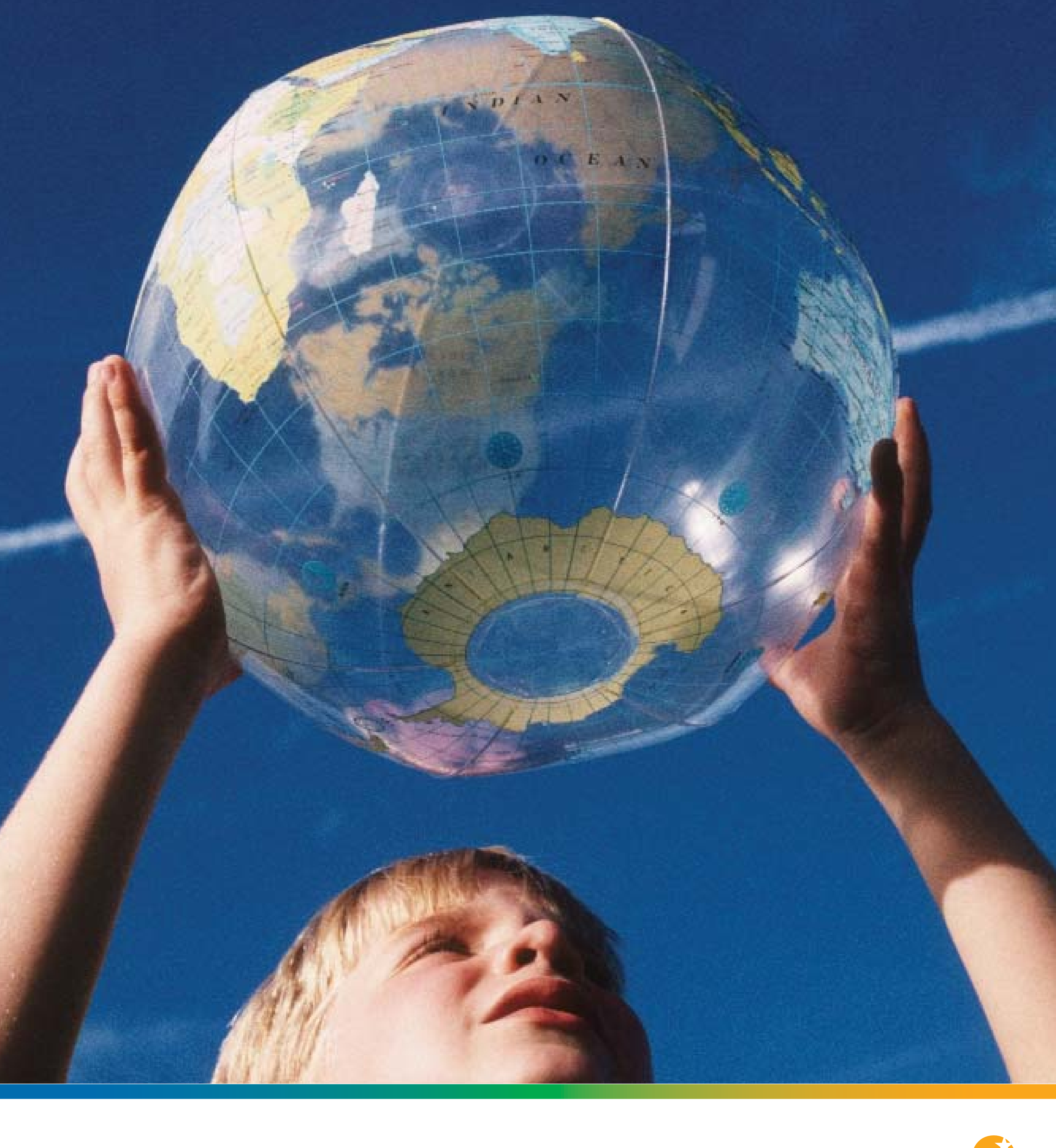
CURBING CLIMATE CHANGE

An outline of a framework leading to a low carbon emitting society



VATTENFALL

Executive Summary

The overriding environmental challenge of our time is climate change. In relation to Kyoto and beyond, humanity is facing some really tough choices. There is no such thing as a handful of simple short-term solutions. Economy, energy and environment are closely interlinked, so we have to realize that we are implementing a major shift in the world economy that will ultimately influence everything and everybody and that a long-term perspective must be applied stretching up to 100 years. Combating climate change must and will be a part of everyday life all over the globe.

In the report, an outline of 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 we start now by forming a burden-sharing model built on commitments to long-term reductions.

Curbing climate change is about combining technology, finance and policy in a wise way. If that is done worldwide a carbon dioxide market will follow. Technology is not an unsolvable problem, given time and incentives, neither is financing. The real challenge is policy.

An issue of outstanding importance is the future role of the international business community. Up to now, business leaders in general have made a strategic mistake by letting politicians and NGOs handle the challenge mainly on their own. Looking forward, business and industry have to show leadership and instead of being pulled by society business leaders should be pushing and in a positive way integrate climate issues into the world of markets and trade on a global scale.

In the report, climate change policy is discussed from three aspects:

- global burden-sharing
- The need for a global price on carbon dioxide emissions and how markets can contribute
- implementation

Preface

The subject of this report is climate change and how, over the next 100 years, we can promote development towards a society with a considerably lower level of greenhouse gas emissions.

The report has been produced on behalf of Vattenfall's President and CEO in order to develop his ideas on a global and long-term burden-sharing model, as well as the ideas that have emerged in the course of Vattenfall's internal discussions on the greenhouse effect and how it can be combatted. Initially, the report summarises the challenges now facing humanity, after which an outline of an adaptive global burden-sharing model is presented. The third chapter discusses various policy instruments and how market-based solutions can be applied, while the final chapter summarises what needs to be done to achieve a low carbon emitting society.

The report is first and foremost about how emissions can be limited and distributed, the necessity of pricing the emissions and of co-operating across national borders to find solutions. Technology and technological development are addressed only generally. The report has seven appendices that each relate to specific sections, see the Table of Contents.

Background material and data for the report has been produced by a working group consisting of Bo Nelson from Vattenfall, Peter Keresztes and Daniel Johansson from Swedpower and Niclas Damsgaard from the consulting firm Econ. Göran Svensson, Jürgen Krause, Marko Voss, Lars Strömberg and Daniel Genz, all from Vattenfall, have also contributed extensively. Åsa Petterson has proofread and edited the report. Margareta Engström has commented on the final version. I would like to thank all those involved for their very valuable contributions.

Stockholm, January 2006

Arne Mogren

Chairman of the Climate Working Group

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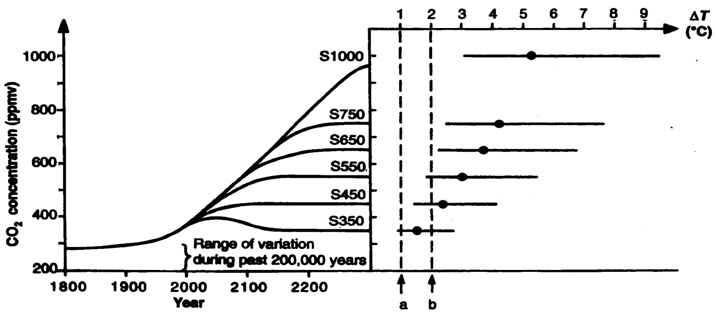
1 The Challenge[1]

The overriding environmental challenge of our time is climate change. The problem originates from the emission of greenhouse gases, primarily carbon dioxide, mainly from the transport and energy sectors. If humanity fails to come to terms with this problem, we (humanity) will be forced to make dramatic changes in the way we live our lives, but above all it will radically affect the lives of our children and grandchildren. The climate change issue is by its very nature global and long-term. This is something new. Previously, environmental problems have been short-term and local.

Total global emissions of greenhouse gases in 2000 amounted to 37 billion tonnes[2] of carbon dioxide equivalents, of which more than 23 billion tonnes carbon dioxide.[3] The trend is towards a dramatic increase, especially in countries that are experiencing rapid growth such as China and India. Carbon dioxide from combustion dominates. 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 downwards.[4]

Figure 1. Carbon dioxide scenarios and effects on the global average temperature



Source: SCIENCE • VOL. 276 • 20 JUNE 1997 • www.sciencemag.org Azar & Rodhe

Whatever the level, it is very clear that we must drastically reduce the current level of total emissions. If, in a hundred years time, the per capita emissions, including those of the developing countries, should be equalized at the same time as temperature stability is achieved, then a dramatic reduction in emissions from fossil fuels is required. Global emissions must be reduced by probably more than

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[1] A background to the climate change issue is given in Appendix A.

