countries • Certainty about global emissions • Includes cost-effective reduction options in developing countries through full international emissions trading • Strong support for least developed countries through excess emission rights • Compatible with Kyoto Protocol (reporting and mechanisms, CDM not necessary) 	<ul style="list-style-type: none"> • Concept of immediate per capita allocation will receive strong resistance of all developed countries • As most allowances are redistributed with a fixed price, the resulting allocation is not clear from the proposal • Uncertain, whether the two level emission trading system would work as proposed
Common but diff. convergence	<ul style="list-style-type: none"> • Applies simple rules, thus, making approach transparent and comprehensive • Delay of Non-Annex I countries takes account of the responsibility for past emissions • Certainty about global emissions • Eliminates the component of "hot air" (no excess allowances for low emission countries) • Compatible with Kyoto Protocol (reporting and mechanisms) 	<ul style="list-style-type: none"> • National circumstances not accommodated, except per capita emissions and current membership of Annex I • Possibly too simple and not considering detailed national circumstances
Triptych	<ul style="list-style-type: none"> • National circumstances are explicitly accommodated • Explicitly allowing for economic growth at improving efficiency in all countries • Aims to put internationally-competitive industries on same level • Has been successfully been applied (on EU level) as a basis for negotiating targets • Compatible with Kyoto Protocol (reporting and mechanisms) 	<ul style="list-style-type: none"> • High complexity of the approach requires many decisions and sectoral data, making global application a challenge, and may be perceived as not transparent • Agreement on required projections of production growth rates for heavy industry and electricity may be difficult
Multistage	<ul style="list-style-type: none"> • Gradual phase in of countries, in line with UNFCCC spirit, taking into account national circumstances • General framework that can accommodate many ideas and satisfy many demands • Allows for gradual decision making • Trust-building as industrialised countries take the lead • Compatible with Kyoto Protocol (reporting and mechanisms) 	<ul style="list-style-type: none"> • Can lead to a complex system, requires many decisions and allows for exceptions • Risk that countries enter too late so that some long term stabilisation options are lost • Incentives needed for countries to participate in a certain stage

Table 5. Strengths and weaknesses of the approaches

6.3.7 Comparison of emission allowances

Figure 4 provides the change in emissions from 1990 to 2020 and 2050 under Contraction and Convergence, Common but differentiated convergence, Multistage and Triptych aiming at 450 ppmv CO₂ concentration using the Evolution of Commitments model (EVOC, Höhne et al. 2005a). In all cases, global emissions in 2020 are 30% above 1990 levels and in 2050 -25% below 1990 levels. The error bars show the spread using different reference scenarios.

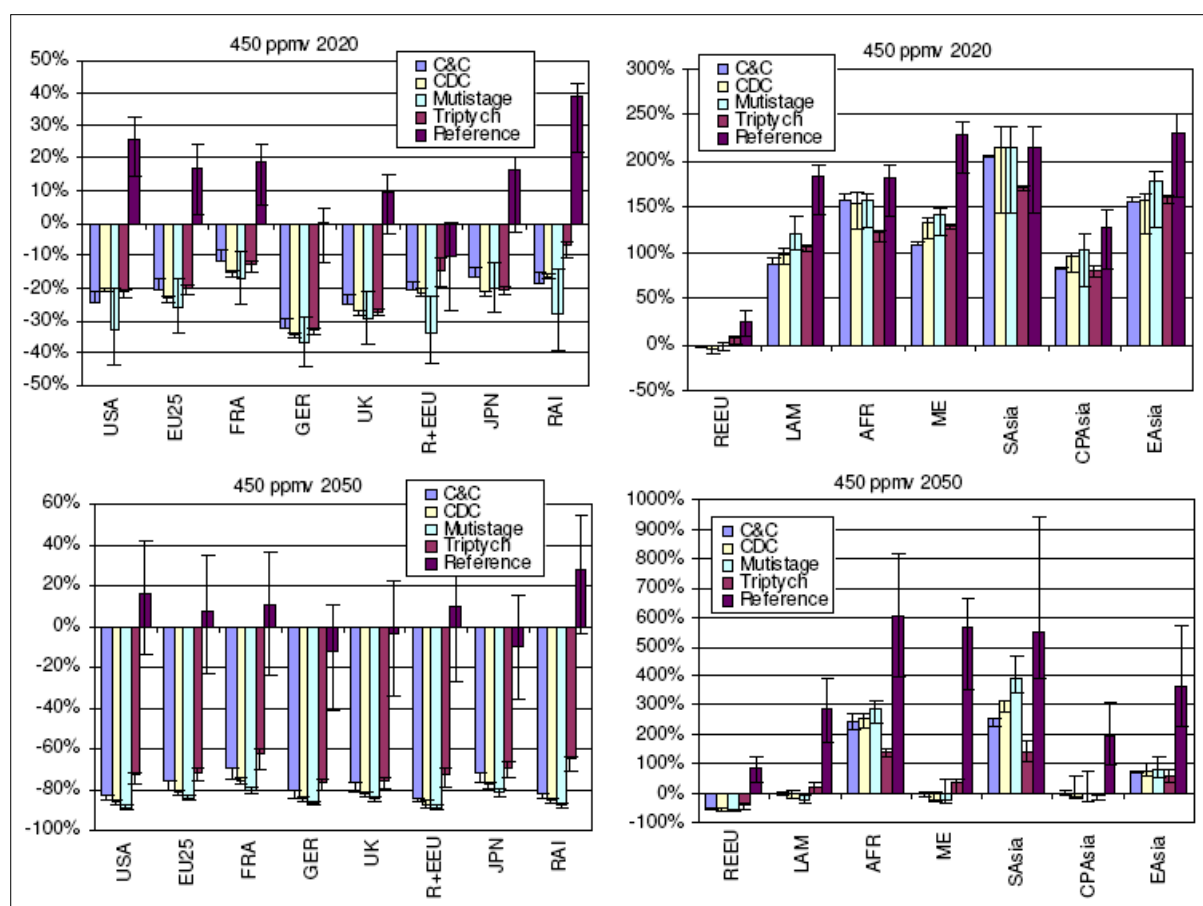


Figure 4. Change in emissions from 1990 to 2020 and 2050 under various approaches aiming at 450 ppmv CO₂ concentration. Error bars show the spread using different reference scenarios (Source: Höhne et al. 2005a)¹

Annex I countries need to reduce emissions below 1990 levels in the order of -10% to -30% in 2020 and -70% to -90% in 2050. A few Non-Annex I countries do not yet participate in 2020 (mainly in South Asia and Africa). Only under a few scenarios, countries receive more allowances than required under the reference scenarios with Contraction and Convergence (in South Asia and Africa). Many Non-Annex I countries (especially in Latin America, Middle East, East Asia and Centrally Planned Asia) would need to deviate from their reference scenarios under these approaches

¹ R+EEU: Russia and Eastern Europe, RAI: Rest of Annex I, REEU: Rest of Eastern Europe, LAM: Latin America, AFR: Africa, ME: Middle East, SAsia: South Asia (essentially India), CPAsia: centrally planned Asia (essentially China), EAsia: East Asia

already in 2020. In 2050 most countries need to deviate from the reference, especially in Latin America and the Middle East. 1 R+EEU: Russia and Eastern Europe, RAI: Rest of Annex I, REEU: Rest of Eastern Europe, LAM: Latin America, AFR: Africa, ME: Middle East, SAsia: South Asia (essentially India), CPAsia: centrally planned Asia (essentially China), EAsia: East Asia. The results for individual countries and regions differ little across the different approaches. We observe that for most individual Annex I countries the resulting reductions under all approaches are within a similar range. For example, the UK has to reduce emissions around 25% to 30% below 1990 levels for all approaches under the 450 ppmv case (Figure 4) with a large range for the Multistage approach from 20% to 40%. Germany's required reductions range from 30% to 35% and for France from 10% to 20%. The starting point in 2010 makes a significant difference: Germany is assumed to reach its Kyoto target at 21% below the 1990 level, while UK would be 12.5% below and France at 0%. For most developing countries the differences between the various approaches are larger, because they apply different assumptions on the countries' participation (e.g. India, Indonesia, Philippines, Nigeria). The Triptych approach, with the parameters used here, may be demanding for coal-intensive countries that would not have participated in other approaches, e.g. India (South Asia in Figure 4). But even here, the Triptych emission levels are still within the range of the reference scenarios, meaning that a Triptych target may not be too ambitious. For other countries that need to participate in all approaches, such as countries in the rest of Eastern Europe and the Middle East but also South Korea, Thailand, South Africa, Brazil, Argentina, Mexico, the levels across approaches are uniform as they are for Annex I countries. The differences between countries within one geographical region can be large. For example, Malaysia is participating in the Multistage system almost immediately, while participation of the Philippines is delayed until the middle of the century. In general the difference in emission allowances for most countries or regions between all approaches (structurally different to the Kyoto Protocol like C&C or an incremental evolution like multistage) is small compared to the total long-term effort. This leads to the conclusion that an agreement on the approach is less relevant compared to an agreement on the overall ambition level.

6.4 Conclusions

This paper discussed the global emission levels allowed to limiting temperature increase to 2°C above pre-industrial level, the long-term climate target of the EU. This target would require stabilization of the CO₂ concentration *below* 450 ppmv CO₂ and therefore a change in the global emission trend within the next 20 years at the maximum. The delay of global reduction efforts of 5 to 10 years after the first commitment period of the Kyoto Protocol (2008 to 2012) endangers meeting this limit. Consequently, approaches that only focus on long term technology development and not on short-term emission reductions are not compatible with the goal to keep global temperature increase below 2°C. The paper compared emission allowances of various approaches which are structurally different to the Kyoto Protocol, like C&C, or which are incremental evolutions of the Kyoto Protocol, like the multistage approach. One can observe that the differences in allowances between the approaches are small compared to the necessary total long-term effort. This leads to the conclusion that an agreement on the approach is less relevant compared to an agreement on the overall ambition level. The paper also compared the approaches qualitatively. New architectures like C&C, GCCS, CDC are based on

a few principles and can be viewed as fair. But taking the current negotiations and the current sequential decision making, it is likely that the final system is an incremental evolution, based on the current structure with the following elements:

- Participation in stages (e.g. Annex I, intermediate, Non-Annex I)
- Possibly alternatives to binding emission reduction targets for some newly participating countries
- Incentives for developing countries to participate

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7. Reflections on transatlantic climate policy, by Lee Lane¹

¹ Climate Policy Centre, Washington D.C., USA

7.1 Introduction: Challenging dubious assumptions

The structure of the Kyoto Protocol's second phase is a much-discussed question of international climate policy. Economists have lavished enormous ingenuity on the design of hypothetical systems for international GHG limits. (Aldy, Barrett, Stavins 1) The papers around which this European Climate Forum (ECF) conference is organized add to this corpus.

The intensity of these efforts is understandable. Climate change is a serious problem. (Many thoughtful people regard it as one of mankind's greatest challenges.) Sufficiently broad-based international greenhouse gas (GHG) limits could contribute importantly to a solution. And cap-and-trade would be a more cost-effective mitigation strategy than would command-and-control regulations.

That something is potentially important and desirable does not mean, however, that it is feasible. The broad rejection of mandatory GHG caps casts great doubt on this project's realism. This paper will argue that:

- Unless an international GHG cap-and-trade regime can encompass almost all major emitters, it will be: a) prone to collapse, b) cost-ineffective, and c) environmentally ineffectual.
- Today, the apparently meager net benefits from GHG abatement and the high transaction costs of constructing a comprehensive international cap-and-trade regime block implementation of such a regime.
- These barriers can be surmounted, if at all, only by developing technologies featuring dramatically lower abatement costs.

Under these circumstances, the quest for clever mechanical fixes that could rescue a global cap-and-trade regime from infeasibility is doomed to fail. The problem is not mechanical. It rests in the nature of the international state system and in the unappealing trade-offs entailed by GHG abatement.

7.1.1 Kyoto as a 'green' Kellogg Briand Pact

Discerning a rational future course of action requires facing the harsh realities of today's climate policy landscape. I find myself in complete agreement with Professor Wicke's assessment of Kyoto's ineffectuality. My diagnosis, however, suggests that the problem is much deeper than Professor Wicke or Dr. Billfalk believe. An analogy may illustrate, and perhaps dramatize, the point. Many observers have likened the Kyoto Protocol to the Montreal Protocol. Actually, the differences between the two are much more important than the similarities. Specifically, Montreal was expected to produce large net benefits. And it had workable enforcement mechanisms. Kyoto fails on both counts. (Barrett 2003, 228-229)

A better analogy, and one that drives home the importance of enforcement, would be to compare the Kyoto Protocol to the Kellogg-Briand Pact of 1928. In the Kellogg-Briand Pact, launched only about a decade before the outbreak of the Second World War, all the major powers renounced war. An eminent diplomatic historian offered the following assessment:

The ... [the Kellogg-Briand Pact] was no more than a declaration of intent divorced from any enforcing agency or means; in retrospect it may appear quite futile, as in fact it was destined to be, and, under the best interpretation, the expression of naïveté that may seem difficult of understanding. To the enforcement of peace, the Kellogg-Briand Pact contributed nothing but it is a perfect expression and symbol of the widespread atmosphere of 1928. Briand characterized it as a date in the history of mankind, a view to which many at the time would have subscribed. (Albrecht-Carrie 442)

Many climate specialists seemed to react to 2005 (the year of Kyoto ratification) almost as optimistically as Briand did in 1928. The GCCS and Vattenfall papers deserve credit for dispelling the specious optimism of this new “era of illusions”. This contribution makes them an important addition to the debate. The papers are less insightful about the intractability of the enforcement problem. The Kyoto Protocol and Kellogg-Briand Pact analogy extends to this point too. Had the signatories of Kellogg-Briand suddenly noticed the enormous problem created by the absence of enforcement, no realistic remedy would have been available. Inability to enforce the agreement was solidly anchored in its nature and in global political realities. For GHG cap-and-trade, the enforcement problem will be almost as intractable.

7.1.2 The core of the problem

The GCCS and Vattenfall papers make yet another important contribution. They explicitly trace through some of the logical requirements for a workable global GHG cap-and-trade system (although not all of them). One may quibble with details, especially the unrealistic equal *per capita* allocation decision. In general, though, the papers raise important questions about what is required to make global cap-and-trade workable. By doing so, they expose some of the concept’s internal contradictions. Unfortunately, both Professor Wicke’s Global Climate Certificate System (GCCS) and the Vattenfall plan illustrate that even the most cunningly constructed global cap-and-trade proposals clash with fundamental realities. The papers allude to the problem of political feasibility, only to assume it away. By slighting the difficulties posed by enforcement, the GCCS and Vattenfall papers end by proposing systems that are impracticable.

One paper, for example, pleads, “Real long-term global governance is needed.” (Billfalk 3) But ‘Global governance’, if it emerges at all, must do so from cooperation of egoistic nation states. Many real and serious global problems do not become rallying points for such cooperative solutions. Or, as with Kyoto, a narrow, tepid, and ineffectual ‘alliance’ may crystallize.

The GCCS paper insightfully notes that acceptance and implementation of any efficient post-2012 GHG mitigation system will be extremely difficult. (Wicke 7) Both papers offer cap-and-trade proposals that would be more expensive and complex than Kyoto. Neither paper offers a mechanism for enforcing participation and compliance. Economists characteristically assume that with sufficient creativity it is possible to devise a cure for every market failure. The current obsession with international GHG cap-and-trade painfully exemplifies this self-assurance. Whatever the merits of the economists' hopes in the realm of domestic policy, in the international policy arena, it is hybris.

7.1.3 Net benefits of GHG limits

The uncertain, but apparently small, economic net benefits of GHG abatement cabins the implementation of mandatory GHG limits (at least outside Europe). British Prime Minister Tony Blair recently observed, "The truth is that no country is going to cut its growth or consumption substantially in light of a long-term environmental problem." (Hennessy A13) Yet the prospects for deep GHG reductions depend on all major GHG emitters being willing to do exactly that.