[2] Personal communication with Professor Christian Azar of the Institute for Physical Resource Theory at the Chalmers University of Technology, Spring 2005.

[3] Assessment made by Vattenfall. Based on IEA data regarding emissions in 1990 and 1995.

[4] In the latest material, even lower levels, 450 or less, are indicated as more realistic stability levels.

50 per cent. During this period, the developing countries will increase their economic activity tremendously, so the presently industrialised 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. At the same time, we must also ensure that the measures taken do not lead to unnecessary costs. 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 this Kyoto period is still unclear, which makes long-term planning and investment decisions extremely difficult. Furthermore, the commitments under the Kyoto Protocol only apply to the industrialised countries (the so-called Annex I countries[5]) that have ratified the Protocol. A number of countries with large carbon dioxide emissions, most notably the USA, and fast growing economies such as China, do not face these restrictions. This is not a sustainable situation. When countries with commitments have to take measures their cost level, primarily for energy, will increase. If so, in the short term, energy-intensive industry will most certainly stop investing in these countries and, in the long term, companies affected will probably completely move out. The economic effect on the commitment countries will be substantial, while the environmental benefits will be very limited or even negative due to carbon leakage.

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, a long-term global framework that will provide governments, citizens and corporations with a stable and predictable environment must be established. A framework is crucial to ensure that correct and relevant decisions are taken and that a sufficient reduction of greenhouse gases is achieved at the lowest possible cost to society. 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.

The climate change issue is global and long-term. Drastic reductions must be made and in the long term global total emissions must be capped to a sustainable level, i.e. we must switch over to a low carbon emitting society. Emissions are closely coupled to economic activities. Real long-term global governance is needed. Is a common effort really possible? In this report three important aspects of this challenging need are discussed:

- An outline of an adaptive global burden-sharing model
- The need for a global price on carbon dioxide emissions and how markets can contribute
- What is needed to implement a global market-based regime regarding carbon dioxide?

[5] The Annex I countries are listed in Appendix B.

2 An Outline of an Adaptive Global Burden-sharing Model

In this chapter, 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 by providing some food for thought. The results presented here rest on a number of high-level assumptions, based on other material. It should be underlined that these assumptions should not be seen as a prognosis of future development.

The focus of this chapter is the allocation of emissions between countries on a global level. It is of course not enough to allocate emission rights between countries to reduce the emissions, concrete measures must also be taken to reach the target. National policies are then a necessity. Later on (chapter 3), different methods that may be used to reach the national targets are discussed, but it can already be stated that economic instruments, e.g. taxes or tradable emission allowances, are the options that are most likely to lead to cost efficient abatement.

The allocation to each country in the outline primarily depends on the country's share of the global production. In addition, developing countries will be phased in to the system and face emission restrictions once they have reached a certain pre-determined gross domestic product (GDP) threshold. Several adjustment mechanisms are also applied. These mechanisms are introduced for different reasons. One aims at compensating countries early in an industrialisation phase that are likely to have a more energy-intensive economy than countries later in the industrialisation phase. This is primarily based on the empirical fact that highly-developed economies in general are less energy intensive relative to GDP than countries early in the industrialisation process. Another mechanism aims at avoiding unnecessary high costs due to the forced early retirement of existing long-lived investments.

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 extra cost burden on the poorest
- 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 shall not change 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 gross global product (i.e. gross 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. Without disregarding the fact that some measures need to be taken also in the near future, 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. Very rapid reductions will lead to an early closure of such plants and create a need for replacement investments at a high cost. 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. In order to limit the negative economic impact, it is thus reasonable to limit the speed of the required adjustment. However, reducing the speed will also lead to stricter limitations later since the total emissions could not be allowed to increase for this reason.

The mechanism has been outlined for two different reduction path scenarios, labelled the early peak and the late peak scenarios, which are described below.

2.1 The allocation model

The allocation of emission permits is performed in three steps:

- First, a global target cap is set to reach a specific carbon dioxide concentration level by year 2100. The calculations presented in this report are based on a 550 ppm CO_2-equivalent target. Whether this target is too lax, or too harsh, is beyond the scope of this work, but the same principles can be used for other target levels.

- Secondly, the (assumed) emissions of developing countries that do not face any emission restrictions are deducted from this cap. Developing countries should not face restrictions on their emissions until they have reached a certain level of economic development. This is measured in terms of their GDP/capita quota. However, all countries should commit themselves from the start. Thus, individuals and companies in developing countries will, from the start, know that once a certain level has been reached activities in their country will also face restrictions.
- 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.[6] Countries poorer than average receive a higher allocation per unit of GDP, while richer countries receive a lower allocation per unit of GDP. The allocations have been calculated for every fifth year between 2015 and 2100.

In the model, all Annex I[7] 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 the Annex I countries in 2002. When the GDP/capita exceeds this threshold, the country begins facing emission restrictions and the allowances are calculated based on its share of global GDP. The poorest countries among the Annex I countries had a GDP/capita quota in 2002 that was about 25 per cent of the average in the Annex I countries, and it seems reasonable that also non-Annex I countries should be able to take on commitments at least when they have reached a GDP/capita level that is twice as high.[8]

For the non-Annex I countries, an assumed business-as-usual emission scenario has been used, as described below (see Figure 4). This has been allocated to each country relative to its assumed growth in GDP. Eventually, all countries will face restrictions as their GDP/capita exceeds the determined threshold.

Adjustments

As mentioned initially, three adjustment mechanisms have been introduced in order to limit the negative economic effects and to create a more fair division of the emissions between countries that are in different phases of the industrialisation process.

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.[9] The extra allocation increases linearly below the average GDP/capita and the maximum extra allocation is reached if the country

[6] GDP is throughout this paper converted to US$ using purchasing power parity (PPP) and not market rates. PPP will generally better reflect actual physical production than if market rates were used. This choice has a clear effect. The GDP of China in 2002 was 1208.9 billion US$ (1995) using exchange rates, while it was 5197.4 billion US$ (1995) using PPP (US GDP would in both cases be 9196.4 billion US$).

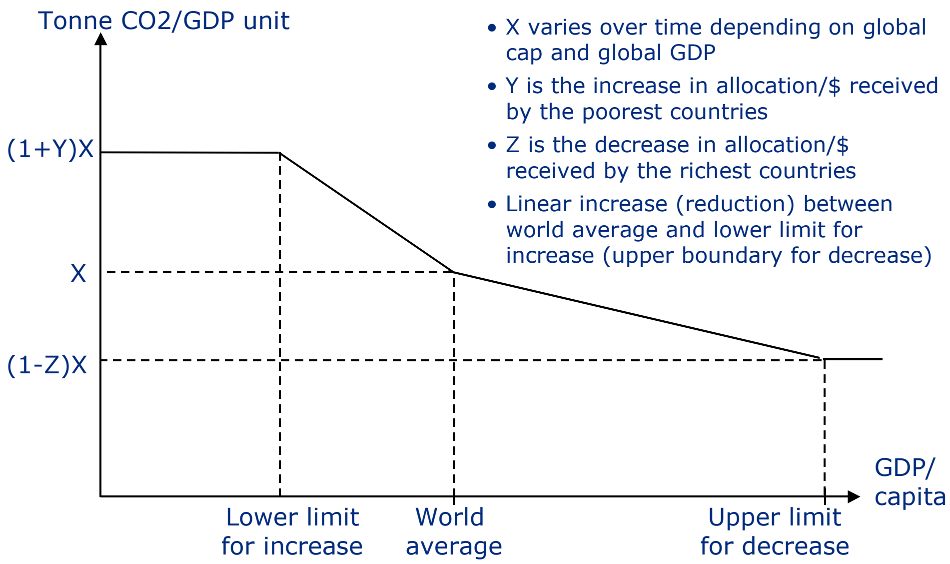
[7] The expression "Annex I countries" refers to the countries listed in Annex I to the United Nations Framework Convention on Climate Change. For a complete list of Annex I countries see Appendix B.

[8] The poorest Annex I countries are countries such as Belarus and Ukraine that faced an enormous economic downturn following the collapse of the Soviet system. There are non-Annex I countries that have a clearly higher level of GDP/capita than these countries.

[9] Note that this first applies when a country has a GDP/capita above the set threshold, otherwise the country faces no restriction on its emissions.