Although the benefits of abatement are substantial, the costs are also high. (Nordhaus and Boyer 163-165) Therefore, GHG controls offer limited net gains:

The problem is that the benefits appear to be relatively small for aggressive mitigation programs. Aggressive programs involve large mitigation costs that begin immediately but the benefits may be delayed by several decades or even a century. The present value of the benefits are [sic.] small compared to the present value of the costs. The economic assessments of climate change thus suggest modest low-cost control programs that only slow warming slightly. (Chang, Mendelsohn, and Shaw, 5-6)

Thus, large emission cuts are not cost-beneficial. And, seemingly, small ones have been insufficient to defray the expected transaction and enforcement costs of global cap-and-trade (about which more later). The GCCS and Vattenfall papers ignore this problem. Both papers start with the tacit assumption that imposing some low cap on atmospheric GHG concentrations is cost-beneficial. The Torvanger paper also implicitly endorses this approach by replacing a benefit/cost test with the "environmental efficiency" criterion. (Torvanger 4) In reality, no scientific consensus exists about optimal concentration levels or the damage curve for GHG emissions. The best available economic analysis, suggests a low marginal damage estimate of about \$15 per tonne carbon, although with large uncertainties. (Tol 2067 and 2070) Unless this value is a drastic under-estimate, stabilization at the levels implied by the GCCS and Vattenfall papers would cost more than its benefits. Of course, the best current damage estimates may be too low (or too high). But until the science greatly narrows the uncertainties, the world is unlikely to pay the costs of renouncing the use of fossil fuels in order to buy climate protection. Scientific certainty, moreover, seems a distant goal. "The best the IPCC can do – apparently the best anyone can do – is to give us a range of possible warming for any given increase in carbon dioxide. And the upper bound for that range has been, for over twenty-five years, three times the lower bound!" Uncertainties about the economic consequences of climate change,

particularly in light of human adaptation, compound the scientific ambiguities. (Schelling 2005 582) Raising the benefit-cost issue does not imply that rational benefit-cost calculations determine national policy (although, occasionally, such considerations may be influential.) Rather, the point is that, *ceteris paribus*, the higher are a policy's net costs, the stronger are the incentives for organizing a coalition to oppose it. Ideology, institutions, the whims of powerful individuals can all warp the outcome. Hence, many policies impose net costs on the polities that implement them.

Nevertheless, in some states, the expected net costs of GHG controls' have generated winning oppositional coalitions. Their political successes escalate the costs for states that do implement controls. Internationally, such states will be at a competitive disadvantage. At some point, stronger oppositional coalitions may arise in even the most zealously pro-control polities. All this can occur without anyone explicitly using an overall benefit-cost analysis to justify opposition.

7.2 Free riding and transaction costs

Compounding the benefit-cost problem, erecting a global GHG control regime entails countering each nation's incentive to free ride, *i.e.* shirk on abatement in hopes that other nations will bear the costs. To overcome this tendency, the states most interested in constructing global GHG controls must also pay certain transaction costs that are required in order to discourage free riding. For climate change, these transaction costs are likely to be very high relative to the likely benefits of abatement. Thus, transaction cost might sink the cause of GHG controls.

7.2.1 The free rider problem

International collective action must often overcome what economists call the 'free rider' problem. GHG controls are no exception. Countries that reduce greenhouse gas emissions incur costs. (Their energy costs increase; the productivity of their capital stock declines.) But countries that do not reduce emissions will capture some of the benefits resulting from other nations' sacrifices.

For international GHG controls, free riding is a potentially fatal problem. In considering now much to spend on abatement, a nation that is free riding will consider only its own share of the benefits from reduced emissions. But even for the most vulnerable country, most of the potential benefits of its abatement expenditures would accrue to other nations. Thus, unless nations make and keep a cooperative agreement, they will dramatically under invest in emission controls. Without cooperation, one study estimates that, on average, the level of abatement effort (as measured by marginal abatement costs) would be only 1/25 of that, which would prevail with a fully cooperative outcome. (Nordhaus and Yang 762)* Absent effective international cooperation, economic rationality dictates that many countries entirely abstain from controlling GHG emissions. (Nordhaus and Yang 753) Moreover, even a few free riders can undermine a cooperative system. Free riding, encourage energy intensive businesses and activities to relocate. Such businesses will leave countries with controls for countries without them. In that case, the countries with

* I am indebted to Professor Henry Tulkens for pointing out the Nordhaus and Yang analysis, which adds an illustrative quantification to the free rider problem.

controls incur economic losses; yet they succeed only in changing the geographic pattern of emissions. They do not reduce them. In that case, the entire control regime may unravel politically.

If the free rider problem could be solved, global net benefits would rise. But a cooperative solution may be unattainable. Not all nations gain from the somewhat higher marginal abatement costs needed to maximize global welfare. Presumably, these nations will refuse to impose controls that are more stringent. In theory, side payments might induce these nations' cooperation. In practice, such deals are difficult to strike. (Nordhaus and Yang 756 - 757) Alternatively, the holdouts could be threatened with sanctions. Lacking a third party enforcer, though, other sovereign states are the only agents capable of deterring free riding. No international police power exists to force participation and compliance of those states harmed by imposition of more stringent GHG controls. Affecting the behavior of other states, moreover, typically costs something. These costs diminish their net benefits from a potential agreement. (Barrett 2004, 10) Thus, the universal temptation to free ride significantly raises the bar for the viability of an international GHG control regime. For such a regime to succeed, gains to the prospective beneficiaries of emission reductions must exceed the combined value of abatement costs *plus* the costs of setting up and maintaining the control regime. Far from being secondary, these transaction costs are likely to be high.

7.2.2 Nature of the transaction costs

The transaction costs associated with international GHG controls include the costs of negotiating the agreement, monitoring other states' behavior, and enforcing participation and compliance. Each of these activities is likely to entail hefty political and economic costs. Transaction costs will continue for the agreement's life. The international negotiations needed to produce agreement on a greenhouse gas cap-and-trade program like Kyoto are extraordinarily complex. Moreover, the negotiation must be a continuing process, not a one-time agreement:

Any stringent regime would involve allocating emission rights worth trillions of dollars among rich nations and poor, rapidly growing nations and more mature economies, and countries with fossil fuels and countries without. I see no possibility of any such compact being arrived at. If there were such quotas, they would certainly have to be renegotiated periodically as estimates changed and as nations experienced greater and lesser difficulties. Any nation that "sold" part of its quota would clearly be evidencing a too generous original quota. (Schelling 2005, 588)

Thus, negotiations will have to be more or less continuous to keep the system in tune with the ever-changing economic, scientific, and political environment. The stakes will be high. The process will be contentious. Negotiations, though, are only one category of transaction costs. An international agreement to produce global public goods must somehow enforce participation. Kyoto's drafters omitted effective enforcement provisions. Then, they drafted weak and unrealistic ones. The result was an agreement lacking incentives against non-participation and non-compliance.

(Barrett 2003b, 15) Consequently, the agreement cannot command the participation of countries, without which it is incorrigibly ineffective.

To avoid Kyoto's toothlessness, a GHG control system would have to incorporate credible enforcement mechanisms. But, in the case of international GHG limitations, is such an enforcement mechanism possible? Confronting this issue directly, three economists have recently proposed applying international sanctions, possibly trade sanctions, against nations that fail to implement emission limits. (Aldy, Orzag, and Stiglitz 15) Such proposals, however, are likely to shatter on the same rocks that sank prospects for adding meaningful enforcement provisions to Kyoto. Relative to the benefits of expanding the GHG limitation regime, the sanctioning countries would incur potentially high costs. In that case, the threat of sanctions would not be credible, whatever an international agreement might say.

Sanctions large enough to be effective deserve skepticism. Punishing poor countries will not be attractive; punishing rich countries, or large countries, or powerful countries, will not be attractive. I can imagine the United States agreeing to quotas it believes it can live with and making serious efforts to live within the quotas; it is hard to imagine any international body or consortium of nations imposing sanctions on the United States, or the United States accepting severe sanctions. (Schelling 2005 588)

Recent history bears out this skepticism about sanctions' credibility. It suggests that, countries do not impose sanctions even in instances that are 'easier' than that of climate change:

Granting, for argument, the apparent logic that nations will not make sacrifices in the absence of sanctions, there is no historical example of any international regime that could impose penalties on a scale commensurate with the magnitude of global warming. (It is notable that the current most legally cohesive regime, the European Union—certainly stronger than any greenhouse regime that one could imagine—calls for severe penalties on any nation that runs a deficit greater than three percent of gross domestic product for three years running. In 2004, both France and Germany violated the rule, and nothing was expected to happen to those two nations, and nothing did happen.) (Schelling 2005 588)

Not only are EU institutions stronger than are those of a future climate policy regime, but also the causal links between German and French fiscal behavior and the Continent's economic health is clearer and more immanent than that between any one nation's current emissions and another nation's harm from climate change. If Europe does not enforce the Economic Stabilization Pact, why should members of a future climate pact do so? Enforcement raises another problem. Like GHG reductions, they are themselves public goods. Either imposing sanctions or making payments to induce others' cooperation imposes costs on the states that are attempting to change other nations' behavior. However, those states that shirk enforcement/inducement efforts cannot be excluded from the benefits of other

countries exertions. Thus, enforcement/inducement evokes a kind of free rider meta-problem.

7.2.3 The international distribution of benefits and costs

The distribution of the benefits of climate change mitigation among states eliminates some otherwise appealing potential solutions to the transaction cost problem. Hypothetically, cooperation among a few highly motivated, rich, and powerful states might represent the best possible prospect for enforcing an agreement on the wider world. A small coalition of highly motivated great powers would minimize the temptation to free ride on enforcement efforts. And such a coalition would maximize the chance of successfully coercing less powerful states into participation and compliance with emission reductions. Alas, for one reason or another, most of the global great powers are unwilling to incur significant costs in order to achieve GHG cuts. Of course, the appearance of reluctance is advantageous in itself. The indifferent state may attract concessions from others. Conversely, visible eagerness invites exploitation. (Mitchell and Keilbach 896)

Great power reluctance, though, is grounded in more than caginess. A recent study concluded that for the United States, the next century of climate change would produce an annual net benefit equal to about .2 percent of GDP although over time climate change may become increasingly harmful. (Mendelsohn and Neumann 321, 323) Russia may benefit even more. China, too, has little to fear. (India and Europe may be more vulnerable.) (Nordhaus and Boyer 96-98) India, despite its apparent vulnerability, faces more a pressing concern of poverty alleviation. Moreover, economic development enhances a country's ability to adapt to climate change. For India, economic development may be a better climate strategy than the alternative of expensive investments in mitigation. (Schelling 2002, 3) Whatever their various motivations, then, most of the world's current or emerging great powers are less committed to climate change mitigation than are Europe and Japan. (Japan, of course, in some senses, is a great power, and, in principle, Europe might someday become one.) Meanwhile, the US, China, Russia, and India all reject mandatory GHG limits. The stance of these four states profoundly affects the prospects for constructing a global mitigation regime. Individually, the US, China, Russia, and India are largely immune to coercion. Collectively, they certainly are. In such cases, inducement rather than coercion is the only feasible strategy. (Mitchell and Keilbach 892) Those states wishing to implement GHG cuts globally must buy the cooperation of the big four.

However, the states with the highest vulnerability to climate change are in no position to effect such transactions. These countries are (typically) small, tropical, and economically torpid.

The bulk of the developing world has higher current temperatures, larger fractions of their economy in vulnerable sectors, more primitive technologies, and lower incomes or resources for adaptation. All of these factors would suggest that that the economies of developing countries will be more vulnerable to climate change than the U.S. economy. In addition, these countries could experience a suite of nonmarket effects that

would not be represented in analyses of developed countries, for example disease epidemics, local famines and desertification. (Mendelsohn and Neumann 329)

As well, small countries are especially prone to free riding. (Nordhaus and Yang 752) Such countries are unpromising as an international political base for GHG controls.

Instead, Europe is the heartland of support for international GHG cap-and-trade. Many Europeans are understandably proud of their leadership on the climate issue. At the same time, Europe is a relatively narrow political base from which to attempt to impose a GHG cap-and-trade on a reluctant world. The GCCS and Vattenfall papers propose to modify the “order of battle” by offering huge transfer payments to less developed countries (LDCs). Such a solution merely begs the question of who will make these proposed transfer payments.

7.3 International transfers as a climate policy tool

The GCCS and Vattenfall plans propose to use income transfers to lure China, India, and other LDCs into participating in GHG controls. They propose a standard of equal *per capita* emission allocations as a rule for implementing these transfers. As mentioned, some countries will be losers from the imposition of GHG controls. Many economists have proposed to use international transfer payments to solve these problems arguing, “...for a voluntary international mechanism to be successful, it must include a mechanism for transferring gains to countries that would otherwise not benefit from joining an agreement.” (Stavins 298) Many difficulties lie concealed within this seemingly simple concept.

7.3.1 Transfers as a zero sum game

First, international transfer payments are a zero sum game. Such payments might encourage some countries to participate. This advantage is purchased, however, at the expense of increasing the costs to other countries. (Barrett and Stavins 361) The obvious risk is that these higher costs may deter the participation of countries that might have reaped net benefits from abatement but are net losers if they must also make transfer payments. Some cap-and-trade advocates assert that wealthy nations’ transfers to LDCs are not foreign aid. (Wicke 5) Nevertheless, the expected net benefits of climate change mitigation are small. A disproportionate share of those expected benefits accrue to the LDCs. The First World pays all the costs. The facts would seem to dictate a net loss for the First World. First World countries might choose to make such altruistic payments. But labeling the payments anything but “foreign aid” is clearly misleading. The idea of an equal global *per capita* allocation of emission allowances, an idea embodied in one paper prepared for this conference, highlights the eleemosynary nature of the transfers. Many poor and populous countries have almost no prospects of becoming major sources of GHG emissions. From an emission limitation viewpoint, these countries have nothing to offer. Yet they would receive large transfers. Unequivocally, the payments would be foreign aid. (I would note parenthetically that prospects are nil that the United States would ever accept a *per capita* distribution of emission rights.)

In reality, First World willingness to implement altruistic international income transfers, while real, is demonstrably limited. The sense of international community is

not great enough to sustain large international wealth transfers, “Indeed it is not that great within the United States today.” (Cooper 24) On the face of the matter, large altruistically motivated income transfers (implied by both the GCCS and Vattenfall plans) are politically impracticable.

7.3.2 Transfers do not solve the enforcement problem

Second, the proposed international income transfers do not solve the enforcement problem. They merely postpone it. Initially, LDCs receive net subsidies rather than incurring net costs. Eventually, however, the emission control costs would begin exceeding the transfer payments. At that point, nothing prevents LDCs from withdrawing from the emission rights trading system. According to one paper presented at this conference, countries eschew such opportunistic behavior because, “... an overwhelming majority of all countries can be convinced to participate in the system on the understanding that they will only face restrictions once the country is wealthy enough in relative terms.” (Billfalk 7) Were this model of national behavior valid, the US, and Australia would have adopted limits. Canada would not have withdrawn its Kyoto commitment. And more countries would be on course to implement their Kyoto targets. Realistically, then, some LDCs are likely to defect when control costs rise. And quite a few rich countries may decline at the outset or defect as circumstances dictate. Creating a system of egalitarian income transfers offer no remedy for this temptation and for its potentially fatal consequences for the regime’s viability. Furthermore, neither history nor common sense suggests that today’s governments can reliably commit their nations thirty or fifty years hence. Investing significant sums on the hope that a future government would honor such commitments would be rash, especially if fulfilling commitments imposes significant net costs.

7.3.3 Transfers in the larger context of international tensions

Third, attempts to affect the plans’ income transfers may collide with the larger dynamics of international power politics. Reaching an international agreement on GHG limitation would be unlikely to signal “the end of history” – in either the Hegelian or the more popular sense. The normal course of international rivalry will continue. The coming decades seem destined to witness the sharpening of several important international conflicts. (Huntington, 185 (1996), Mearsheimer 385-386, Kugler and Lemke 146) Expecting large international income transfers to occur between powers experiencing tense bilateral relations and growing rivalry is certainly speculative and probably unrealistic.

7.3.4 Institutional weaknesses in the LDCs

Fourth, international emission rights trading schemes are likely to founder on the institutional problems that plague many LDC legal systems. Problems include pervasive corruption, politicized legal systems, weak law enforcement, untrustworthy national statistics, and regime instability. Such conditions preclude participation in international cap-and-trade. (Wyant and Hill xxvii-xxix) Time may ameliorate some of these problems. LDCs will not be able to develop successfully without instituting a firmer rule of law. But where progress will occur and how quickly remain uncertain.