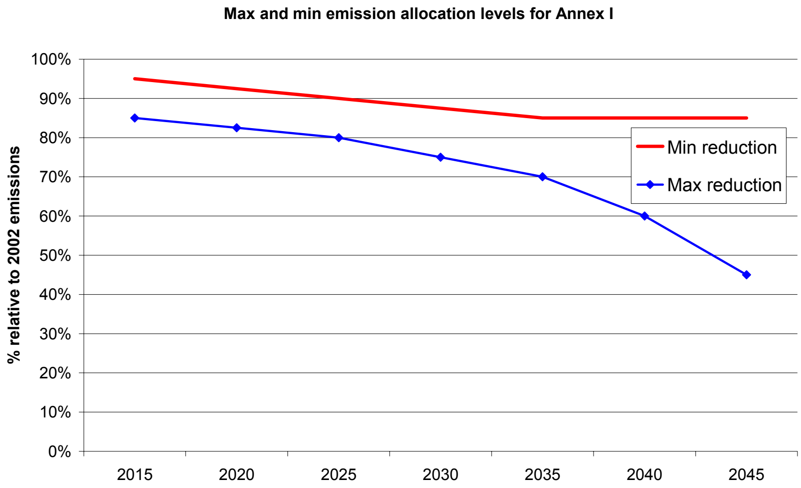
has a GDP/capita that is equal or less than 0.5 times world average GDP/capita. In a similar manner, countries that are richer than the world average receive less allocation/GDP unit. For countries with a quota twice, or higher, than the world average, the allocation/GDP unit is 0.9 times the allocation for a country at the average level. The declining energy intensiveness at higher GDP/capita levels is handled by means of this adjustment. The allocation mechanism after applying this adjustment mechanism is showed in Figure 2.

Figure 2. Description of the GDP based allocation mechanism



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 (see Figure 3). In 2015, the minimum reduction level is 5 per cent, increasing to 15 per cent in 2035, independent of what the base model allocation is. After 2035, the restriction is kept at 15 per cent, although this restriction will not be binding in the long run as the total global cap is decreased, forcing all Annex I countries to make at least these reductions. The maximum reduction level means that no country has to reduce its emissions by more than 15 per cent in 2015, relative to 2002 levels, and this gradually increases to 55 per cent in 2045. Then the maximum speed restriction is lifted and the allocation is fully determined by the base model. The actual allocation to each country will be in the area between these two levels. As already stated, these two rules only apply for the current Annex I countries. The maximum reduction level is imposed primarily to allow existing capital to serve its lifetime. If this rule was applied to the developing countries that gradually qualify into the system, it would lead to perverse incentives to invest in particularly high-emitting technologies.

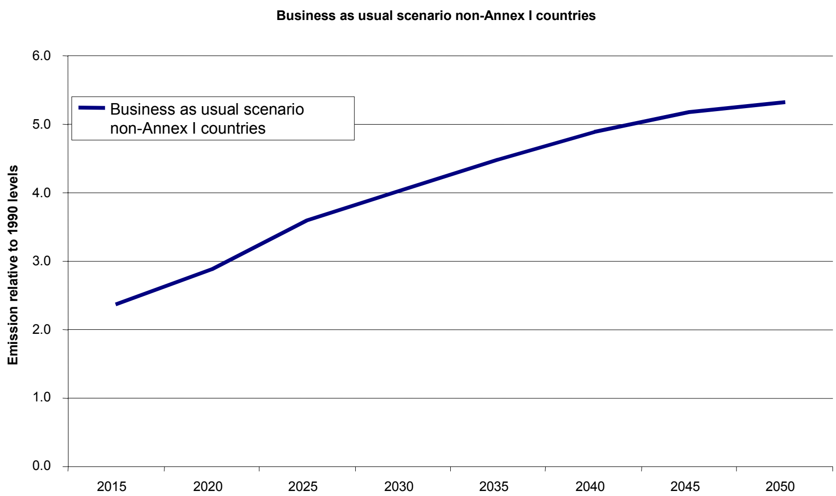
Figure 3 *Restrictions on minimum and maximum allocation levels for Annex I countries*



Emissions of non-restricted countries

For the non-Annex I countries, an assumed business-as-usual emission scenario has been used as described in Figure 4. Emission levels have been allocated to each country relative to its assumed growth in GDP, i.e., a country with higher growth has a higher increase in emissions. These assumed business-as-usual emissions have been used for the countries that do not face restrictions in a particular year.

Figure 4. *Business as usual emission path for non-Annex I countries. Emissions relative to 1990 levels.*



GDP over 100 years

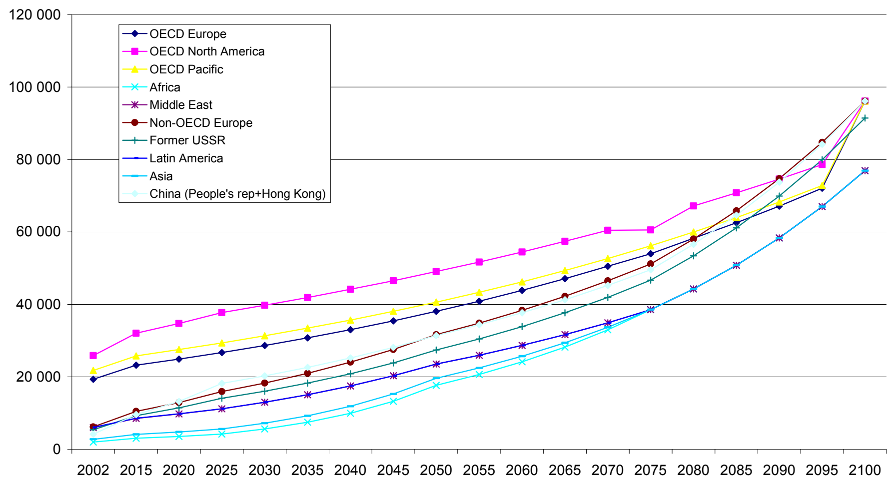
GDP in Annex I countries is assumed to increase by a factor of six between 2002 and 2100. This is broadly in line with the average of the GDP projections in the scenarios presented by IPCC[10]. For the remaining countries, growth depends on

[10] Data for the scenarios are available from the IPCC Data Distribution Centre

an assumed convergence in GDP/capita towards the Annex I average. All countries are assumed to converge towards the average GDP/capita level in 2100. Full convergence has, however, not been assumed until 2100, but the relative differences are reduced to a considerable extent.[11] The assumed GDP growth for different regions is displayed in Figure 5.

There are no strong arguments for assuming that it is impossible for any part of the world to experience similar economic development to that seen in parts of Asia in recent decades and in Europe and North America in the centuries before that. Thus a rather high degree of convergence has been chosen as an assumption for the calculations made. Clearly, however, the projections used in the calculations should not be seen as a prognosis of the actual future development.

Figure 5. Assumed GDP/capita development



Whether this convergence will take place or not is a debatable issue. The time span is 100 years, a very long time period, and predicting the future is as always extremely difficult. During the last decades parts of Asia, and in later years especially China, have exhibited very rapid economic growth. At the same time, other parts of the world are falling behind and some have actually become even poorer. Economic research has shown convergence between countries or regions that are similar, while rejecting convergence across all countries.[12] There is also a weaker convergence thesis, which says that convergence will occur among countries, if one holds factors such as the initial level of human capital, measures of government policy, political stability, etc. constant. This kind of convergence is supported by the broadest cross-country samples indicating a rate of convergence that is about two percent per year. That implies that it would take about 35 years for an economy to eliminate half of the gap between its initial level and its long-run level of per-capita income.[13] The rate of convergence that has been assumed here is in many cases lower than this, but on the other hand the convergence that

[11] The poorest regions (countries) are assumed to have a GDP/capita that is 80% of the richest regions. Currently, Africa has a GDP/capita that is below 8% of the GDP/capita in OECD North America.

[12] Baumol (1986) finds support for convergence among OECD countries, while Barro and Sala-i-Martin (1991, 1992a, 1992b) find support for convergence across American states, regions of several European countries and prefectures of Japan.

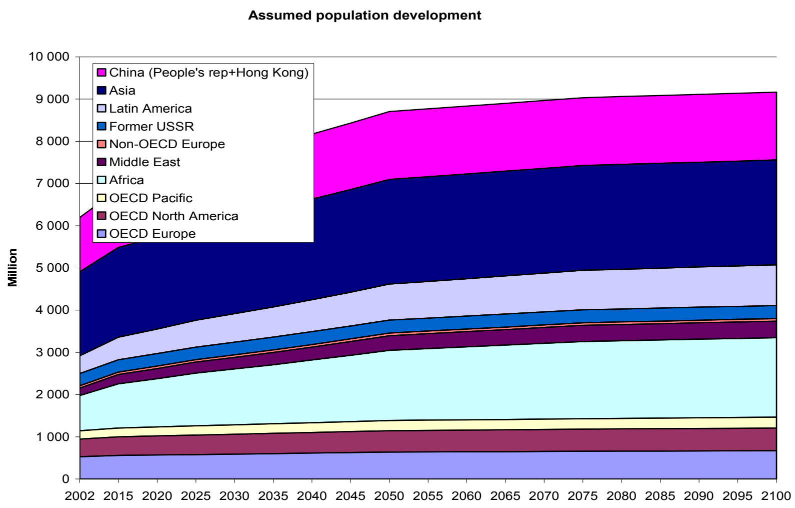
[13] Barro (1991), Mankiw, Romer and Weil (1992).

has been assumed is not conditional, but absolute.[14] Thus, economic research, looking at past experience, does not generally support this rather optimistic view. But, as mentioned above, some countries have obviously grown very rapidly and, within the century in scope, a similar development could hopefully be also seen in areas that are currently lagging behind. There is no firm basis for assuming that it is impossible for any part of the world to have a similar economic development as has been seen in parts of Asia in the last decades and in Europe and North America in the centuries before that. Consequently, a rather high degree of convergence has been chosen.