And if a cap-and-trade system encompasses countries lacking a dependable rule of law, that system's credibility is at risk.

7.4 An alternative vision

From the foregoing analysis, it seems unlikely that a global cap-and-trade system is feasible at this time. Such a system would be desirable. Absent some version of cap-and-trade or carbon tax, it is hard to see what can motivate the deployment of climate-friendly technologies. But pursuing global cap-and-trade, when the conditions for its success do not yet exist, is bound to be futile. Worse, it distracts attention from other more realistic and urgent tasks.

7.4.1 Public sector R&D

Cap-and-trade proponents have often spurned proposals for major public sector investments in R&D. Part of the rationale for this rejection has been the belief that cap-and-trade would stimulate the needed technological innovation. If, however, the enforcement costs block the spread of cap-and-trade, finding another policy tool to stimulate innovation is imperative. Furthermore, the notion that cap-and-trade will generate sufficient R&D investment is false.

Attempts to use emission controls to force the private sector to accelerate R&D efforts will collide head on with the private sector's bias against the needed kinds of research. No large emission-free energy sources lie just over the horizon. (Hoffert *et al* 981) Thus, successful innovation in this area will require unusually high risks and long lead times. Because developing these technologies will entail breakthroughs in basic science, much of the most essential work will be ineligible for patent protection. These are precisely the conditions in which firms are least likely to select R&D as an approach to problem solving. (Edmonds and Stokes 163) Empirical studies suggest that imposition of controls alone will only modestly increase private sector R&D directed toward technological solutions to climate change. (Popp 15) In any case, attempting to decree emission allowance prices or tax rates into the distant future encounters an acute dilemma. Given the private sector bias against long-run R&D, future GHG allowance prices or taxes that are low enough to be politically credible will be too low to stimulate the needed level of R&D. And investors will not believe that a future government would actually impose allowance prices high enough to justify expensive R&D. In neither case, then, will the R&D occur. (Montgomery and Smith 20) Public sector subsidies to R&D are the only escape from this dilemma. Some public sector R&D programs have been spectacularly successful. In the US, the National Institutes of Health and the Defense Advanced Projects Research Agency are examples of long sustained institutional productivity. Many other public sector R&D models have been less successful. The immediate challenge is finding an organizational model that fits the task of climate-related R&D. One root difficulty of the current European / US climate policy impasse is that neither side has enunciated a clear strategic vision of the relationship between R&D and GHG limits. On one side, European policy has reversed the causal relationships, falsely believing that controls will motivate adequate private sector R&D or ignoring the need for better technology. On the other side, the Bush Administration has discussed R&D as if it were a substitute for internalizing environmental costs. Yet, without the prospect of at least modest future emission limits, the private sector would lack an incentive to

deploy technologies developed by government-funded R&D. In reality, successful R&D is a prerequisite for effective GHG limits. Unless GHG abatement cost fall substantially, many key governments will continue to stand aloof from an international control regime. They will do so because participation would inflict net costs on their countries. Conversely, any broad based emission control regime will be lenient because most countries' willingness-to-pay for climate protection is small. New technology is essential for achieving large environmental gains from modest emission limits. We might regard technologies that lower abatement cost as a 'force multiplier' that allows quantitatively limited emission limits to accomplish their mission.

7.4.2 Adaptation and geoengineering

Whatever the results of mitigation strategies, some climate change is inevitable. Adaptation can significantly reduce net damages from it. More recent economic analyses of climate change damages typically produce results that fall below those of earlier studies. And one important reason is that the more recent studies have better accounted for adaptation's ability to blunt the harm from climate change. (Joel B. Smith 31)

Adaptation's evident power to reduce costs suggests using R&D to boost that power.

It [adaptation] means *inter alia* pushing ahead with both the basic science and applications of genetic engineering in many areas, especially agriculture, but also to provide potential substitutes for possible useful species that may be lost. That could be supplemented by a systematic program for collecting, cataloguing, and storing genetic material, mainly but not exclusively from plants, in the form of seed banks and DNA. (Cooper 43)

Taking the logic of adaptation one-step further suggests conducting R&D on geoengineering. Climate policy must cope with the possibility of low probability but high cost events. (Nordhaus & Boyer 98) Should the climate system manifest a large and harmful discontinuity, having a mechanism for 'scramming' the climate change process could prove invaluable. (A 'scram' is the rapid emergency shutdown of a nuclear reactor or other system.) Indeed, unless we are prepared to assign a zero probability to "nasty surprises" from climate change, there seems good reason to undertake such research. (Keith and Dowlatabadi 293)

Some scientists, therefore, have proposed research on geoengineering:

Geoengineering in the climate change context refers mainly to altering the planetary radiation balance to affect climate and uses technologies to compensate for the inadvertent global warming produced by fossil fuel CO₂ and other greenhouse gases. An early idea was to put layers of reflective sulfate aerosol in the upper atmosphere to counteract greenhouse warming. Variations on the sunblocking theme include injecting sub-micrometer dust to the stratosphere in shells fired by naval guns, increasing cloud

cover by seeding, and shadowing earth by objects in space. ... Climate model runs indicate that the spatial pattern of climate would resemble that without fossil fuel CO₂. Engineering the optical properties of aerosols injected to the stratosphere to produce a variety of climate effects has also been proposed.” (Hoffert et. al. 986)

The natural analogue of this ‘scram button’, large volcanic eruptions, can have a powerful impact on global temperature. In the year following the Mount Pinatubo eruption, global mean temperature fell by .6 degree C. This experience suggests the existence of a possible opportunity. As insurance against runaway climate change, research on geoengineering may be superior to attempting to reach consensus on rapid emission cuts. Because mitigation is so slow, it would have to be initiated many decades before science confirmed the danger of rapid climate change. (Realistically, political consensus is impossible under these circumstances as the Kyoto experience is demonstrating).

Geoengineering, in contrast, could be implemented relatively rapidly. For one thing, reaching international agreement for geoengineering would be relatively easy. A geoengineering strategy would not require governments to negotiate to impose massive lifestyle changes on their populations. Instead, a geoengineering agreement would be about the sharing of monetary costs, a type of negotiation for which we have much experience. (Schelling 2005 592) Meantime, the costs would be confined to the R&D needed to prove-up the technology’s feasibility. If geoengineering technology had to be deployed, it may be inexpensive compared to draconian emission cuts. The U.S. National Academy of Science, after studying geoengineering, concluded, “Perhaps one of the surprises of this analysis is the relatively low cost at which some of the geoengineering options might be implemented.” (NAS 460) Of course, until R&D is done, geoengineering options remain speculative. The technologies may prove to be ineffectual or to entail intolerable side effects. Then too, geoengineering is somewhat ‘politically incorrect’. For now, however, buying knowledge about cost, feasibility, and possible side effects is all that is required.

7.5 Addendum: Morality and global climate policy

The discussion at the European Climate Forum (ECF) conference at which this paper was presented raised two additional arguments. One argument was that the United States has a moral obligation to participate in international GHG abatement schemes even though doing so is contrary to US national interests. (A representative of the German Government advanced this argument among others.) The second argument builds upon this initial claim and supplements it. It asserts that America’s continued rejection of European climate policy proposals will leach away US international moral capital and diminish America’s capacity for global leadership.

7.5.1 Morality and foreign policy

This approach fits well with the European tradition of ‘moralizing’ the climate policy debate. European rhetoric about US climate policy has traditionally been heavily freighted with moralism. Many Europeans regard US rejection of global cap-and-

trade as a dereliction of moral duty. According to this view, the fact that such schemes conflict with US national interest is no excuse for rejecting them. This line of argument raises an old question. What moral principles should guide a nation's foreign policy? In my view, the pursuit of *enlightened* national self-interest is the most that can be expected of any nation's foreign policy. Enlightenment, in this context, means taking a long run and broad-gauge view of the nation's interests. The logic of great power politics precludes altruism. The international system is anarchic, *i.e.* no over-arching government provides security. Great powers inherently possess at least some offensive capability. States can never be certain of other states' intentions. Under these conditions, a rational great power seeking its own survival will strive relentlessly to increase its power *vis-à-vis* all other great powers. (Mearsheimer 30-35) Because wealth is one basis for power, this striving for relative power position, *perforce*, excludes policies that would voluntarily diminish national wealth.

The US security umbrella has permitted Europeans to withdraw from great power competition. US armed force protects Europe from external aggression, each other, and even the disorder of the Balkan periphery. Thus sheltered, Europe has developed a foreign policy style that stresses assertions of 'morality' as a means of constraining the great powers, especially the US. (Kagan 38, 57) This style may also be well suited to the intra-European diplomacy connected with the experiment of transforming many polities into one. It is also true that not every policy that is in the enlightened self-interest of the US will redound to the advantage of European, or *vice versa*. Conflicts are inevitable. Climate policy is an example.

That Europe would extend its moralistic style to climate policy is predictable. The US, however, operates in a different international environment. As Kagan has argued, American foreign policy cannot ignore Hobbsian realities. This difference in strategic situation makes America more susceptible to bargaining than to preaching. Understandably, Europe would prefer to get its way without having to bargain.

7.5.2 Facts versus moral rhetoric

The moral basis for demanding implementation of Kyoto-like climate policies is particularly weak. For the world as a whole, implementing the Kyoto Protocol in its original form would have been economically harmful. *Globally*, its costs would have exceeded its benefits. According to one model, it would have produced a net decrease in global economic welfare of \$120 billion. The original Kyoto agreement's benefit-cost ratio was. The more draconian GHG cuts now being demanded by European governments would, if implemented, be still more harmful. A ukase of the European Union Council of Ministers has proclaimed that temperature rise must be contained to 2 degrees C. This policy defies a large body of economic evidence showing that the drastic emission cuts needed to implement this policy are probably counter productive. European governments have not informed their electorates the costs implied by such targets. And informing them of these costs would certainly shatter the political consensus for implementing the policy. Having surveyed numerous studies of both the costs and the benefits of GHG emission reductions, one economist summarized the results, "Though the estimates vary widely, the evidence ... suggests that a 20 percent cut from 1990 levels is almost certain not to be justified. It is not even obvious that stabilization of CO₂ emissions could pass a benefit-cost test." (Barrett 2003 379) *A fortiori*, the European goals for stabilizing

temperature at 2 degrees C would reduce global net welfare rather than increasing it. The potential losses would be enormous. Interpolating from the Nordhaus Boyer results, the 2 degree C standard implies a global net cost of between \$2.4 trillion and \$26.5 trillion. (Nordhaus and Boyer Table 7-3 130) Strangely enough, according to this analysis, Europe *alone* of all the regions of the world reaps net benefits from these policies. (Nordhaus and Boyer Table 7-4 131)

Thus, to many Europeans, deep GHG cuts are a moral imperative. But the total cost of these cuts would exceed the total benefits by many trillions of dollars. Some philosophers do regard moral principles as standing above benefit-cost calculations. But, to my knowledge, the case that Kant's categorical imperative requires implementing a temperature cap of precisely 2 degrees C has yet to be made. Absent such philosophical proof, some Americans suspect that European governments' advocacy of international cap-and-trade constitutes 'eco-mercantilism' – a beggar-thy-neighbor policy cloaked by lofty sounding environmental goals. These suspicions may have a basis in fact. Many Europeans have long been obsessed with their economies' difficulties in competing with that of America. International cap-and-trade with limits defined by a historical base year is inherently disadvantageous to any high growth economy. Applying this form of international GHG cap-and-trade resembles handicapping a horse race. The faster horses are burdened with higher weights in order to even the competition. This is a good system – for slow horses. Allocation schemes like the two discussed at the ECF conference, would also impose heavier burdens on the US than on Europe. The global *per capita* allocation is patently unfavorable to the US. The Vattenfall Plan, although not as blatant, penalizes more energy intensive developed economies – such as those of the US, Canada, and Australia – to the relative benefit of Europe.

That European nations would promote allocation plans that shift abatement costs from themselves to other countries is, again, understandable. That the schemes would be wrapped in a fog of rhetoric about 'equity' is probably inevitable. Nonetheless, this approach is hardly the best way to attract US participation in a GHG control regime.

7.5.3 Moral capital in international relations

As mentioned, some participants of the ECF conference expanded the moral responsibility claim into a prudential one. In their view, continuing resistance to European demands on cap-and-trade would erode US moral capital. Diminished moral capital, the argument goes, would degrade American ability to lead. Ultimately, US interests will be harmed. Specifically, some the claim is that, by refusing to behave altruistically about climate policy, the US will eventually harm the legitimacy of its alliance system. The principal premise behind this reasoning is questionable. It is true, that the perceived legitimacy of US goals enhances America's ability to lead and manage its loose and informal global alliance system. It is false that American legitimacy grows from the altruistic motivation of its policies. Instead, the system's legitimacy derives from the net benefits that it generates for the US itself and for its non-US members. Since the end of WW II, America has massively subsidized the supply of public goods to a broad array of formal and informal international allies. Military security and peacekeeping are prime examples. So is leadership in developing liberal economic institutions including the WTO, G-8, the IMF, and the

World Bank. (Odom and Dujarric 45) The domestic political consensus needed to support such large and sustained investments would long since have collapsed had the venture been fundamentally altruistic. In fact, the United States gains immensely from maintaining international security systems and liberal international institutions. These gains are both economic and in security. (Odom and Dujarric 56) And despite frustrations with some aspects of American policies, the European and Asian countries who cooperate in the American hegemony are large-scale beneficiaries of the public goods that it supplies. (Odom and Dujarric 56-57) This mutual self-interest under-girds the legitimacy of American power. Indeed, historically, durable empires and hegemonies have been based on the relatively efficient supply of security, governance, property rights enforcement, and common language. Efficient supply of these public goods provides benefits for both the metropolis and the periphery. (Lal 42-43)

7.5.4 A caution

Within this mutually beneficial international framework, climate policy is now an irritant. Europe's climate policy establishments are deeply wedded to imposing draconian cap-and-trade approaches. And the Continent's moralistic and legalistic foreign policy style is rooted in its strategic position. (Kagan 39-40) That European climate policy will soon change is, therefore, unlikely. It is, then, without much hope of success that I offer my European colleagues another historical analogy. In the wake of WW I, the victors inserted the 'infamous' Article 231 into the Versailles Treaty. It stated that the Central Powers were solely responsible for starting the war. The Versailles Treaty's "*Schmachparagraphen*" incensed Germans. Germany resisted Article 231's assertion of war guilt more vociferously than any of the Versailles Treaty's onerous substantive provisions. (Black and Helmreich 89) The essential problem with the war guilt clause was that most Germans did not, in fact, feel guilty about the origins of WW I. Historians have been debating the merits of the case ever since – with intractably ambiguous results. It is, however, very clear that by casting their reparation demand in moral terms, the Allies literally added insult to injury – not an ideal basis for forging durable international accord. European governments might ponder this example. Today, Americans evaluate their country and its culture very favorably. Public opinion research indicates that US levels of national pride greatly exceed those in most of contemporary Europe. (Micklethwait and Wooldridge 300) US attitudes on this point suggest that efforts to exploit Americans' environmental guilt feelings will be tilling very thin soil.* Worse, it may risk sparking a miniature version of the German reaction to Article 231. (Some aspects of Bush Administration climate policy have this appearance.)

Because American foreign policy rhetoric is so moralistic, Europeans might harbor great hopes for the political efficacy of a guilt-based approach to climate policy. However, one of the most insightful observers of American society recently noted, "In conducting their foreign policy most states give overwhelming priority to what are generally termed the 'realist' concerns of power, security, and wealth. When push comes to shove, the United States does this too." (Huntington 2004 79) Historically, US action – as distinct from rhetoric – has been remarkably realistic. In private, American statesmen have traditionally used the language of power and national

* The more susceptible fringe of fervent environmentalists is a small minority. (Ladd and Bowman 44-45)

interest. America, moreover, typically manages to apply its liberal ideology in causes that are compatible with the dictates of national interest. The national 'blessing' that so many of America's enemies have been illiberal has allowed the US to conceal, even from itself, its obedience to the iron logic of Realpolitik. (Mearsheimer 25-27) If these analyses are right, persuading America to sacrifice its national interests on the matter of climate policy may prove more difficult than many Europeans might initially believe.

In the end – however reluctantly – the European governments will abandon dreams of draconian cap-and-trade. Europe cannot proceed alone with these policies. And the rest of the world clearly rejects them (although the US may someday impose suitably modest national GHG limits). The longer Europe persists in following the bankrupt policy of unrealistic goals and moral aspersion, the longer the delay before a constructive search for mutually beneficial climate policies can commence.

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8. Forests, carbon and international climate policy, by Pierre L. Ibisch¹, Joerg Seifert-Granzin² and Michael Dutschke³

¹ Faculty of Forestry, University of Applied Sciences Eberswalde, Germany

² Fundación Amigos de la Naturaleza, Santa Cruz, Bolivia

³ Hamburg Institute of International Economics, Programme International Climate Policy, Offenburg, Germany

8.1 Introduction

Forests belong to the most structurally and compositionally complex ecosystems. Many of them are important actors in continental or global hydro-climatic and biogeochemical processes, such as the carbon cycle. Forests are well-known as a major carbon stock, and deforestation has been recognized as a main factor for the increase of greenhouse gas emissions and subsequent global warming (annual emissions of 1.1 to 1.7 billion tonnes of carbon per year equalling one fifth of human CO₂ emissions; Brown *et al.* 1996). Santilli *et al.* (2005) calculated that the current annual rates of tropical deforestation from Brazil and Indonesia alone would equal four fifths of the emissions reductions gained by implementing the Kyoto Protocol in its first commitment period.

Much has been written about forests and the importance of stopping or at least slowing down deforestation, both for the sake of climate protection and biodiversity conservation (e.g., Hansen *et al.* 2001, Totten *et al.* 2003). While international conventions on climate change and biological diversity have come into force, a forest convention lacks even to this day. Since scientists and policy makers began discussing the problem of rapid anthropogenic climate change, the relevance of the forests as a major carbon pool to be conserved has been addressed on a regular basis, often with a focus on the rapidly vanishing tropical forests, e.g., compare the 968 pages second report of the Enquete-Commission "Preventive measures to protect the earth's atmosphere" of the 11th German Bundestag: Protecting the tropical forests. A high-priority international task" (German Bundestag 1990). However, in spite of the enormously increasing knowledge accumulated by conservation biologists and development scientists, as well as innumerable initiatives and conservation projects carried out during the last decades, there is no progress in abating deforestation which has in fact become worse over the years.

To many conservationists and climatologists it appeared to be very logical that before working on the re-sequestration of carbon, the emission of existing carbon stocks into the atmosphere must be prevented. Even so deforestation avoidance failed to be included as a creditable Clean Development Mechanism (CDM) activity during the first Kyoto commitment period. The issue became politicised in the years following the Kyoto Protocol. For several reasons, a diversely motivated coalition of NGOs and Parties led to the exclusion of deforestation avoidance from the mitigation options under the CDM, losing out on the voluntary commitment and experience gathered under the AIJ. Meanwhile, the failure to include deforestation avoidance in official strategies of climate change mitigation already meant lost opportunities for both climate and biodiversity protection (Totten *et al.* 2003). In the context of the current discussions of the second commitment period of the Kyoto protocol, forest scientists and conservationists are again raising their voices, pleading for a formal

inclusion of deforestation avoidance into climate change mitigation strategies (e.g. Santilli *et al.* 2005).

Additionally, in some regions of the world, such as Europe, forests come into the focus of climate protection through their usage as a renewable energy source, which has the potential to contribute to the reduction of greenhouse gas emissions. The corresponding demand might imply conflicts between climate change mitigation and forest biodiversity conservation. The bioenergy approach could even bear the risks of unintended counteractive effects related to international and inter-sectoral leakage.

This paper tries to bring together recent research results on forests as ecosystems contributing to and suffering from global change, policy, and mitigation approaches, to include experiences with deforestation avoidance initiatives. Further objectives of this essay are to show the principal challenges in forest conservation as arising in the context of global change and climate protection and, especially, to judge whether the inclusion of emissions reductions from reduced deforestation in climate protection agreements is a reasonable and feasible option.

8.2 Forests: more than carbon sinks and sources

Still, many climate policy actors have rather mechanistic ideas of the forests' function and interaction with the atmosphere. However, forests are not simply terrestrial carbon stocks that can act as sources or sinks of CO₂ which increase or reduce global warming. As living biological systems they interact in a complex way, both with the atmosphere and climate system as well as with geochemical cycles. Of course, the manifold interactions go far beyond simple carbon exchange. Among others, the difference in albedo between poorly vegetated areas and forests is a relevant parameter impacting the climate system. In this context, the increase of forest areas, e.g. in boreal or desert zones, has the potential to enhance global warming through higher rates of energy absorption from radiation.

Forests, as well, are complexly involved in hydroclimatic processes, although certain processes and their relevance are discussed controversially (e.g., Calder 2002). Among others, certain forest ecosystems can increase water availability through the effect of horizontal precipitation (between 0.27 mm/day in Hawaii to maybe 6.3 mm/day in Panama; various sources cited by Bruijnzeel 2001). However, "the predicted effect of cloud forest conversion to pasture on annual water yields at the operational and national scale" in Costa Rica, "was very limited" (Bruijnzeel 2006). Obviously, "the value of forests must be expressed in terms of their benefits for water quality, (long-term) regulation of flows, suppression of erosion and (shallow) land sliding, conservation of biological and genetic diversity, carbon sequestration potential, and aesthetic and eco-touristic values rather than water yields" (Bruijnzeel 2006).

At any rate, forest ecosystems tend to have higher evapotranspiration rates than open land systems. This means that they 'recycle' a significant quantity of precipitation in the sense of giving humidity back to the troposphere required for rainfall elsewhere. For instance, it has been documented that deforestation of lowland forests has impacts on formation and height of clouds in adjacent montane

regions (Still *et al.* 1999, Nair *et al.* 2003, Richardson 2003). Lawton *et al.* (2001) showed that the deforestation of lowland forests, in the dry season, reduces water supply in the cloud forests of Costa Rica.

Especially, under continental circumstances, forests can be very important providers of air humidity required by other ecosystems that are less influenced by oceanic precipitation (compare Shukla & Mintz 1982). Corresponding effects might be especially important for the self-maintenance of forests in the Amazon (Salati 1987, Lean & Warilow 1989, Shukla *et al.* 1990, Nepstad *et al.* 2001). This implies that in certain regions a threshold value of critical mass of (humid) forest required for forest stability might exist. Actually, Alcock (2003) has modelled that the clearing of 25%–30% of the Amazon forest may shift regions of the rain forest ecosystem to instability. With current deforestation rates and projected land cover changes in the Amazon basin (e.g., Laurance *et al.* 2001, Ometto *et al.* 2005), forest loss – without taking climate change into account- will approach potentially critical values very soon.

In all reality, the threats to the world's largest forest blocks are greater than illustrated by the deforestation rates. Forests are not suffering from conversion alone, but are additionally subject to fragmentation and multiple disturbances. The numerous disturbances that impact the integrity of forests interact with one another and are partially connected through complex feedback cycles. Forest fires are a main agent of forest loss. For instance, it has been shown that the presence of humans in forests and especially logging activities increase the risk of forest fires (Uhl & Buschbacher 1985, Cochrane *et al.* 1999, Holdsworth & Uhl 1997). Siegert *et al.* (2001) demonstrated that in Indonesia forest fires actually concentrate in logged areas. 90% of forest fires in the Brazilian Amazon are related to forest edges (Cochrane 2001); thus, there is a clear positive feedback between forest use, fragmentation, and fires. The magnitude of logging impact on forests tends to be underestimated. For instance, recent scientific work indicates, that Amazon forest areas degraded by logging are equivalent to 60% to 123% of reported deforestation area (Asner *et al.* 2005).

Forest fires themselves are promoted by extreme weather events related to drought and strong winds; in many regions, drought and winds seem to increase with the rise of global temperatures (Nepstad *et al.* 2001). Phenomena such as El Niño-Southern Oscillation (ENSO) seem to be influenced by climate change in terms of frequency and intensity (Rowell & Moore 2000, Watson *et al.* 2000). In recent history, there has not been a comparable incidence of fire-caused forest damages as in the years 1997-1999, three extremely dry years influenced by ENSO (Rowell & Moore 2000). That being said, biodiversity of burned forests is even more heavily damaged by fires, and forests already affected by fires tend to be inflamed more easily (Rowell & Moore 2000).

Apparently, recent climate change and the rapid rise of atmospheric CO₂ concentration seemed to have a generally positive impact on forest productivity when water was not limiting (Boisvenue & Running 2006). However, the various facets of climate change will increasingly represent further direct stresses for forest ecosystems, probably reducing their integrity and resilience. The intimate interconnection of the two global change processes, deforestation and climate

change gives special reasons for concern (Totten *et al.* 2003). There is an increasing chance of extreme weather events, the impact of which might exceed the consequences of higher mean temperatures and changed precipitation regimes; especially, in combination with the manifold subtle indirect effects such as the previously discussed changes of fire regimes, or others, such as invasions and outbreaks of pathogens (Aber *et al.* 2001, Dale *et al.* 2001, Benning *et al.* 2002). In this sense even single events such as heat waves and droughts can make forests – at least regionally and temporarily - become a source of greenhouse gases instead of acting as a sink (Baldocchi 2005).

In the context of the currently observed and the projected climate change, it is absolutely necessary to be aware of its historical velocity. The last significant warming experienced by the Earth's biodiversity, at the end of Pleistocene, was about 1°C per millennium (Bush *et al.* 2004). Today, we are facing over 1°C *per century!* According to recent climate simulations, performed by the Max Planck Institute for Meteorology (Röckner *et al.* 2006), the global, annual mean temperature will increase by 2.5°C to 4°C at the end of the 21st century, if emissions of carbon dioxide and other greenhouse gases continue to grow unabatedly. Therefore, it is difficult to derive future reactions of vegetation from paleoecological data. Definitely, there is a high risk that many ecosystems and species will be overstrained by climate change in the near future.

In the Amazon for instance, according to Mayle *et al.* (2004), “[t]he predicted 3 °C rise in temperatures and 20% reduction in precipitation in Amazonia over the 21st century, would, under natural conditions, be expected to cause similar vegetation responses to those of the Early–Mid-Holocene, i.e. renewed expansion of drought-adapted plants such as semi-deciduous–deciduous dry forest trees, lianas and savannahs in response to increased fires and water stress brought about by an increase in aridity and/or length of the dry season”. The authors do not put very much emphasis on the high velocity of change in combination with the multiple anthropogenic disturbances that actually might favour non-forested open land. They only discuss that the Early–Mid-Holocene should not be considered a perfect analogue for projected atmospheric CO₂ concentrations, which by 2050 will reach levels at least twice as high as those during the Mid-Holocene. In addition “the amplitude and frequency of ENSO, which causes increased aridity in most of Amazonia during strong El Niño years” “is significantly greater today than it was in the Early–Mid-Holocene” (Mayle *et al.* 2004). Either way, drastic and detrimental impacts can be expected.

Currently, tropical forests have been known to show largely unexpected reactions to environmental changes. From a large network of forest plots in the Amazon basin, it has been concluded that the world's largest block of tropical forests, regardless of diverse site conditions, changes its dynamics: for example, in the 1980s and 1990s, mortality of trees, recruitment rates, and stem density had all increased (with recruitment exceeding mortality) (Laurance *et al.* 2004, Lewis *et al.* 2004, Phillips *et al.* 2004). The reasons might be related to enhanced resource supply through increase of solar radiation, CO₂ concentrations, and air temperatures (Lewis *et al.* 2004). On the one hand, this means that even old-growth forests, formerly considered as mature, continue accumulating biomass and sequestering carbon and contribute to climate change mitigation. On the other hand, biotic feedbacks,

such as an increase of lianas that may substantially suppress tree biomass, “may ultimately limit biomass accumulation (Phillips *et al.* 2002), and given the recent acceleration in forest dynamics (Lewis *et al.* 2004; Phillips *et al.* 2004), potential changes in tree composition may also have important implications for carbon cycling and biodiversity within these forests” (Baker *et al.* 2004). Actually, this mentioned increase of lianas has already been observed being associated with a higher rate of tree mortality; with the expected climate change towards increased seasonality in certain Amazon regions, lianas may be favored even more strongly (Phillips *et al.* 2002).

Theoretical considerations as well as experiments suggest that the forests’ reaction of enhanced growth and carbon sequestration will cease sooner or later when other factors such as the lack of the scarcest nutrients will outweigh the CO₂ fertilisation (Lewis *et al.* 2006, Reich *et al.* 2006). In fact, the Amazon rain forests may become a source of CO₂ instead of remaining a sink when climatic parameters, in the course of increasing temperatures and drought periods, surpass critical threshold values of water availability. First model results suggest that climate change could convert large regions of the Amazon forest into carbon-poorer savannas (Lewis *et al.* 2006, Cox *et al.* 2000, 2004, Cowling *et al.* 2005, Met Office Hadley Centre 2005).

In the previous paragraphs, much of the analysis has focused on the Amazon and neotropical forests. This is easily justifiable as these forests represent the world’s major block of acutely threatened ecosystems, and one of the critical ‘Schellnhuber tipping points’ (Kemp 2005) of the biosphere-atmosphere system. Additionally, it is worthwhile to stress that the Amazon forests belong to the most species-rich terrestrial ecosystems (Kier *et al.* 2005). For being so species-rich, with forests comprising of hundreds of tree species, these ecosystems should be relatively better prepared for adaptive reactions to climate change than other forest ecosystems, which consist of only a few taxa. In this context, for example, it is suspenseful to see how the large remnant blocks of boreal forests will react to climate change. Due to lower diversity and a presumed lower resiliency and higher rates of global warming in the boreal zones, it should be even more sensitive than temperate or tropical forests (Stewart *et al.* 1998). Observed reactions, among others, refer to increased productivity, increased fir activity, or accelerated phenology of spruce bud worm (Mattson & Haack 1987, Stewart *et al.* 1998). Actually, since the publication of the Greenpeace report on the ‘boreal forest carbon bomb’, in 1994 (Jardine 1994), evidence has increased, suggesting these giant forest blocks might be severely affected by climate change.

8.3 Forest use and management in the light of climate change

Deforestation is especially relevant for the last wilderness areas and the hardly managed/used forests, and the most important issue is to protect ecosystems from land-use driven degradation to less complex and relatively carbon-poor vegetation. The sustainable use of the forests will be preferable to their destruction. Often, selective logging - ideally according to sustainability criteria of international certifiers such as FSC – might represent an economically viable land use that prevents forest conversion and degradation. However, it must be acknowledged, as it has been mentioned above, that management and use of forests increase their sensitivity to

degradation (Uhl & Buschbacher 1985, Cochrane *et al.* 1999, Holdsworth & Uhl 1997, Siegert *et al.* 2001) and in most cases will lower their carbon content.

8.3.1 Adaptation of forestry to climate change

Even so, the forest ecosystems already being managed can and must contribute to climate change mitigation. In this context, a crucial issue is that an adequate adaptation of forestry to the rapidly changing climate achieves the management of forests which can be maintained to be as carbon-rich, functional, and long lasting as possible.

In Europe, 'nature-friendly' forestry is increasingly becoming widespread. This is so, on the one hand due to the insight that forestry must become compatible to biodiversity conservation, yet on the other hand, because it is acknowledged that forests with multiple stresses must become healthier (i.e., more resilient against calamities, windbreak etc.). For instance, in Germany, important paradigms at least of governmental forestry are:

- orientation of silviculture imitating natural forests which explicitly means targeting the so-called potential natural vegetation (Tüxen 1956); often this leads to a conversion of the traditional evergreen conifer plantations towards structurally rich more or less mixed deciduous forests
- accordingly, concentration on native species and local seed provenances if not natural regeneration
- prolongation of rotation cycles or at least achieving a higher mean age of the trees (e.g., selective logging of target diameter trees, conservation of a minimum quantity of single 'biotope trees')
- enhancement of structural diversity, including - among others - the accumulation of significantly higher amounts of deadwood.