Population growth

The population growth is based on the (unweighted) population assumption in the different IPCC scenarios, which were reported for four regions.[15] It has been assumed that the population growth is equal within each of these four regions and, based on that assumption, population growth paths for each of the regions have been constructed. The results are shown in Figure 6.

Figure 6. Assumed population development



2.2 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 over the entire time period (2015-2100). In both scenarios, the path towards the long-term target means a gradual decrease in the emissions from the industrialised countries, while developing countries are initially allowed to increase their emissions. In total, this means that the global emissions will increase at first, but eventually start to decrease towards the long-term target. The early-peak scenario implies that the increase in total global emissions will be broken rather early in the future, around 2025, while the late-peak scenario implies that the emissions increase for an additional 15 years. Since the accumulated emissions up to 2100 are unchanged, this essentially means

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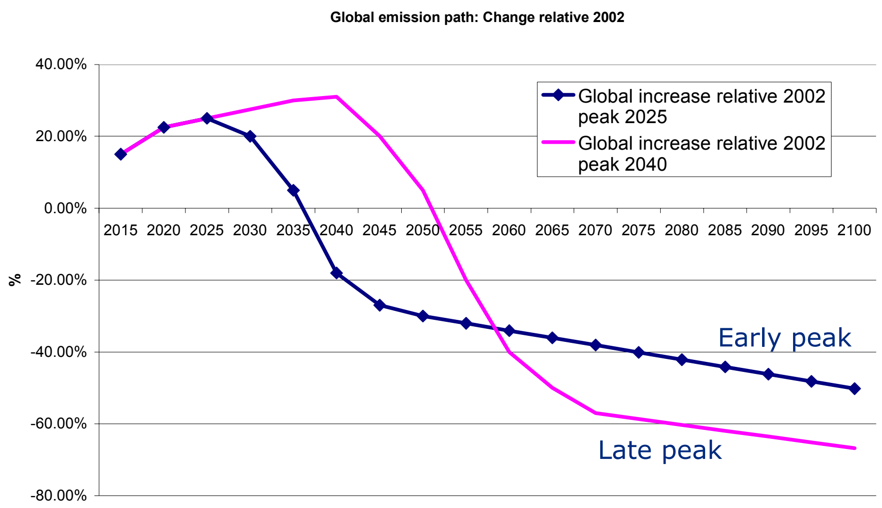
[14] For instance, in the period 2002-2040 it is assumed that GDP/capita in Africa will converge from about 10% of average Annex I GDP/capita to almost 30%. If Africa's long-run level was in line with Annex I GDP/capita, the gap would be halved during this period.

[15] OECD90 covering the OCED member states in 1990, ASIA covering Asia, REF covering eastern European and former USSR and ALM covering Africa, Latin America and Middle East.

moving the emissions forward in time. [16] Both the target and the path in the late peak scenario have been adjusted to get the same accumulated emissions, about 1 600 Gt CO_2, in both scenarios.

Figure 7. CO_2 Emission path scenarios, % change relative to 2002



2.3 Results

The early-peak scenario

The long-term target is set to 12 000 Mt CO_2 in the year 2100, compared with approximately 24 000 Mt in 2002. This long-term target, together with the reduction path, is intended to approximate to the emission path of a 550 ppm CO_2 equivalent target.[17]

The national allocations have been calculated for all Annex I countries and for a choice of non-Annex I countries with illustrative different characteristics (China, Tanzania, Iran, Brazil, South Africa, India, Korea and Mexico). The rest of the world is aggregated into regions (Asia excl. China, Africa, Latin America, etc.), and each of these regions is then treated as one country. The results of the allocation mechanism for a few selected countries are presented in Figure 8.

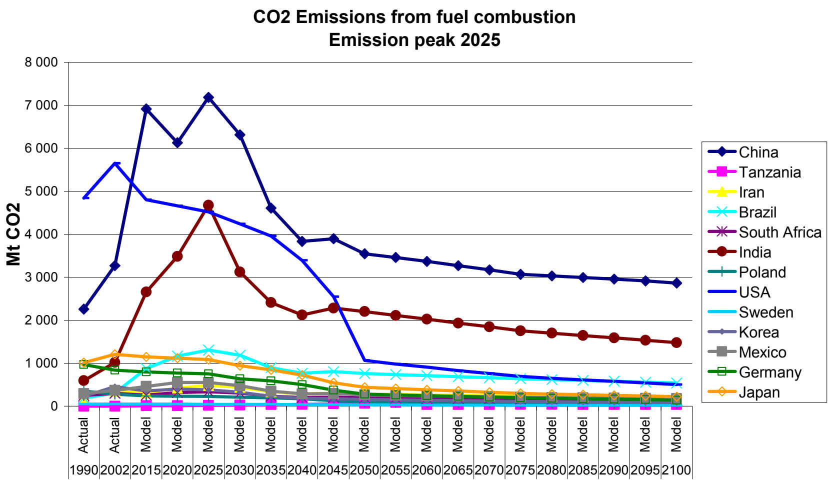
The figure shows that China would be allowed to increase its emissions substantially until 2015. By 2020, the GDP of China is assumed to have grown sufficiently so that the country will face emission restrictions. After 2025, China would have to start reducing its emissions towards its long-term target. 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. There is obviously a risk that they will invest in high-emitting technologies, creating the same adjustment problems that we will have in the industrialised

[16] No attempt is made to judge whether the chosen target concentration level is sufficient or not in terms of acceptable climate consequences. The level chosen is by many sources viewed as reasonably ambitious. A 550 ppm carbon dioxide equivalent level is expected to result in a temperature increase exceeding the EU target of 2 degrees Celsius.

[17] We have only included CO_2 from fuel combustion in our calculation. The levels presented here will thus be lower than if we included all greenhouse gases. The CO_2 emissions from fuel combustion represent about 80% of total greenhouse gas emissions in Annex I countries (in 2002) and about 60 per cent of global greenhouse gas emissions. Source: IEA, CO_2 emissions from fuel combustion, 2004 edition.

world. A development in that direction must be avoided. For this reason it is of vital importance that all countries enter into the agreement at the start, even though some will not face any restrictions in the beginning. A pre-commitment will send a clear and strong signal to investors, and presumably also affect policy choices at an early stage. This is likely to affect investments from the start, and reduce the risk that developing countries invest in high emitting technologies. It is quite possible that it will result in less CO_2-intensive investments and thus lower emissions in the period up to 2015 compared with a normal business-as-usual scenario.[18] This argument clearly rests, however, on the assumption that this framework will provide a stable and predictable setting, which illustrates how vital it is that all countries participate in the agreement from the start and do not wait to enter into an agreement until they have reached a level of economic development that justifies that they should take on binding commitments themselves.

Figure 8. Allocation of emissions (CO_2 emissions from fuel combustion) in early peak scenario for some selected countries, Mt CO_2



For the USA, the imposed restriction on the maximum speed of emission reductions allows the country to continue with its relatively high level of emissions for a period. This is most clearly seen in Figure 9, in which the allocations of CO_2 emissions per unit of GDP are presented. For the sake of clarity, the curves representing the USA, Japan, Germany and Sweden are presented with bold lines. The basic allocation model would give similar emission levels to both the USA and Sweden. The Swedish emissions are however forced down, due to the restriction on minimum reductions, while the USA gets an extra allocation due to the restriction on maximum reductions. The latter is also the case for some other countries, such as Poland. For Germany and Japan, which are not bound by the maximum or minimum restriction, the basic allocation mechanism determines the allocation and the allocation per GDP unit lies between the allocation per GDP unit for the USA and Sweden. Initially, there is a small difference in the allocation per GDP unit between Japan and Germany, which is due to the adjustment mechanism that gives a lower allocation per GDP unit for a relatively richer country.