Climate change impacts are increasingly discussed among foresters, but until now there is no systematic adaptation strategy. "The life cycles of forests range from decades to centuries. Decisions made today are based on the assumption that the climate will remain relatively stable throughout a forest's life. This may have worked well in the past, but future climate change challenges this assumption" (Spittlehouse & Stewart 2003). Actually, the current paradigms, especially related to targeting the potential natural vegetation, might be the opposite of a wise adaptation strategy. In times of a rapidly changing climate we are forced to permanently actualize our ideas of a potentially natural vegetation, possibly at a rate that is faster than the generation cycles of tree species. This means that we cannot simply convert a pine plantation into a beech forest because today's climate benefits beech forests. The question rather is, whether the climate in 80-100 years from now will still be a beech-friendly climate. At any rate, it seems to be difficult to predict the reactions of individual (tree) species to climate change. It is especially impossible when exclusively considering the change of mean climate values. Risks are not restricted to the future suitability of the bioclimatic envelope. For example, according to recent climate projections (Röckner *et al.* 2006), frequency and length of heat waves will increase significantly: 60 days in average over the 21st century, in contrast to 10 days in the 20th. 'Extreme' temperatures as recorded in the summer 2003 will become normal in the second half of the 21st century. Extreme events, such as periods of very high temperatures, droughts, or storms, in combination with changes of biocenoses, invasive species

and diseases, and other biotic and abiotic effects and synergies may lead to the (local) extinction of species we would not have predicted according to their bioclimatic envelopes. E.g., the German oaks, in the context of a complex disease with water stress being only one participating factor, suffered visibly from the extreme dry summer of 2003, although they would have been expected to tolerate a warmer climate than e.g. the beech.

These reflections and first lessons show that forestry adaptation to climate change cannot mean the concentration on only a few species. And, of course, silvicultural guidelines cannot be derived from a 'potentially natural' vegetation that would be dominant under the current climate. There is an urgent need for sensitizing foresters and rapidly developing climate change adaptation strategies, as required under the different site conditions and the projected climate change. Those "climate change adaptation strategies can be viewed as a risk management component of sustainable forest management plans. The precautionary principle advocates taking steps by implementing strategies that are useful now, but would also reduce the risk of unacceptable losses in the future. Many actions required to adapt to climate change benefit the present as well as the future (e.g., provenance trials)" (Spittlehouse & Stewart 2003).

In many forests it will have to be decided if the "conservationally correct" forest management strategy really is the best solution on the macro-ecological level. Definitely, maladaptation, in the short term, can lead to the loss of forest health, loss of species or in the worst case the collapse of whole forest ecosystems. Under certain scenarios managed forests could easily and rapidly become important carbon sources. This has to be prevented.

8.3.2 Forest loss and degradation fuelled by the production of biofuels?

Another important topic is the use of forests for bioenergy. Especially in Europe, there are tendencies to use the forests more intensively for the production of fire-wood as fuel for local or private wood-power plants and heating systems. Conservationists may worry that this re-intensification of forest use will counteract initiatives to establish more biodiverse and 'nature-like' forest ecosystems. A strong economic pressure for the production of fire-wood, among others, would mean the selection of fast-growing species, short production cycles, and less accumulation of deadwood. Countries, such as Germany, with high energy demand and plans to abandon both fossil fuels and nuclear power production, will face difficulties to cover significant quantities of bioenergy with the use of forest wood. Short-rotation forestry on hitherto agricultural land will be necessary to make an important contribution, but still may not satisfy the overall demand. On the one hand, it is probable that the relatively high production costs in the rich countries, along with high energy demands, will lead to a wood and bioenergy import from low-price countries. This, for instance, is already observable in Sweden, one of the countries with the highest bioenergy supply rates, importing among others alcohol from Brazil. In this context it is possible that e.g. Russian boreal forests will come under additional pressure. On the other hand, there will be strong incentives for bioenergy production in developing countries, such as sugarcane-based alcohol in Brazil (Join Brazil in planting oil; da Silva 2006), which easily could foster tropical deforestation. There is definitely a strong potential for inter-sectoral and international leakage.

It is imaginable that under the projected rapid climatic change, the short-rotation cultivation of fast-growing, less demanding trees for the purpose of bioenergy production makes more sense, both in terms of economic viability and climate protection – it will be a challenge for conservation of forest biodiversity to define how to deal with this trend. Anyway, a common overall and guiding goal of both foresters and conservationists should be the continuity of forests, as healthy and biodiverse as possible, fostering the functionality of the biosphere and minimizing additional contributions to climate change.

8.4 Forests and climate policy – the issue of deforestation avoidance

During its first meeting (COP 1 Berlin 1995) the Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC) launched a pilot phase of Activities Implemented Jointly (AIJ) under which Annex I Parties could implement projects in other countries that reduce emissions of greenhouse gases or enhance their removals through sinks. The purpose of AIJ was to build up scientific experience and foster institutional learning. Being voluntary by its nature, AIJ was not an instrument that allowed for compensating excess emissions by any Party involved under the Climate Convention. Nevertheless, their offsets can be sold on voluntary markets. Unfortunately, the AIJ experiences have not yet been compared and analysed systematically. Although COP 8 decided in 2002 that the synthesis reports should be considered every two years, no synthesis report has been published since then, leaving the lessons learned unexplored.

In terms of greenhouse gases (GHG) impacts, the Noel Kempff Climate Action Project (NKCAP) is the second largest AIJ in forest preservation. It provides an excellent working example of how carbon is sequestered in the living biomass of forests. Its emissions reductions achieved through forest conservation are being scientifically quantified, monitored and certified. The project started in 1997, when 832,000 hectares of tropical forest adjacent to the Noel Kempff Mercado National Park in north-eastern Bolivia were threatened by timber harvesting and deforestation. The Nature Conservancy and the Bolivian conservation organization *Fundación Amigos de la Naturaleza* (FAN) jointly created the Noel Kempff Climate Action Project. Together with the Bolivian government and three energy companies, the partners terminated the logging concessions, and the land was incorporated into the national park. Logging companies were indemnified under the condition that they signed a letter of intent not to expand logging elsewhere. Then the project partners launched a rigorous scientific program to measure the carbon stored in those 832,000 hectares and the carbon emissions avoided by the project.

Carbon emission reductions were generated by this project through two specific activities:

- (i) The project avoids forest degradation through cessation of logging in former concessions. Logging concessions previously granted in the project area were retired with funds generated for project activities. Emission reductions were quantified using a non-linear dynamic econometric optimization model driven by the dynamics of domestic and international timber markets (Sohngen and Brown 2004).

- (ii) Furthermore, the project avoids deforestation along the border of the project site by reducing slash-and-burn agriculture and initiating alternative income programs for the surrounding communities. GHG impacts were quantified using a spatially explicit LULUCF modelling approach based on GEOMOD (FAN Bolivia 2005).

The project included programs and activities explicitly designed to minimize leakage to the greatest extent possible. Project partners detected the leakage was arising in three ways: a shift of logging to areas outside the project boundaries, logging by communities in former concessions, and a shift of domestic timber supply internationally. From 1997 to 2005, project partners calculated a loss of 171,618 tons of CO₂ benefit from leakage (18% of gross carbon offsets). These losses were factored into the calculation of the net carbon benefits from the project.

In order to qualify for the eligibility under voluntary market schemes the board members of the NKCAP decided to initiate an independent certification of the projects' carbon offsets. As no agreed certification standards for AIJ existed, the nascent CDM rules for afforestation and reforestation were applied in analogy, although the project is not eligible under the CDM. The results of monitoring and third party certification show that from 1997 to 2005, a total of 989,622 tons of carbon dioxide sequestered in the forests would have been released into the atmosphere if not for the project (SGS 2005). Revenues from selling the carbon credits are earmarked for the conservation of the park, for improving livelihood systems in indigenous communities around the park, and for the benefit of the national system of protected areas. Thus, NKCAP does not only preserve a rich and biologically diverse forest ecosystem among the Amazonian, Chaco and Cerrado ecoregions, but also contributes to sustainable development by providing alternative, environmentally sustainable economic opportunities for the indigenous population.

Based on 10 years of project experience and successful certification, applying the rigorous CDM standards, the following conclusions can be drawn:

- (i) Large-scale avoided deforestation projects can produce real and measurable carbon offsets based on sound methodologies to quantify baseline deforestation, forest degradation, and corresponding biomass losses.
- (ii) If rules on revenue distribution are agreed in advance, this project type can generate substantial benefits for the climate, for community development, and for biodiversity conservation.
- (iii) Although leakage due to activity shifting remains an issue, it cannot be used as an argument against this project type. The project showed that leakage can be quantified reliably and subtracted from gross carbon offsets.
- (iv) Lastly, the certification of NKCAP using CDM rules indicates, that this project meets rigorous certification criteria.

8.5 Deforestation avoidance post 2012

The 11th Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) invited "Parties and accredited observers to submit to the secretariat, by 31 March 2006, their views on issues relating to reducing emissions from deforestation in developing countries, focusing on relevant scientific, technical and methodological issues, and the exchange of relevant

information and experiences, including policy approaches and positive incentives.” (FCCC/CP/2005/L.2) This decision has stimulated the discussion on how to include deforestation avoidance in an international post-2012 climate regime. Until the end of 2007, a political consensus shall be reached about (i) which types of anthropogenic interventions should be eligible, (ii) which methodologies are suitable for quantifying actual impacts, (iii) how to establish a reliable reference of baseline for future activities reducing GHG emissions, (iv) how to deal with leakage, and (v) how to set up incentives and policy approaches.

(i) Eligible interventions in a post-2012 climate regime

The Marrakech Accords define deforestation as “the direct human-induced conversion of forested land to non-forested land” (FCCC/CP/2001/13/Add.1 p. 55). Apart from that, forest degradation and devegetation are leading to substantial anthropogenic GHG emissions (IPCC 2003) and should be included in a comprehensive approach in future commitment periods. Based on this, a system of Full Carbon Accounting would consider deforestation as including logging, shifting cultivation, anthropogenic fires, and other types of intervention (roads, settlements, clearing, fragmentation).

Current provisions under the Kyoto Protocol (KP) have led to fragmentation and inconsistencies in the LULUCF system. Considering that human activities in forests, on croplands, rangelands and grasslands can have significant impacts on the level of anthropogenic emissions, a more comprehensive approach is needed under a post-2012 climate regime. Art. 3.3, 3.4 and 3.7 already allow for Annex I countries to include revegetation, forest management, cropland management, and grazing land management into their emission accounting. A Full Carbon Accounting approach would allow for comprehensive accounting of all terrestrial carbon stock changes. The IPCC Guidelines for National Greenhouse Gas Inventories 2006 prepare the way by offering generic methodologies for an approach integrating agriculture, forestry, and other land use (AFOLU).

(ii) Methodological issues to quantify GHG emissions

In order to allow for internationally consistent accounting procedures, standards for classification schemes, data processing, and monitoring should be established. Today, state-of-the-art methods in remote sensing, forest inventories and biomass measurements are available to accurately measure and detect changes in forest cover. Experience shows (GTOS 2006), “... that that changes in forest area can be monitored through such methodologies with confidence” (GTOS 2006). Taking into account the rapid technology change in remote sensing, further high-resolution sensor products will be available before 2012 to estimate changes in forest cover and the relating GHG emissions (Achard, Belward *et al.* 2006).

Accurate biomass measurements for each forest type are needed to convert area measurements into carbon stocks. Multilateral institutions like IPCC and FAO are already facilitating the exchange of measurements techniques and methodologies. Joint efforts are needed to establish consistent inventory approaches covering agreed vegetation classes, calibration and monitoring protocols. Complementary

remote sensing based mechanisms (LIDAR, videography) to directly measure biomass have been tested successfully, and might be operational in the near future.

Carbon accounting schemes at a national scale should build on already agreed methods: IPCC GHG inventory methods (IPCC 1996, and currently under revision) and the LULUCF Good Practice Guidance (IPCC GPG 2003) already contain methods and default values for various processes and pools. Soon, AFOLU Guidelines for National Greenhouse Gas Inventories will be available (IPCC 2006, Vol. 4 forthcoming).

(iii) Relevant aspects of projecting future emissions

To provide for robust projections of avoided deforestation, degradation, and devegetation, agreed definitions are needed on historical baseline periods, projection methods, and validation procedures. As these interventions show different regional dynamics in tropical countries, each country should propose country-specific baseline periods. Countries with large forest cover, relatively low deforestation rates, and low economic development should be allowed to use higher deforestation rates in their projections than countries with low forest cover or good economic performance. Spatio-temporal coverage of remote sensing data is an important criterion to select the appropriate baseline period in differentiated country based approaches (Achard, Belward *et al.* 2006). Setting deforestation baselines will always result in a negotiation process. The risk of creating excess emission allowances is undeniable. In principle, four non-exclusive options exist for baseline determination:

- a) a deforestation base period per country,
- b) a base period per ecosystem
- c) a deforestation trend, based on a longer base period
- d) modelling of deforestation based on known drivers (e.g. road development)

With a base period too short, single events like fires may be overstated. Too long a baseline will level out observable deforestation trends. An international baseline for tropical countries has been suggested. Countries whose deforestation rate lies below the global average would adopt a growth baseline (Achard *et al.* 2006). Given the necessary data, it may be broken down into specific ecosystems and/or ecoregions. Trends can project dynamic processes to a statistical rather than an explanatory baseline. Finally, deforestation modelling has been proven successful in project-based approaches like NKCAP.

To establish robust projections, the detected areas of intervention have to be related to corresponding biomass values. These biomass values might be specific for different vegetation types or a mean over a broad spectrum of different vegetations. Default values for various vegetation types already exist (IPCC LULUCF GPG 2003). Using them or other biomass measurements requires knowledge of where and how much deforestation, degradation, or devegetation will be avoided in the future. Spatial LULUCF modelling might play an important role in detecting areas under high risk of deforestation, degradation, and devegetation. Different LULUCF models are already in use to spatially project land use change (Parker *et al.* 2003, Verburg & Veldkamp 2005). Separately, model results can be used to allocate economic

incentives to those areas, where marginal changes profiting sustainable forestry could make a difference.

During the last fifteen years, various approaches to land use/cover modelling have been developed. Parker *et al.* (2003) discern equation-based models (e.g. economic general equilibrium models), systems models (e.g. system dynamics), statistical techniques (e.g. spatial econometrics), expert models (e.g. DELPHI), evolutionary models (neuronal networks), cellular models (e.g. Markov models), hybrid models combining different modelling techniques (e.g. GEOMOD using cellular models and statistical techniques) and (multi-)agent based models (e.g. DINAMICA). Although expectations exist that multi-agents systems might overcome some of the limitations of other modelling approaches (Parker *et al.* 2003), predicting the location of changes accurately remains a challenge (Laine & Busemeyer 2004).

Experience with GEOMOD using different parameter settings in the case of NKCAP shows that the accuracy of locating deforestation depends on the accuracy of predicting the corresponding regional deforestation rate, which is used as a model input. If the deforestation rate in a given area is too low, the model performance measured by spatially explicit validation techniques (Pontius *et al.* 2004) will be poor. Thus, the model is especially suitable for areas with high deforestation rates (>0.1%), predicting medium and large scale deforestation at coarser resolutions (>= 250 m).

Standards should be agreed upon, which allow for a model-independent validation of spatially explicit land use change models. A feasible and rigorous proposal already exists (Pontius *et al.* 2004) and has been successfully applied in NKCAP. The use of mean values might be feasible, when it is impossible to allocate avoided interventions *ex ante*.

The combination of principal and underlying causes of deforestation is changing over time: New roads are built, new settlements emerge, markets for timber and agricultural products show dynamic behaviour. Thus, the selected combination of drivers for deforestation and degradation has to be revised periodically, modifying the baseline, if needed. Baseline adjustments should be possible after an agreed period, in order to account for technology change in remote sensing and LULUCF modelling.

Under certain conditions, it might be impossible, to implement a national baseline covering all types of intervention: factoring out anthropogenic from natural fires might be difficult at a national scale; logging impacts might occur only within certain areas. Thus, countries should have the right to choose and combine national and project-based approaches as appropriate. In order to avoid cheating, an international review process should assure conservativeness and consistency among different national approaches.