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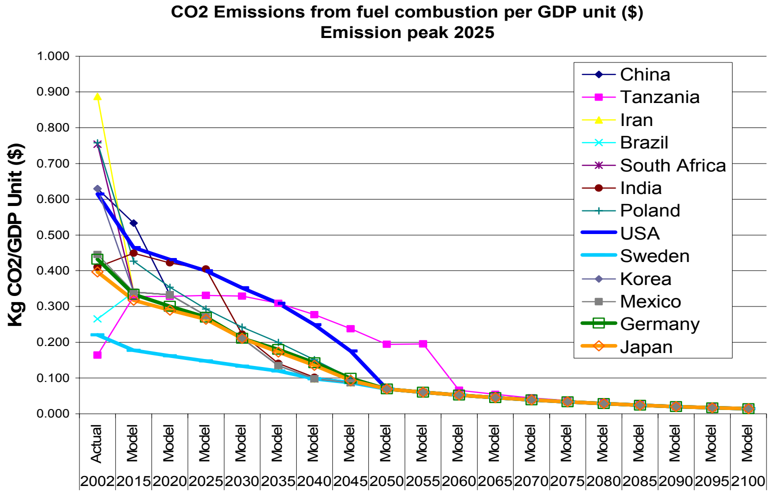
[18] A mechanism similar to the current Clear Development Mechanism (CDM) would make it possible for countries already having a cap to carry out reduction measures in countries still without any cap.

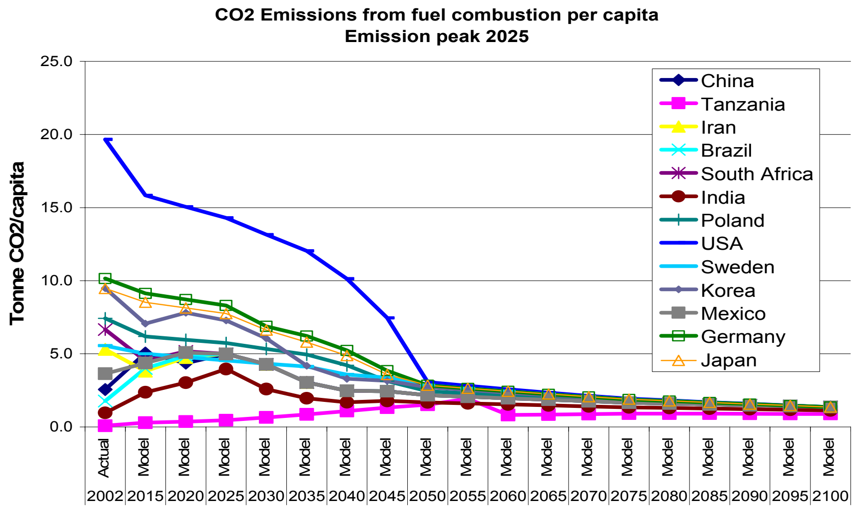
The adjustment mechanisms applied have a large impact on the allocations. If the effects are judged too large, the adjustment mechanisms could easily be changed.

Figure 9. *Allocation of emissions per GDP unit (CO_2 emissions from fuel combustion) in early peak scenario for some selected countries, Mt CO_2/$ GDP*



In the long run, the emissions per GDP unit converge for all countries. Furthermore, as GDP/capita is assumed to converge, the emissions per capita will also converge in the long run (see Figure 10). This will result in a more equal distribution of the emissions between different regions.

Figure 10. *Allocation of emissions (CO_2 emissions from fuel combustion) per capita for some selected countries - early peak scenario, tonne CO_2*



The areas in Figure 11 represent the allocation between different regions[19], while the line is the global target cap.[20] Furthest to the left in the figure, the actual data

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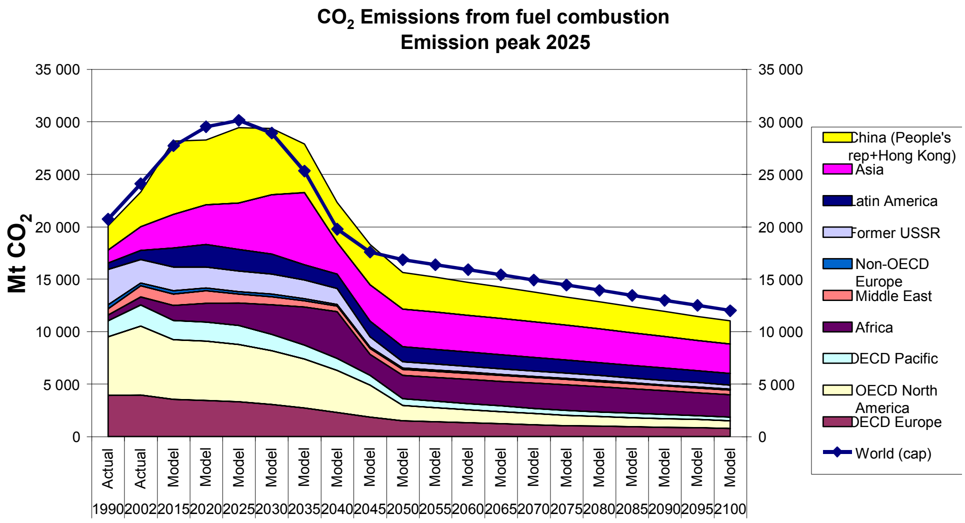
[19] The regions follow the division used in IEA (2004).

for 1990 and 2002 are used, thereafter data from the model calculations are used. As illustrated in Figure 11, non-OECD Asia (incl. China and the Middle East), Africa and Latin America today only account for about 35 per cent of the global emissions of CO_2 (from fuel combustion), while about 75 per cent of the world population live in these areas. At the same time, North America and OECD Europe are responsible for over 40 per cent of the emissions, while only about 15 per cent of world population live there. According to the proposed model, this division will gradually become more equal towards the end of the period (2100). North America and (current) OECD Europe will only be allocated about 12 per cent of the global cap, while the above mentioned developing regions will be allocated about 72 per cent of the global cap.

Figure 11. *Regional allocation of emissions - early peak*



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

The basic results in the late-peak scenario are very similar to the ones for the early-peak scenario. This is quite natural since the same allocation mechanism is used in both cases, and the only difference is that the emissions are allowed to increase more in the first half of the period in question. This then has to be compensated by larger reductions in the latter half of the century. The focus here is on the differences between the two scenarios.

The late-peak scenario implies that all countries that face restrictions will be awarded a (non-strictly) 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 Mt in 2100.

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[20] Due to the different adjustment mechanisms described above, the actual allocated CO2 allowances will not exactly sum up to the target cap. It would of course be possible to make the model more complex in order to solve this problem, but since the purpose of these calculations is to provide an illustration for a discussion of principles and the degree of precision is not that high, it is not meaningful to conduct such an exercise. The total allocated CO2 allowances and sum of the emissions according to the target cap over the period 2015-2100 are also almost identical.

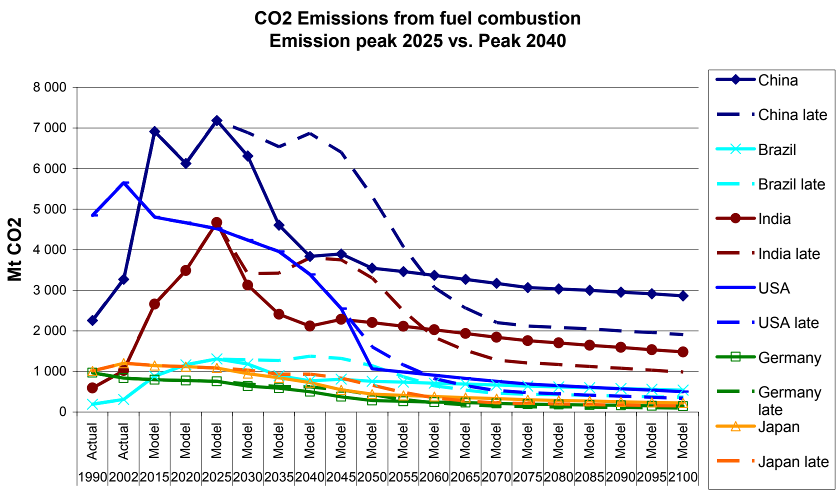
The fact that the reduction in the level of emissions comes later in the late-peak scenario, i.e. that a larger share of the total emissions comes early, has some effect on the climate, although the difference is likely to be fairly limited since it is only a matter of a few decades. Guesswork based on IPCC material indicates that the effect will be minor and has been judged negligible in comparison to the overall uncertainties in the calculations made. Consequently, no compensation is made for this effect.

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). Some poor countries, which first start facing restrictions on their emissions in the latter part of the century, will, however, not directly reap the advantages of higher allocations in the first half of the century, but will receive lower allocations in the latter half.

Figure 12 illustrates the differences between the early and late-peak scenarios for a few selected countries. The choice between the two scenarios hardly affects 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 and a slightly lower allocation thereafter. The maximum reduction speed for high-emitting countries will primarily be set by the adjustment mechanism rather than the timing of the global peak.

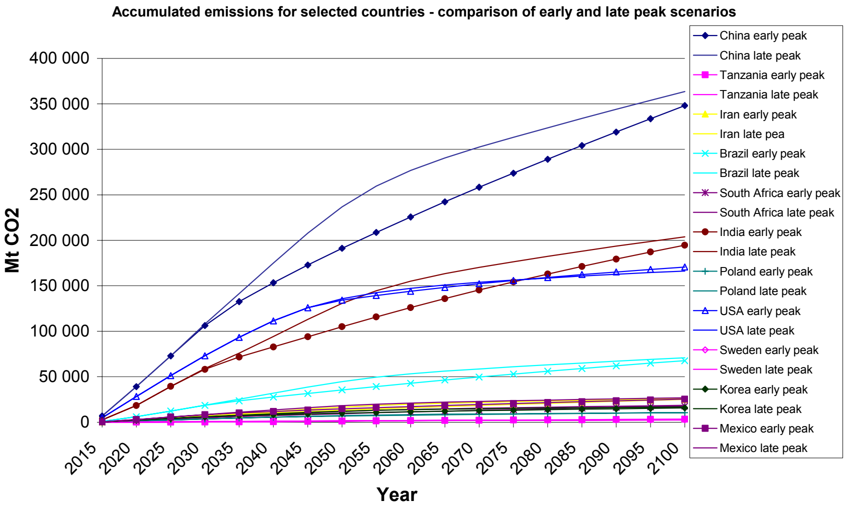
The late-peak scenario will, however, shift the reduction requirements quite substantially for a few developing countries. From the figure, it is quite clear that China, India and Brazil will be allowed to continue with relatively high emissions for a longer period of time, but will have to make substantially larger reductions in the latter half of the period in the late-peak scenario compared with the early-peak scenario. A similar pattern will be the case for all countries facing restrictions fairly early in the century, at least if the country is not too heavily affected by the different adjustment mechanisms applied (i.e. Annex I countries, newly industrialised countries, and fast growing developing countries).

Figure 12. Difference in national allocations between early and late-peak scenarios



The speed of reductions affects both the timing and the total accumulated emissions for individual countries. These effects are displayed in Figure 13 and in Table 1. Fast growing developing countries and newly industrialised countries seem 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[21]. 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. As mentioned above, the industrialised Annex I countries are protected in the early-peak scenario from too drastic reductions, and the main effect of the late-peak scenario for these countries is that the emissions in the latter half of the period will have to be reduced even further.

Figure 13. Accumulated CO_2 emissions for selected countries - comparison between early and late-peak scenarios



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[21] The countries presented in the table are chosen to indicate the effect for different types of countries, with different levels of emissions, GDP levels and growth rates, etc.

Table 1. Accumulated CO_2 emissions for selected countries

Countries	Accumulated emissions in early-peak scenario	Accumulated emissions in late-peak scenario	"Gain" from late peak	% "Gain"
China	348 056	363 552	15 495	4.5 %
Tanzania	3 432	2 963	-469	-13.7 %
Iran	25 104	26 295	1 191	4.7 %
Brazil	67 657	70 855	3 198	4.7 %
South Africa	17 747	18 577	830	4.7 %
India	194 612	203 753	9 142	4.7 %
Poland	10 526	10 449	-77	-0.7 %
USA	170 582	166 271	-4 311	-2.5 %
Sweden	2 590	2 489	-101	-3.9 %
Korea	15 673	16 862	1 189	7.6 %
Mexico	25 386	26 879	1 493	5.9 %
Germany	31 459	32 086	627	2.0%
Japan	30 524	31 437	913	3.0%
Total above	**943 348**	**972 469**	**29 121**	**3.1 %**

Additional information on the late-peak scenario:

The following graphs show the development in carbon dioxide emissions per GDP unit (Figure 14), per capita (Figure 15) and the allocations per region (Figure 16). The allocations per GDP unit for the selected countries have converged by 2060, which was also the case in the early-peak scenario. This is completely driven by the underlying assumptions about GDP growth and the implementation of the allocation mechanism.

Figure 14. Allocation of emissions (CO_2 emissions from fuel combustion) divided by GDP for some selected countries – late-peak scenario, Mt CO_2/\$ GDP

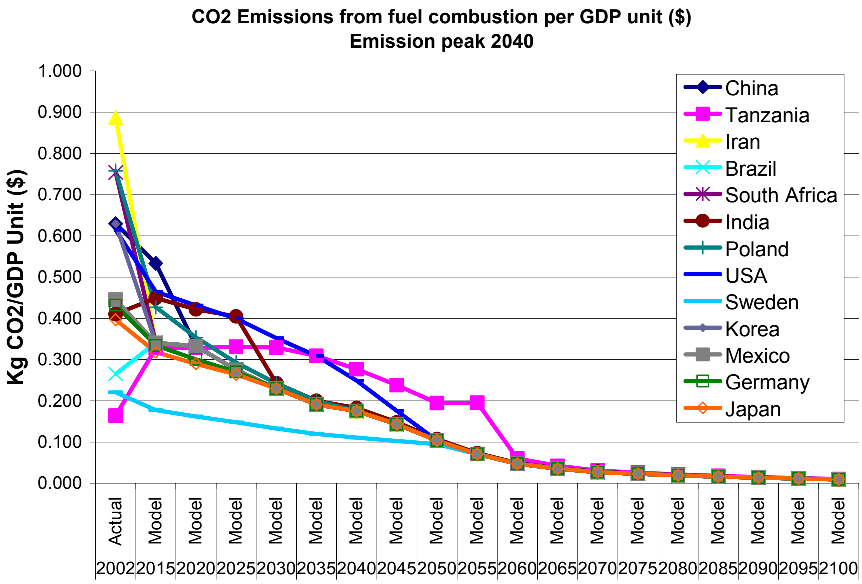


Figure 15. Allocation of emissions (CO_2 emissions from fuel combustion) per capita for some selected countries - late peak scenario, tonne CO_2/capita

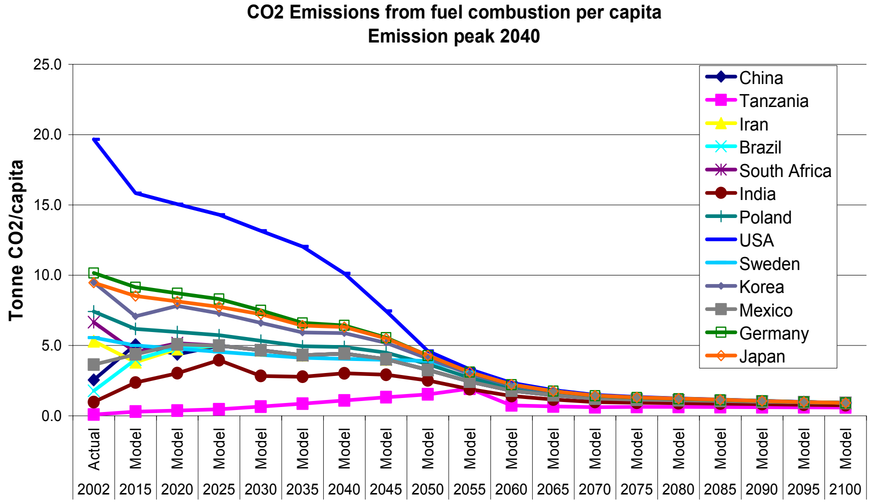
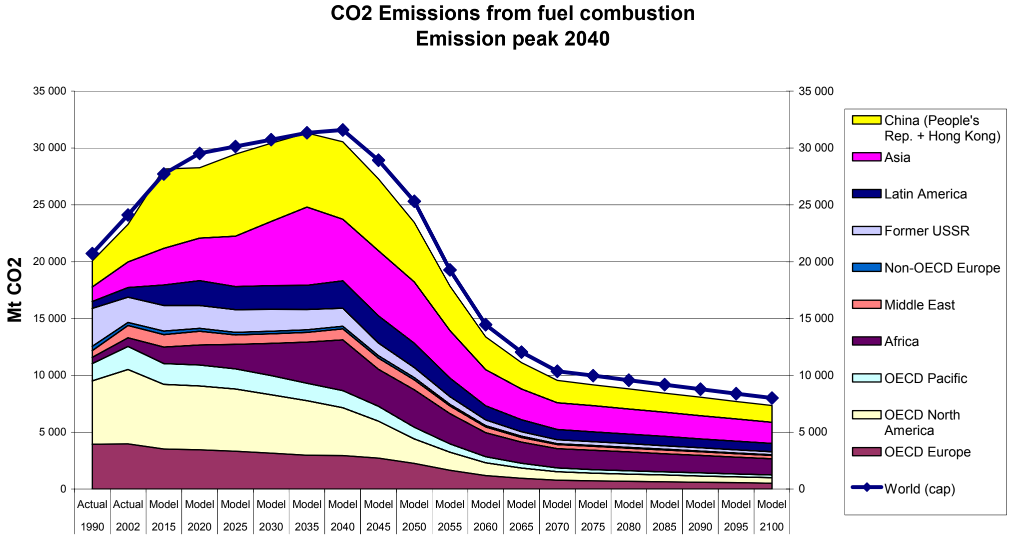


Figure 16. Regional allocation of CO_2 emissions - late peak



2.4 Concluding remarks on the burden-sharing outline

The overriding ambition in this chapter has been to outline a burden-sharing model that both results in a practical and acceptable way of reducing global emissions and at the same time creates a stable and predictable environment for governments, individuals and corporations. It is based on the belief that this can be achieved by setting long-term rules that all parties are prepared to accept, and that these rules should include commitments to reduce emissions. Different methods can be used to achieve these reductions.