(iv) Leakage

Leakage has been one of the main concerns preventing the UNFCCC Parties from including avoided deforestation into the Kyoto Mechanisms during the late 90ies. As the successful certification of NKCAP shows, leakage caused by activity shifting can

be calculated using a combination of forest inventory, remote sensing, and econometrics modelling approaches (Sohngen and Brown 2004, FAN 2005) providing for robust leakage estimates at local, regional, and national scale. This approach is particularly useful for monitoring leakage of project or regional approaches. Avoiding deforestation in one country might leak to non-participating countries. International leakage remains an issue, but can be either reduced under a comprehensive framework for avoided deforestation under the UNFCCC or monitored extending already existing econometric models (Sohngen and Brown 2004, Murray *et al.* (2002). Nevertheless, market leakage and trans-border leakage are issues common to all project-based mechanisms. Thus, leakage should no longer be used as an argument against including avoided deforestation under the UNFCCC. The current definition of leakage within LULUCF relates to project-based approaches. Once avoided deforestation is part of developing countries' national commitments, the only conceivable leakage within national borders is forest degradation, an issue faced today by Annex-I Parties, that can be tackled by greater precision in monitoring

(v) Incentives and policy approaches

The first discussion on reducing emissions from deforestation in developing countries during the session of SBSTA 24 (Bonn, 18-26 May 2006) showed that market-based incentives to reduce deforestation and degradation are most controversial. Especially Brazil is opposed to setting up incentives using market-based mechanisms; on the other hand, the US insists that any crediting mechanisms should occur under the auspices of the Kyoto Protocol (FCCC/SBSTA/2006/MISC.5). Thus, an international political consensus about incentive schemes is still a long way off. Consequently, the conclusions do not mention them explicitly, but indirectly as “financial mechanisms and other alternatives” (FCCC/SBSTA/2006/L.8 3.b).

As in the case of Activities Implemented Jointly, it is important to promote some voluntary national-level pilot initiatives that can deliver experiences to support the development of positive incentives and to agree on outstanding technical and scientific issues. Implementing such voluntary pilot initiatives is able to prove that the reduction of deforestation is environmentally effective, scientifically sound, equitable, politically acceptable, cost-effective, and practicable to contribute to the stabilization of GHG concentrations in the atmosphere.

In order to stimulate participation in pilot programs “early crediting” of avoided emissions should be granted by a decision of the COP. Early crediting and voluntary pilot initiatives could set up a framework in which practical experiences can be gained. Since experiences with market-based instruments are quite limited, such a regime would benefit institutional learning. At this early stage, it is necessary to provide a clear signal that the UNFCCC COP, as a Supreme Body of the Convention (UNFCCC Article 7, para.2.), will guarantee market access as a means to promote the effective implementation of the Convention. Under the COP’s “Guaranteed Carbon Market Access” decision, the COP could guarantee that any tropical country that, between 2006 and 2012, reduces its deforestation below its business-as-usual scenario would be compensated on a fair and equitable basis, and it would also establish a process for reaching agreement on unsettled issues (Petsonk 2005). Yet,

uncertainty over accounting would persist until future commitments are decided, and market demand becomes foreseeable. Furthermore, the Parties need to decide on fungibility between emission reductions from industrial GHG emissions, on the one hand, and carbon removals or emission reductions from LULUCF on the other.

To implement any action addressing deforestation and to develop the institutional capability of tropical countries in implementing any mechanism for the reduction of deforestation, up-front financing is essential. As some tropical countries might face financial barriers to prevent them from participating in this mechanism, early financial support should be agreed and generated, making resources available at the time the investment is needed. Up-front financing could come from debt-for nature swaps, ODA funds, revolving funds, inter-party incentives, loans with conditionality, advanced payments, new donor programs, and the climate change adaptation fund, amongst others.

Tropical countries should select a voluntary national deforestation stabilization and reduction target. Voluntary targets could safeguard the environmental integrity of the policy regime by increasing the possibility of negotiating more stringent targets. However, targets and baselines should be set at a level that – to the greatest extent possible – avoids creating “hot air” (excess emission allowances) within the climate regime.

8.6 Conclusions: deforestation avoidance and forest management – short-term options for climate change mitigation

Does climate change mitigation through forest management and conservation impose incalculable risks and should it therefore be proscribed? The correct answer is complex but clear:

1. Forests comprise enormous carbon stocks, and forest loss contributes significantly to the emission of greenhouse gases. Traditional and current conservation initiatives have not led to visible impact on global deforestation schemes caused by complex socioeconomic and political factors. The loss of a critical mass of forests, especially in areas like the Amazon or the boreal forests could trigger a non-linear emission of forest carbon, and thus, the enhancement of climate change towards dangerous levels.
2. Forests are not simple and mechanistic carbon sinks or sources, but highly complex systems subject to a variety of abiotic and biotic synergies and feedbacks, among others, related to the impact of multiple stressors and changing conditions including the atmospheric carbon dioxide concentration or climate change itself, the performance of individual species, and the remaining area of forests.
3. The world’s forest systems are not sufficiently understood to predict how they will tolerate current and future changes of both carbon dioxide concentration and climate change, and where the critical thresholds of functionality are. However, it is probable that the risk is ever increasing, especially when global warming reaches levels of >2°C above pre-industrial levels. This means that it is crucial to use the forest mitigation potential as soon as possible, especially in areas with the lowest warming rates, such as the tropics. It is impossible to guarantee that the forest carbon stocks are permanently safe. However, the

discussion of permanence is misleading, as any significant immediate reduction of emission is urgently required. Deforestation avoidance is available immediately while many potential technological solutions currently discussed are not.

4. At the same time, it is a crucial task that forestry reacts to the projected climate change developing climate change adaptation strategies as a central risk management component of sustainable forest management plans. Forest continuity and maximum carbon storage in managed ecosystems shall be given top priority. This requires paradigm shifts related to the conservation of forest biodiversity.
5. There is a narrowing time-frame for making use of the option of deforestation avoidance. In one or two decades it will be too late to activate it. The longer deforestation remains unabated, the higher the risk that the last large forests blocks will become victims of climate change itself, thus leading to a feedback situation. "There is a small window of opportunity to obtain the low-cost carbon mitigation benefits associated with forest protection. Timing is critical, since unrealized opportunities will probably result in higher carbon mitigation costs in the future and the loss of substantial ancillary benefits. Preventing deforestation in the first place is much less expensive than ecological restoration after the fact – if that is even possible" (Totten *et al.* 2003).
6. If deforestation avoidance is to make a substantial contribution to short-term emission reductions, this means that a relatively small number of developing countries with large primary forest areas have to play a major role, none being as important as Brazil, the Democratic Republic of Congo, and Indonesia (FAO 2006). These countries will not consider playing this role, unless deforestation avoidance becomes a real and worthwhile source of economic welfare.
7. From an economical point of view, any market based-solution to generate incentives should be preferred. Carbon trading schemes in the US, the EETS, and the CDM prove to be effective and efficient in generating and allocating resources to reduce emissions. Grants and technical and financial assistance can facilitate the implementation of these solutions, but by no means do they have the potential to replace them.

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9. Climate Policy Beyond Kyoto: Economic Impacts of a Global Cap-and-Trade System, by Christoph Böhringer¹

¹Centre for European Economic Research

9.1 Introduction

Climate change due to anthropogenic greenhouse gases has emerged as one of the most important issues facing the international community. Greenhouse gases - particularly fossil fuel-based carbon dioxide emissions - are accumulating in the atmosphere as a result of human activities, and the ongoing increase in greenhouse gas concentrations is expected to raise the global average temperature and cause other changes to the climate. Global consensus exists that climate change represents a significant potential threat requiring a considerable reduction of greenhouse gas emissions in the long term. Presuming that uncertain future outcomes of climate change could be extreme and irreversible, risk aversion justifies the adoption of a precautionary approach rather than hinging on cost-benefit analysis (see e.g. Gollier et al. 2000). In this vein, the United Nations Framework Convention on Climate Change (UNFCCC) aims at establishing an ample margin of safety based on recommendations from natural science on “tolerable” emission levels. The UNFCCC’s stated goal is the “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system” (UNFCCC 1992, Article 2). To comply with such stabilization targets, the Intergovernmental Panel on Climate Change (IPCC), which serves as the scientific advisory board to the UNFCCC, postulates reductions of global carbon emissions till 2100 by up to 50 percent below current levels (IPCC 2001).

Given the public good character of the global atmosphere and the inherent free-riding incentives, 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 previous climate negotiations under the Kyoto Protocol and proved extremely difficult to solve even though the overall abatement targets under discussion were very moderate in comparison with the emission reduction requirements to meet the long-term stabilization targets as suggested by the IPCC.

Proposals on the allocation of emission entitlements can be grouped in terms of two main focal principles (Grubb 1995): Egalitarianism (equal-per-capita allocation) and sovereignty (allocation related to the status quo). The 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 Bertram 1992, Kverndokk 1995). At the opposite end of the spectrum, a strict status-quo allocation - proportionate to current emissions - has been considered in the literature (see e.g. Young and Wolf 1992). According to this view, current emissions would constitute a status-quo right established by past usage and custom.

Egalitarianism and sovereignty mark the range of positions held by the players in international climate diplomacy. 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 and - if applied on short notice - induce potentially large adjustment costs in countries with currently high per capita emissions.

Given the discrepancy of positions held, the ultimate question arises as to if and how they can be reconciled. A natural way of reconciliation could involve the idea of convergence, allowing for gradual adjustment from current emission patterns towards a terminal point where future entitlements to emit will have become proportional to population. The global emission budget in such a scenario would have to be continuously reduced, in line with the climate protection requirements mentioned above (Formulations such as this have been discussed independently by Grubb and Sebenius 1992, Shue 1993 and Welsch 1993).

Apart from equity considerations, the opportunities for cost effectiveness of global abatement policies play another major role in climate policy negotiations. 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 keeping with 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. To date, international climate policy has mainly focused on the incorporation of “where“-flexibility: The Kyoto Protocol foresees several market-based flexibility mechanisms to achieve environmental targets – as adopted by signatory industrialized countries (so-called Annex B parties) – in a cost-efficient manner: First, under Joint Implementation (JI), Annex B countries can form a bubble in order to reach their targets. That is, countries must no longer meet their emission targets individually but it is sufficient if a group of countries meets their aggregate target. Second, the protocol allows for emission trading among Annex B countries without any restriction. Third, the Clean Development Mechanism (CDM) allows Annex B countries to meet their emission targets by financing “project activities resulting in certified emission reductions” in developing countries. The purchased reductions must be additional to “any that would occur in the absence of the certified project activity”. Fourth, each country can figure out how it translates its target into domestic policy. That is, no article requires specific technological standards or harmonized measures.

The contentious issue of burden sharing on the one hand and the deliberate incorporation of flexibility mechanisms on the other hand are intertwined. The overall prospects for achieving some burden sharing agreement may crucially depend on the magnitude of the cost “cake” to be distributed: The lower the total compliance cost are, the more likely – *ceteris paribus* – is an international climate policy

agreement. Efficiency can be the handmaiden of solving the burden sharing problem. Rather than necessary being a trade-off between efficiency and equity, the two can be complementary in designing an attractive global warming policy (Harrison and Rutherford 1999).

Notwithstanding the philosophical appeal of a “contraction and convergence”-approach to global climate policy (as a reconciliation of the egalitarianism and sovereignty principles) and the promotion of flexibility mechanism, the prospects for a broader political agreement, climate protection strategies will ultimately depend on their economic implications in terms of the magnitude and distribution of adjustment costs across regions. However, the quantitative cost assessment is a complex task. Apparently, the costs of emission abatement depend not only on the profile of emission entitlements as such but also on whether emission entitlements are tradable or not. In addition, emission constraints do not only trigger adjustment effects in the energy system but have implications for all - domestic and international - markets. The economic implications of climate policy strategies thus cannot be assessed at “face value” but requires a consistent and comprehensive assessment of market interactions. As it is not possible to simulate the economic effects of large-scale policy interference within the real world modeling economic adjustment is an important tool to gain insights for policy making. The use of economic models allows for the systematic analysis of policy reforms where aggregate economic impact may be determined by a number of partial effects which can work in opposite directions.

We illustrate the usefulness of model-based quantitative analysis along the economic impact assessment of one specific long-term climate policy proposal, the so-called *Global Climate Certificate System (GCCS)* put forward by Wicke (2005). The *GCCS* has been designed (with funding of the Ministry for the Environment and Transportation of the State of Baden-Württemberg) as a global cap-and-trade system with a three-fold claim: (i) to ensure economic efficiency by comprehensive international emissions trading, (ii) to achieve stringent stabilization targets as mandated by the IPCC, and (iii) to find broad-based political acceptance in the industrialized as well as the developing world. The remainder of this paper is organized as follows. Section 2 provides a brief characterization of the *GCCS* climate policy proposal. Section 3 lays out in a non-technical manner the model in use for the quantitative impact assessment of the *GCCS*. Section 4 summarizes model-based quantitative results. Section 5 concludes.

9.2 Summary of the GCCS Proposal

The key elements of the *GCCS* (Wicke 2005) are driven by considerations on long-term requirements of climate protection, global cost-effectiveness, and fundamental equity rules. The exogenous prescription of a global emission cap reflects recommendations by the IPCC to achieve the UNFCCC’s stated goal of stabilizing greenhouse gas concentrations towards the end of the 21st century. With respect to cost-effectiveness, the *GCCS* postulates global trade in CO₂ emission entitlements. Following the egalitarianism principle, the *GCCS* suggests an equal-per-capita allocation of the global emission cap. In order to foster political feasibility of the egalitarian allocation rule among industrialized countries, the *GCCS* suggests some specific transfer schemes that could help to reduce the burden of an initial equal-per-capita allocation for industrialized countries.

The parametric framework of the *GCCS* proposal following Wicke (2005) can be briefly summarized as follows: Global CO₂ 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 CO₂ in 2100. The concrete CO₂ ceiling is meant to be in line with the 550 ppmv stabilization of atmospheric CO₂ concentration that has been set out by the initial IPCC reports as a desirable long-term climate policy target (IPCC 2001). 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. In addition, there is some safety valve which is adjusted over time in order to prevent CO₂ 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 CO₂, are raised to 60 \$ per ton of CO₂ in 2025, and amounts to 90 \$ per ton of CO₂ from 2035 onwards. In addition, backstop technologies are assumed to be available at a price of 35 \$ per ton of CO₂ between 2015 and 2030, and from 2030 onwards at a price of 25 \$ per ton of CO₂. 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 CO₂ 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 CO₂ per annum yielding a global limit of 23 Gt of CO₂ in 2050; from 2050 until the end of the century a further mandated decline of 0.25 Gt of CO₂ per annum yields a final cap of 10.5 Gt.

9.3 Method of Assessment

CO₂ 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. General equilibrium provides a comprehensive framework for studying price-dependent market interactions; the simultaneous explanation of the origination and the spending of income of economic agents allows addressing both, economy-wide efficiency as well as equity implications of policy intervention. Therefore, computable general equilibrium models have become a central method for the assessment of the economy-wide impacts of emission policies on resource 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 often calls for an explicit dynamic framework since policy intervention applies over longer time periods. 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). Against this background, we use an intertemporal multi-sector multi-region computable general equilibrium model of global trade and energy use which features – in addition – a climate sub-module to capture dynamics of climate change. The latter corresponds to the climate component of the RICE-99 model (Boyer and Nordhaus 2000). Figure 1 sketches the basic structure of our integrated assessment model PACE-IAM (see Böhringer, Lösschel, and Rutherford 2005 for a detailed description).