The model is founded on the belief that a GDP-based mechanism has the best 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 reductions, 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. This also means that if the GDP/capita quota converges, then the allocation of CO_2 allowances per capita will also converge, thus giving equal entitlements to everyone.

In the ongoing discussion on allocation, several different approaches can be identified:

- *The multi-stage approach* implies that countries participate in several stages depending on certain thresholds. This approach directly deals with the need principle. It does not, however, deal with the long run, or final burden sharing.
- *The contraction and convergence approach* deals directly with the principle of equal entitlements, and implies that emissions per capita first converges (contracts for some and increases for others), and then contracts towards the long-run target. This approach also takes care of the principles of need, responsibility, capacity and comparability to a large extent, but fails to meet the opportunity criteria.
- A third approach was suggested by Brazil in 1997 (*Brazilian proposal)*. This proposal is based on the principle that the burdens should be allocated according to each country's relative responsibility. This approach is directed towards the responsibility principle, but is also likely to take care of the need, equal entitlements and capacity principles to a large degree.
- A fourth approach could be labelled *the ability to pay approach,* which naturally is designed to deal with the capacity principle, but will also to a considerable extent take care of the need and comparability aspects. This approach implies that the responsibilities are allocated according to per capita GDP and the developed countries would thus carry the majority of the costs.
- *The triptych approach* is a fifth example, which is directed towards the principle of opportunity and the obligations are decide based on the emission structure of the countries. Originally it included analyses of energy-intensive industry, the power sector and the domestic sector, but it has subsequently been extended to cover additional sectors and more emissions.
- A sixth approach is the *equal mitigation costs* approach*,* which deals with the comparability of efforts. This approach implies that the economic burden should be distributed equally between all countries (as a percentage of GDP).

To what extent is the outline proposed here in line with these approaches? To begin with, the proposal clearly follows the multi-stage approach, since it is suggested that countries should "qualify" into the system when they reach a certain pre-determined threshold. All countries should, however, commit *ex-ante* of doing so. To some extent, the proposal also follows the contraction and convergence approach, although the convergence towards equal per capita allowances depends on the assumption of convergence in GDP per capita. This means that the proposed model provides a possibility of meeting the equal entitlements principle. The outline also has the potential to lead to equal mitigation costs, although not necessarily as a share of GDP. Given that the right instruments are used to reach the targets, equal marginal mitigation costs and thus cost efficiency can be achieved. This also means that the actual emission reductions will take place where the opportunities are best. High-emitting economies also have to make larger reductions and thus take on a larger share of the total burden, which in practice means that wealthier countries will take on a larger burden.

One important aspect for whether any allocation principle is acceptable is if it is considered fair. This is especially problematic since there is no universally accepted definition of fairness, and each party has its own view of what is fair. Several equity principles and perspectives on fairness can be formulated, such as:[22]

- Need: All countries should have the right to emit the quantity needed to meet basic needs (food, warmth, shelter).
- Equal entitlements: Everybody has the same right to emit.
- Responsibility/polluter pays principle: Those who have caused the problem should also bear the costs for solving it.
- Capacity: Commitments should be based on the ability to pay.
- Opportunity: Commitments should be based on the availability of low-cost mitigation options.
- Comparability of effort: The commitments of different parties should be "comparable".

The proposal outlined here can clearly not satisfy all the, partly conflicting, views on fairness. But no other proposal can do so either. What is important is that the proposal has the potential of allocating the burdens in a way that is acceptable to most, or hopefully, all parties. For a given level of global emissions, it will not force the industrialised countries to commit to unreasonably fast reductions, 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. In the long run, it is also necessary that it will be more attractive to be a part of the system then to stay outside. Given the establishment of an international system, each single country's relation to this system will be a new and important part of that country's role in the international community.

It should be noted that the adaptive nature of the model in combination with a long time span and uncertainty about the future development of GDP (both regarding the total amount and its distribution) and the global population will lead to special demands on how the emission allowances must be constructed. The total emissions allowed for a specific year will be set by the global cap, but how this total amount is allocated among countries depends on how their economies and populations develop in relation to each other. This is of course a complication but, on the other hand, it is not more complicated than the present state regarding already ongoing international trade in currencies. The implementation of the proposed model will to a great extent have to be based on forecasts regarding GDP development and population growth at the country level. Employing an envelope curve as well as opening up for checkpoints (i.e. international re-negotiations) in, for example, 2025, 2050 and 2075, can level out short-term variations.

The most important issue is the robustness of the method, not the calculations as such. Two conditions must be fulfilled; the climate change effects must be

[22] See e.g. Wrang and Busk (2005) for a discussion of these issues in the context of climate policy.

acceptable (and this is due to global policy commitment) and the short-term economic consequences must be acceptable to all countries. The calculations made indicate that an adaptive model based on a long-term target is an interesting, clear-cut alternative to the present short-sighted Kyoto accord.

3 How Can the Need for a Global Price on Carbon Dioxide be Met?

Given an international burden-sharing agreement, with allocation based on each country's share of global GDP, what measures must be taken to fulfil the national commitments at the same time as the global emission target is reached? Policy measures need to be taken to create incentives for action. It is likely that these measures, at least to some extent, will be a matter of national policy. At the same time, as countries are mutually dependent, too large differences may lead to an undesired outcome. As mentioned above, commitments made only by some countries are likely to result in unacceptable long-term effects. Similar problems, although probably to a lesser extent, may arise due to differences in national policy.

The implementation of a policy to reduce emissions of greenhouse gases, as well as any other policy, includes 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?

A large number of different policy options exist,[23] and each one of them may have its place. Which policy instruments should then be used? First of all, there are many different aspects that it is important to consider when evaluating different policy instruments, and a number of important evaluation criteria can be identified.[24] Five important criteria are:

- *Environmental effectiveness:* How effective is the programme in meeting its emissions-reduction target?
- *Cost-effectiveness:* Will the programme design permit cost-effective compliance?
- *Administrative feasibility:* Can the programme be administered effectively?
- *Distributional equity:* Are the burdens shared in a fair way?
- *Political acceptability:* Will the programme be politically acceptable?

In addition to these general criteria, when it comes to climate policy one must also bear in mind that it is a global issue. It is thus not sufficient that these criteria are met at the national or regional level, they should also be met at the global level. Considering, for instance, cost efficiency, it is not sufficient to equalise the marginal abatement costs within a country or region, this should be achieved on a global basis. The price of greenhouse gas emissions should thus be global to create the right incentives.

[23] The most important ones are probably taxes on emissions (or energy), tradable permits, subsidies, deposit/fee-refund system, voluntary agreements, non-tradable permits, technology or performance standards, product ban and direct government spending or investments.

[24] See for instance Nordhaus and Danish (2003) or IPCC (2001).

Taxes and tradable permits do however have the distinct advantage of providing the incentives for achieving cost-efficient abatement through the equalisation of marginal abatement costs. Taxes or trading set a price on the emissions. As for all other resources, setting a price provides clear incentives for efficient use. In the longer run, technology will develop if the resource becomes more costly. Thus, setting a price on emissions will create incentives for each individual and each company to consider options to reduce the emissions both in the short- and long run. New inventions will be made and new options will be found, simply due to the fact that prices create incentives for action.

Thus, economic instruments generally provide the best means of achieving emission abatement at the lowest possible cost, i.e. of achieving a cost-efficient solution, by giving incentives to all the parties involved. In practice, the burden will also be shared among different parties in society.