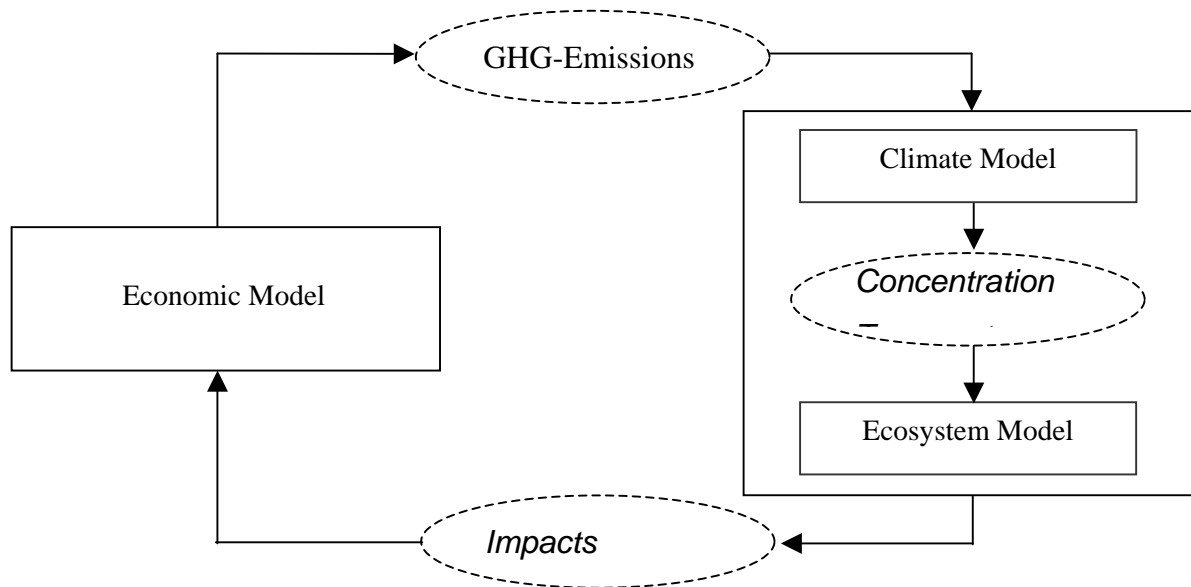


Figure 1: Generic model structure

Due to the large uncertainties in damage estimates for climate change, PACE-IAM in its current version does not attempt to translate global warming into market impacts and non-market impacts. Thus, the current model version can not be employed for comprehensive cost-benefit analysis of climate policy strategies but (only) provides an appropriate framework for cost-effectiveness analysis of alternative policy strategies: Neglecting consciously the benefits from greenhouse gas abatement and abstracting from major second-best effects (e.g. due to initial distortionary taxes), emissions control policies impose gross economic costs. Clearly, the societal desirability of abatement policies can not be assessed based on such a gross of cost accounting. However, the model is well suited to derive cost-efficient climate policies given long-term temperature or concentration targets and to compare the efficiency costs of alternative policy scenarios (meeting the same exogenous climate policy targets in the long run). Table 1 summarizes the regional and sectoral aggregation of the model that is adopted for the impact assessment of the GCCS. The global economy is divided into 7 geopolitical regions which are linked through bilateral trade flows. The economic structure of each region consists of 7 production sectors (2 non-energy good sectors and 5 energy sectors) whose outputs are demanded by intermediate production, exports, investment and final consumption.

Production Sectors	World Regions
<i>Energy</i>	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)
<i>Non-Energy</i>	Rest of the World (ROW): Africa, Middle East, Non-Industrialized Asia
Energy-intensive sectors	
Other manufactures and services	

Table 1: Model dimensions

The impacts of climate policy interference are measured with respect to a reference scenario – usually termed *business-as-usual (BaU)* – where no policy changes apply. In order to simulate the economic and environmental implications of climate change strategies, information on the future *BaU* development of the global economy (and climate) is required. The *BaU* projections forced upon the model determine how climate policy strategies such as *CCS* will restrict the world economy in the future. The compilation of the *BaU* projections is a major challenge imposed by long-term climate policy analysis. For the current simulation, we adopt the WEC/IIASA Scenario B “Middle Course” as our reference case which is based on a cautious approach to technological change and energy availability as well as modest economic growth (Jefferson 2000). Table 2 summarizes the main characteristics of the global *BaU* evolution.

CO ₂ emissions (Gt CO ₂)	35.2 (in 2050) - 41.8 (in 2100)
World economic growth	2.2 % p.a.
Environmental taxes	No
CO ₂ constraints	No

Table 2: Main characteristics of Business-as-Usual scenario

In our dynamic model calibration we differentiate growth rates for developing and industrialized countries: Developing countries start out with a growth rate of roughly 4% which gradually declines to around 2% at the end of the century; industrialized countries have substantially lower growth rates (starting from 2% and declining to 1%). The world interest rate is chosen at 5% together with a depreciation rate of 7%.

9.4 Policy Scenarios and Results

In order to contrast the fictitious long-term stringent climate strategies prescribed by *CCS* and *CCS_Plus* with contemporary climate policies we consider two further Kyoto-type scenarios where only industrialized regions adopt emission constraints:

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 Lösschel 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 3 summarizes the key features of the simulated climate policy scenarios. The availability of carbon backstop options at a price of 35 \$ per ton of CO₂ between 2015 and 2030, and a price of 25 \$ per ton of CO₂ from 2030 onwards holds throughout all scenarios. Figures 2 to 6 visualize the climatic and economic implications of the alternative Post-Kyoto policy regimes as laid out in Table 3 (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 2 depicts the carbon 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 CO₂ emissions vis-à-vis current emission levels. 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 CO₂ 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 3 and 4 translate the carbon 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 CO₂ concentrations below 550 ppmv at the end of the century, the *GCCS* strategy brings down concentrations to roughly 500 ppmv. 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 latter, the temperature increase at the end of the century amounts to 2.35 °Celsius which is roughly one degree Celsius lower than for *BaU*.

Scenario name	Characteristics
<i>BaU</i>	- Business-as-usual without binding climate policies (reference scenario as given in Table 2)
<i>Kyoto</i>	- Maintenance of Kyoto targets after 2012 by industrialized countries (Annex B) till the end of the model horizon (2100) - Developing countries are endowed with <i>BaU</i> emissions - Global “where”-flexibility - Carbon backstop options
<i>Kyoto_Plus</i>	- 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 <i>BaU</i> emissions - Global “where”-flexibility - Carbon backstop options
<i>GCCS</i>	- 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 <i>BaU</i> demand) - Safety valve - Global “where”-flexibility - Carbon backstop options
<i>GCCS_Plus</i>	- Same as <i>GCCS</i> 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 .

Table 3: Summary of scenarios

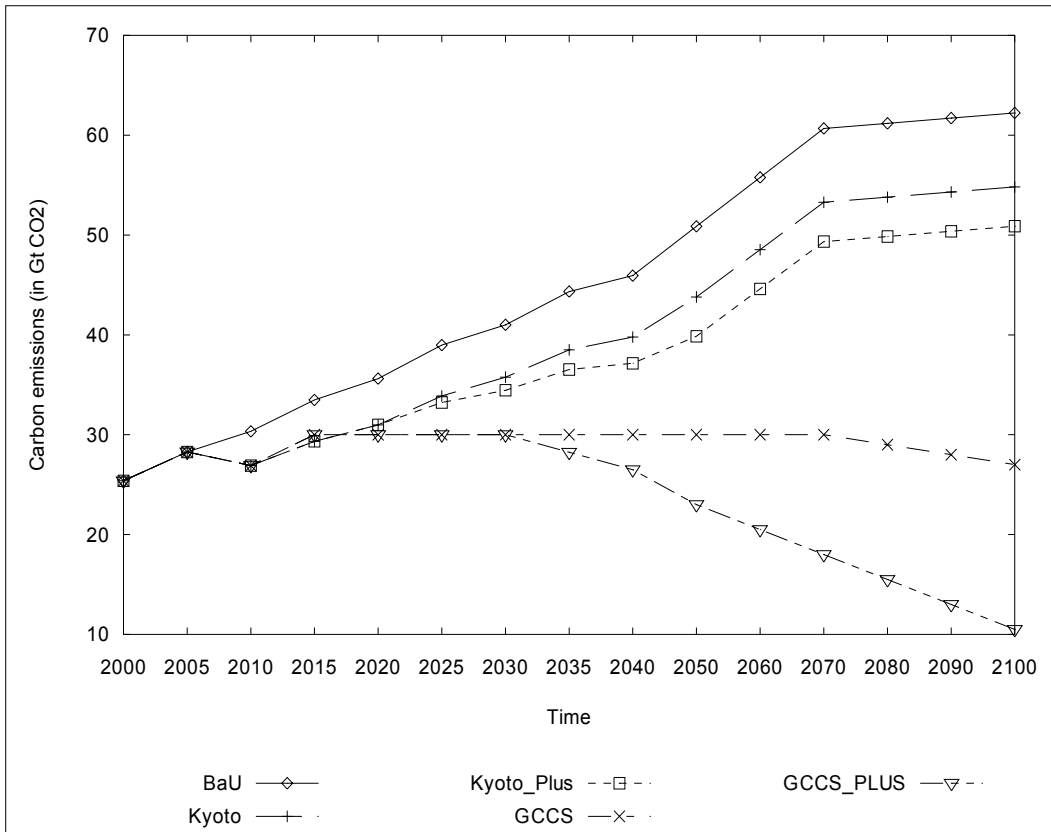


Figure 2: CO₂ emissions (Gt of CO₂)

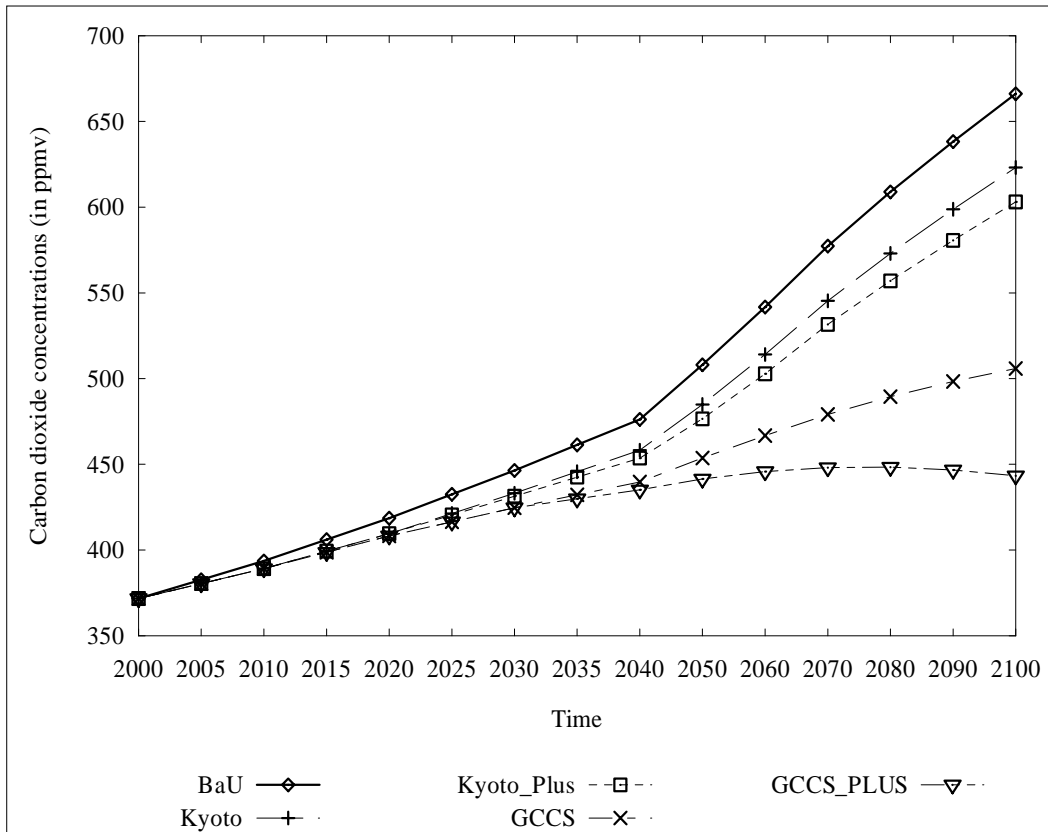


Figure 3: CO₂ concentrations (in ppmv)

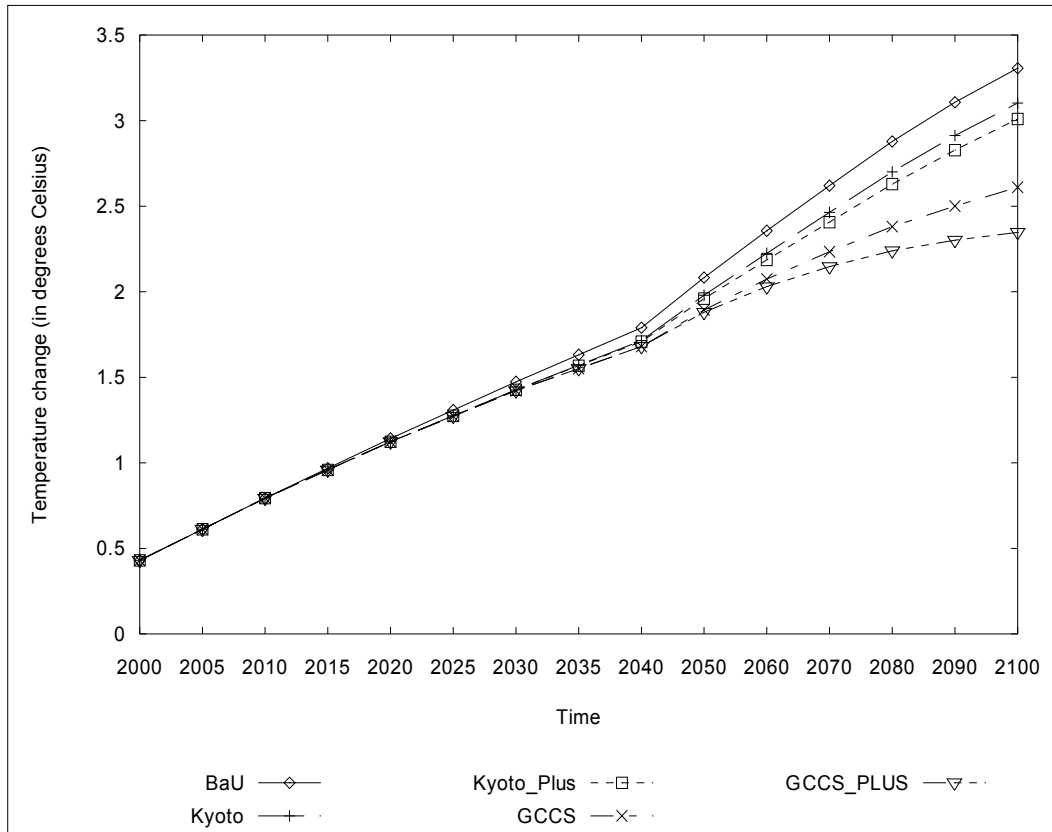


Figure 4: Global mean temperature (in °C compared to the pre-industrial level)

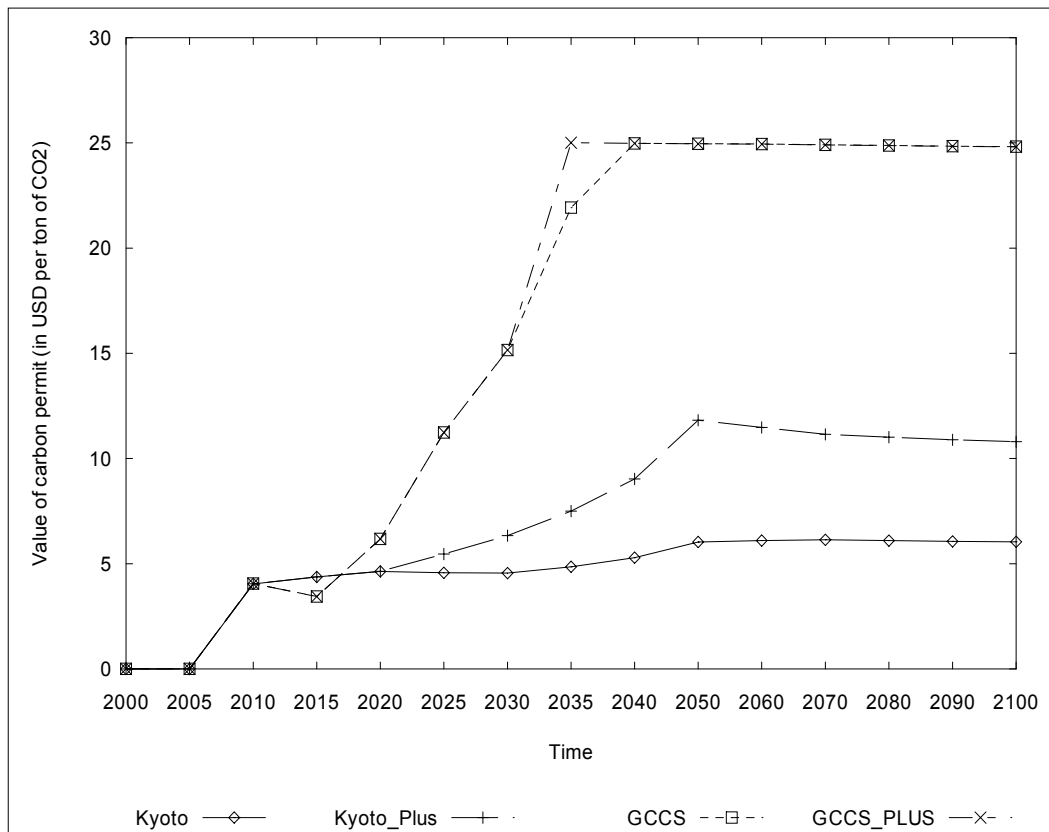


Figure 5: CO₂ Value (in \$US per ton of CO₂)

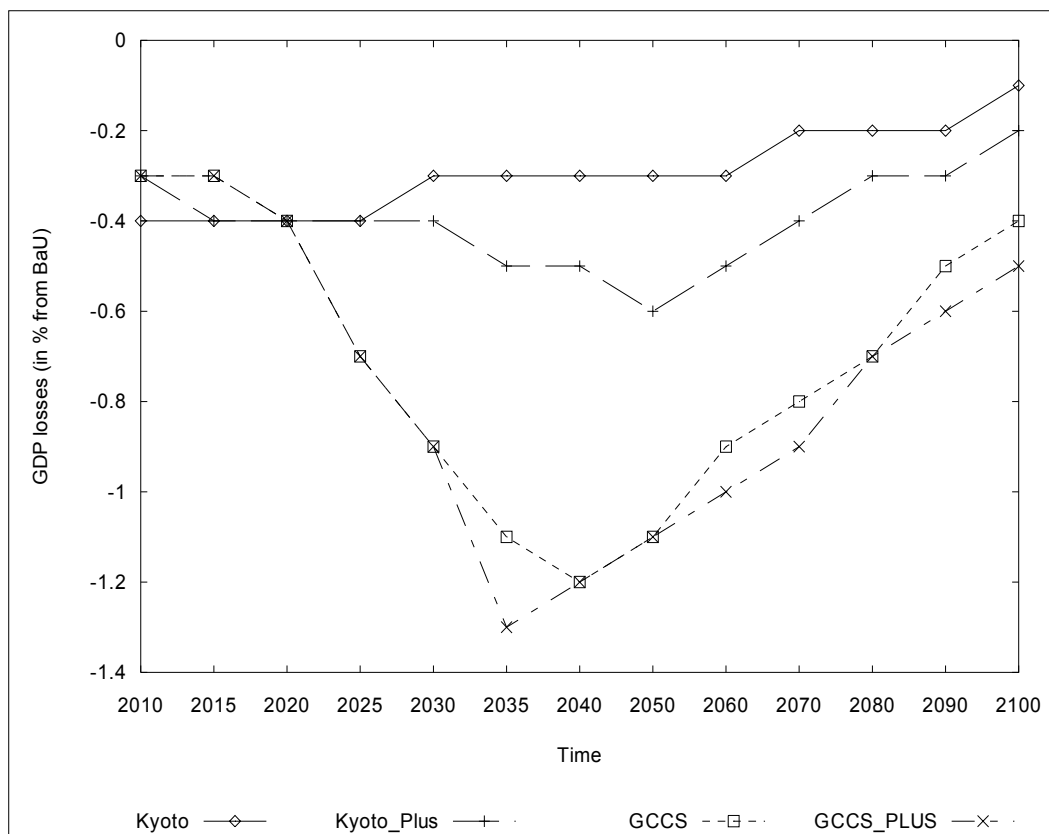


Figure 6: Global GDP (in % change from BaU)

Marginal abatement costs are sketched in Figure 5. For scenarios *Kyoto* and *Kyoto_Plus* CO₂ values remain below 25 \$US per ton of CO₂ despite of the substantial mission 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 CO₂ 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 6 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*. Welfare changes – measured as Hicksian equivalent variation in lifetime – are reported in Table 4.

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

Table 4: Welfare impacts (% change in lifetime consumption)

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. At the 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 2004/2006). 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, 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 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 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.

An important caveat on the presented numerical analysis should be kept in mind: Although our numerical 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.

9.5 Conclusions

Given the shared belief that substantial global emission reduction is required in the long run, the major challenge for climate policy is to push institutional settings that promote comprehensive international cooperation. The Kyoto Protocol constitutes the first international environmental agreement that builds on market-based instruments to determine cost-efficient responses to the undisputed need for greenhouse gas abatement. However, the Kyoto Protocol - as it stands now – only provides very limited emission reduction within its first commitment period. Neither maintenance nor further tightening of the initial Kyoto targets to industrialized countries will effect a drastic decrease of global CO₂ emissions which seems to be necessary the “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system”.

This paper has investigated the economic implications of a specific long-term global cap-and-trade system – the Global Climate Certificate System (*GCCS*) – that tries to meet long-term requirements of climate protection by combining flexibility mechanisms and fundamental equity rules. The quantitative simulations provide evidence that long-term stringent emission constraints as mandated under *GCCS* 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. “What”- and “when”-flexibility that have not been considered

in the current design of the GCCS can provide further substantial reductions in global adjustment costs. Furthermore, the neglect of benefits from global warming – owing to the larger uncertainties of external costs – 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. It is thus important to keep in mind that 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). 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.

For a realistic assessment of the prospects for effective climate policy action, it should be noted that the GCCS proposal constitutes a centrally imposed climate policy regime which presumes voluntary international cooperation of all countries. Thus, the huge free-riding incentives in the provision of climate protection as a global public good (given the lack of a supranational authority) are totally neglected: 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”). 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 CO₂, 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 shortsighted, politicians may not have an incentive at all to undertake costly abatement. 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.

Acknowledgements

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ANNEX 1 PROGRAM

Monday, February 20, 2006

12:00 Registration, Lunch

Welcome

13:00 **Tanja Gönner**, Environment Minister of the State of Baden-Württemberg Federal Republic of Germany

13:20 **Carlo C. Jaeger**, Chair, European Climate Forum

Plenary: Kyoto and beyond

Chair: **Klaus Hasselmann**, European Climate Forum / Max Planck Institute for Meteorology, Germany

13:40 “COP11 and the 2nd commitment period”, **Bill Hare**, PIK (Potsdam Institute for Climate Impact Research)

14:00 “Curbing Climate Change by Global Trade – an outline from Vattenfall”, **Lennart Billfalk**, Executive Vice President, Vattenfall AB, Sweden

14:20 “Global Cap & Trade Schemes: A Global Climate Certificate System (GCCS)”, **Lutz Wicke**, Director, IfUM (European School of Management, Institute for Environmental Management), Germany

14:50 Short break

15:00 “Evaluation methods for screening global climate policy approaches”, **Asbjorn Torvanger**, Senior Research Fellow, CICERO (Center for International Climate and Environmental Research), Norway

15:20 “Comparison of approaches for international climate policy post 2012”, **Niklas Höhne**, Senior consultant, Ecofys GmbH, Germany

15:40 Discussion

16:30 Coffee break

17:00 Parallel tracks

I Developing countries

Chair: **Malik Amin Aslam Khan**, Minister of State for Environment, Pakistan

Introductory speeches:

“The role of China in international climate policy”, **Jiahua Pan**, Chinese Academy of Social Sciences, China

“The role of India in international climate policy”, **Ritu Kumar**, Director, The Energy and Resources Institute – TERI Europe, UK

II Institutional requirements

Chair: **Arthur Runge-Metzger**, Head of Unit Climate, Ozone and Energy, European Commission, DG Environment

Introductory speeches:

“Climate Policy – the short and the long term”, **Karsten Sach**, Deputy Director-

General, Directorate International Cooperation, Federal Ministry of the Environment, Germany

III Beyond 2012

Chair: **Michel den Elzen**, RIVM (National Institute for Public Health and the Environment), The Netherlands

Introductory speeches:

“Requirements to the 2nd commitment period of the European Union Greenhouse Gas Emissions Trading Scheme”, **Delia Villagrana**, Advisor on Emissions Trading, WWF
“Forests, carbon and international climate policy”, **Pierre Ibsch**, University of Applied Sciences Eberswalde

IV Economic implications

Chair: **Claudia Kemfert**, Head of Department Energy, Transportation, Environment, DIW (German Institute for Economic Research), Germany

Introductory speeches:

“Macroeconomic consequences of cap and trade systems”, **Christoph Böhringer**, Head of Department Environmental and Resource Economics, ZEW (Centre for European Economic Research), Germany
“Incremental and structural evolution of the Kyoto schemes: economic implications“, **Carlo Carraro**, Research Director, FEEM (Fondazione Eni Enrico Mattei), Italy

19:00 Plenary: Taking stock - What are the key alternatives we are faced with?

19:30 Refreshments

20:00 Reception with Buffet; Keynote Speech: **Malik Amin Aslam Khan**, Minister of State for Environment, Pakistan

Tuesday, February 21, 2006

8:30 Breakfast

9:00 “Global cap and trade schemes from the US perspective”, **Lee Lane**, Executive Director, Climate Policy Center, USA

10:00 Coffee break

10:30 Plenary Panel

Chair: **Carlo C. Jaeger**, European Climate Forum / Potsdam Institute for Climate Impact Research

Panel members:

Malik Amin Aslam Khan, Minister of State for Environment, Pakistan

Jiahua Pan, Chinese Academy of Social Sciences, China

Ritu Kumar, Director, The Energy and Resources Institute – TERI Europe, UK

Ian Pickard, Head of International Climate Change Policy Unit, Department for Environment, Food and Rural Affairs (DEFRA), UK

Karsten Sach, Deputy Director-General, Directorate International Cooperation, Federal Ministry of the Environment, Germany

Lee Lane, Executive Director, Climate Policy Center, USA

Lutz Wicke, Director, IfUM (European School of Management, Institute for Environmental Management), Germany
Bill Hare, PIK (Potsdam Institute for Climate Impact Research)

12:00 Conclusions

13:00 Business Lunch

14:00 End of Conference

NAME	INSTITUTION
Ante, Christine	European Office of the Bavarian Local Authorities, Germany
Aslam Khan, Malik Amin	Minister of State for Environment, Pakistan
Battaglini, Antonella	Potsdam Institute for Climate Impact Research, Germany
Billfalk, Lennart	Vattenfall AB, Sweden
Böhringer, Christoph	Centre for European Economic Research (ZEW), Germany
Buchner, Barbara	Fondazione Eni Enrico Mattei (FEEM), Italy
Buttgereit, Reinhold	Vattenfall AB, Germany
Carraro, Carlo	Fondazione Eni Enrico Mattei (FEEM), Italy
Duwe, Matthias	Climate Action Network (CAN), Belgium
Ellegaard, Elisabeth	Federal Public Service of Health, Food Chain Security and the Environment DG Environment - Climate Change Section, Belgium
den Elzen, Michel	National Institute for Public Health and the Environment (RIVM), Netherlands
Engelhard, Jürgen	RWE Rheinbraun, Germany
Gallehr, Sebastian	European Business Council for a Sustainable Energy Future, Germany
Goeminne, Gert	Gent University, Belgium
Gönner, Tanja	Minister for the Environment of the State of Baden-Württemberg, Germany
Grasso, Oriana	European Parliament, Belgium
Grewe, Hartmut	Konrad Adenauer Foundation, Germany
Haas, Armin	Potsdam Institute for Climate Impact Research, Germany

Hadj-Sadok, Tahar	THS, Belgium
Haessler, Rolf	Munich Re, Germany
Hare, Bill	Potsdam Institute for Climate Impact Research, Germany
Hasselmann, Klaus	Max Planck Institute for Meteorology, Germany
Höhne, Niclas	Ecofys GmbH, Germany
Hogrefe, Jürgen	EnBW Energie Baden-Württemberg, Germany
Hontelez, John	European Environmental Bureau Brussels, Belgium
Hutton, Guy	Swiss Tropical Institute, Switzerland
Ibisch, Pierre	University of Applied Sciences Eberswalde, Germany
Jaeger, Carlo	Potsdam Institute for Climate Impact Research, Germany
Jeggle, Elisabeth MEP	European Parliament, Belgium
Johannessen, Ola	Nansen Environmental and Remote Sensing Centre, Norway
Kemfert, Claudia	German Institute for Economic Research, Germany
Kennington, Penny	SOL European Sustainability Group, United Kingdom
Kneisel, Martin	State Ministry of Baden-Württemberg, Germany
Kumar, Ritu	The Energy and Resources Institute - TERI Europe, United Kingdom
Klingensfeld, Daniel	European School of Management, Germany
Lambrecht, Jesse	Gent University, Belgium
Lane, Lee	Climate Policy Centre, USA

Lantwin, Christian	NEC High Performance Computing Europe GmbH, Germany
Linnanen, Lassi	Lappeenranta University of Technology, Finland
von Löwenstein, Simone	Representation of the State of Bavaria to the European Union, Germany
Mas, Malgorzata	RAG AG, Germany
Macey, Adrian	Ambassador of New Zealand to France, Permanent Representative to the OECD, New Zealand
Macey, Kirsten	Climate Action Network (CAN), Belgium
Montgomery, Susannah	Foreign & Commonwealth Office (FCO), United Kingdom
Pan, Jiahua	Research Centre for Sustainable Development, Chinese Academy of Social Sciences, China
Pattberg, Philipp	London School of Economics, United Kingdom
Pickard, Ian	Department for Environment, Food and Rural Affairs (DEFRA), United Kingdom
Prodi, Vittorio MEP	European Parliament, Belgium
Raidl, Gregor MEP	European Parliament, Belgium
Renz, Jonas	Representation of Niedersachsen to the European Union, Belgium
Reuter, Bernd	Ministry for the Environment of the State of Baden-Württemberg, Germany
Rittmann, Albrecht	Ministry for the Environment of the State of Baden-Württemberg, Germany
Rothe, Jenny	European Climate Forum, Germany
Ruiz de Elvira, Antonio	Universidad de Alcala, Spain
Sach, Karsten	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany

van Schaik, Louise	Centre for European Policy Studies, Belgium
Schleicher, Stefan	University of Graz, Austria
Schneider, Maria	RAG AG, Germany
Schoeters, Karla	VITO-Vlaamse Instelling voor Technologisch Onderzoek, Belgium
Schubert, Thomas	Robert Bosch GmbH, Germany
Schüle, Ralf	Wuppertal Institute for Climate, Environment and Energy GmbH, Germany
Schwan, Thomas	Potsdam Institute for Climate Impact Research, Germany
Sprinz, Detlef	Potsdam Institute for Climate Impact Research, Germany
Stevens, Sandra	European Commission, Belgium
Thenius, Gregor	Austrian Institute of Economic Research (WIFO), Austria
Tin, Tina	WWF European Policy Office, Belgium
Torvanger, Asbjorn	Centre for International Climate and Environmental Research (CICERO), Norway
Tulkens, Henry	Université Catholique de Louvain, Belgium
Van Steenberghe, Vincent	Federal Ministry for Environment, Belgium
Villagrasa, Delia	WWF European Policy Office, Belgium
Weiß, Martin	Federal Environmental Agency (UBA), Germany
Welp, Martin	Potsdam Institute for Climate Impact Research, Germany
Wicke, Lutz	Institute for Environmental Management (IFUM), European School of Management, Germany
Wilson, Charles	Vlerick Leuven Gent Management School, Belgium
Wolf, Markus	Alstom Power

Wolf, Wolfgang

Landesverband der Baden-
Württembergischen Industrie e.V., Germany

Zeltner, Stefan

EnBW Energie Baden-Württemberg AG,
Germany

Zimmermeyer, Gunter

Robert Bosch GmbH, Germany

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