The possibilities for abatement differ between countries so international trade aspects are important. Virtually all traded goods will consist of a carbon dioxide component. There is thus an obvious risk that countries implement different measures that will seriously distort trading patterns. The result will be an increase in the total cost of achieving the necessary emission reductions. Therefore, it would clearly be beneficial if the instruments implemented facilitated cooperation, exchange and global cost efficiency.

3.1 A short description of tradable permits and taxes

Tradable permits

Tradable permits (allowances) are usually designed as a cap-and-trade system, meaning that an overall cap on emissions is set and emission allowances can then be traded. The cap-and-trade scheme can be implemented as an upstream programme applied to fuel suppliers or a downstream programme applied to individual sources of greenhouse gas emissions.

An economy-wide downstream cap-and-trade programme will represent a great administrative burden, since it applies individual caps on millions of small emission sources such as cars and the heating of individual homes. A large-source downstream cap-and-trade programme, such as the emissions trading system established by the European Union (EU ETS), is however administratively feasible and likely to be environmentally effective with respect to the sectors that it covers. It must, however, be combined with other policies directed at the remaining sectors.

An upstream cap-and-trade programme can be cost-effective, environmentally effective and administratively feasible. Since it covers all sectors it can, however, drive up the prices of gasoline and home heating fuels, which may be politically sensitive.

Nordhaus and Danish (2003) argue that an economy-wide upstream cap-and-trade system would have the best potential for achieving low-cost emission reductions, but a hybrid model (sector by sector) with large-source downstream cap-and-trade combined with product efficiency standards in other sectors may, for institutional and other reasons, be all that can be implemented in the near future. For the second alternative they state that: “If policy-makers take that course, careful attention will have to be given to minimizing economic costs and administrative complexity, and assuring that the programme can be effectively enforced.”

An alternative, which is also mentioned by Nordhaus and Danish (with reference to the McCain-Lieberman bill) is an upstream/downstream programme with a large-source downstream element for electricity generators and other large sources and an upstream programme for other sectors (e.g. transport). This seems to be an interesting option which has the potential of ensuring low-cost emission abatement.

Taxes

A greenhouse gas tax programme can either be an upstream programme applied on the carbon content of fossil fuels or a downstream tax on greenhouse gas emissions. An upstream tax programme could be environmentally effective, but will not guarantee that a particular emission target is met. Also, with marginal abatement costs that are unknown to the policy makers and likely to vary between sectors, actors and countries, setting the right tax level to achieve the right level of abatement is a very challenging task. The primary advantages are that it allows for cost-effectiveness, offers cost certainty and would probably be administratively simpler than a trading system. A greenhouse tax programme would have important distributional effects, but the tax revenues can be re-distributed. The revenues can also be used to reduce other distortional taxes, thus reducing the net cost of emission reductions.[25]

3.2 The choice between price or quantity instruments

If taxes and emissions trading both have the advantage of setting a price on the emissions, does it then matter which option we choose? Or is it so that the choice between a system with tradable emission allowances and taxes may as such not be of crucial importance?

In principle, these two instruments represent a choice between using the price (taxes) or the quantity (emissions trading) as the primary target. If taxes are used, the "price" is essentially fixed, while the market determines actual quantity. If an emissions trading system is used, the quantity will be fixed and the market determines the price. In a deterministic world, regulation based on either prices (e.g. taxes) or quantities (e.g. tradable permits) can yield the economically efficient outcome. The theoretical properties of tradable permits and environmental taxes are to a large extent similar. But in the non-deterministic real world, the differences may be striking. With a quantity limit, the primarily responsibility for finding the right price is handled by the market and not by the government. With a tax system, the government must find the appropriate tax rate and also adjust the taxes for inflation and other changes.

In a tax system, the resource rents are also channelled to the government, while with a tradable permit system they are often retained by the resource users. The latter, however, depends on how the permits are allocated (grandfathering, auctions). Work examining the distortions caused by the existing tax system show that the ability to recycle the revenues could enhance the cost-effectiveness of the system. That would point in the direction of taxes or auctioned permits. On the other hand, grandfathering may increase the feasibility of implementation.

[25] The same will also hold for emissions trading if the allowances initially are allocated through auctions.

In a world of uncertainty, the similarities between taxes and tradable permits may vanish.[26] From a theoretical point of view, the optimal choice generally depends on the degree of uncertainty and the correlation between the marginal damage and the marginal abatement costs (MAC).[27] With uncertainty about costs, the different policies may lead to different outcomes. Taxes are preferable if the environmental damage is flat relative to the marginal abatement cost curve[28] and the lack of a clear, short-term threshold for severe climate changes also favours the use of taxes.[29] A steep marginal damage curve instead favours the quantity approach, since this implies a threshold that should be avoided. Many claim that the marginal benefit curve for emission reductions is relatively flat,[30] which then would favour the use of taxes. This may very well be true looking at the problem from a national perspective.

Taking a global perspective there are, however, thresholds that should not be exceeded. The possibility of a catastrophic development, which cannot be ruled out in this case, speaks clearly in favour of using a quantity-based instrument.[31] The possibility of banking also strengthens the arguments for quantity policies, since banking across a period makes these more flexible and efficient. With full banking and borrowing across all periods, quantity control will behave much like a price control mechanism and quantities rather than marginal costs will fluctuate between years.

One possibility that has been discussed is the possibility of using a safety valve, i.e. a mixed regime.[32] By putting a cap on permit prices, risk-averse firms and households can more easily be convinced and the potential welfare losses from over- or under-estimates of marginal abatement costs can be reduced.[33] In practice, the possibility of banking seems to be more important than a safety valve, especially since, on a global basis, we need to make the necessary long-term reductions.

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[26] In theory, state-contingent policies could achieve this even under uncertainty but are probably of limited practical use.

[27] Weitzman (1974). Climate change is related to the stock of greenhouse gases and the flow (yearly emissions). Weitzman (1974) looked at the problem from a static point of view, but costs and benefits are not only a function of current output. Newell and Pizer (2003) studied the optimal regulation of stock externalities under uncertainty. Like Weitzman (1974) they found that flatter marginal damage and steeper marginal cost curves favour price instruments, and applied to the problem of GHG policy they found that the use of price instruments dominates the use of quantity instruments.

[28] Weitzman (1974), Hoel and Karp (1998)

[29] Hoel (1998) and Pizer (1997)

[30] Nordhaus (1994), Kolstad (1996), and Pizer (2002)

[31] Pizer (2003) studied the effect on the optimal policy choice with the possibility of such a catastrophic development. As expected the results suggest that quantity instruments may be preferable. The *relative* improvements in using quantity instruments rather than price instruments are, however, not very large. At most, the best-possible permit policy never improved the best-possible tax policy by more than 10%. However, in *absolute terms* the improvement can be huge. This is explained by the fact that a quantity approach can limit emissions below the threshold, which can never be guaranteed with a price control instrument. One important explanation as to why the *relative* improvement is small is simply that in the case of "catastrophic" damage, any corrective measure will dramatically improve economic welfare. Even a less efficient policy will thus generate huge welfare gains. This means that even if the difference in absolute terms is huge, the relative difference may be small.

[32] Smith (1999)

[33] Roberts and Spence (1976)

3.3 Climate change – an international problem demanding international solutions

There are strong arguments from the perspective of political feasibility, global cost-efficiency and the certainty of reaching the necessary reductions for using emissions trading on a global basis. Some arguments are in favour of using taxes as an economic instrument to create incentives for carbon dioxide emission reductions. These arguments are, however, most valid in a national context. Climate change is not a national problem, and the solution cannot be national. Both the efficiency and the political feasibility of different systems in a global perspective must be taken into account.

For instance, within the European Union tax policy is primarily a national issue. Discussions about common (minimum) tax levels have been going on for a long time but the results have, for better or worse, been very limited. Implementing a common carbon tax would in this perspective probably have been much more problematic than implementing a common emissions trading scheme. In a global context, it seems even more unlikely that a global carbon tax scheme can be implemented. The use of emissions trading provides a possibility to achieve cost-effective emission reductions at an international level. Even if the formal reduction requirements differ between countries, trading can ensure that these reductions are made at the lowest possible cost.

Curbing greenhouse gas emissions seems to be particularly well suited for emissions trading.[34] 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 more. 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.

[34] This is, for instance, suggested by Ellerman, Joskow and Harrison (2003).

3.4 Experience from the European Emissions Trading Scheme

Overview of the European Emissions Trading Scheme:

Time range: Reduction goals set for the period 2008-2012 in comparison to emissions in the base year (mostly 1990, some exceptions, e.g. Poland: base year 1988); still no goals set after 2012. Two trading periods: 2005-2007 and 2008-2012

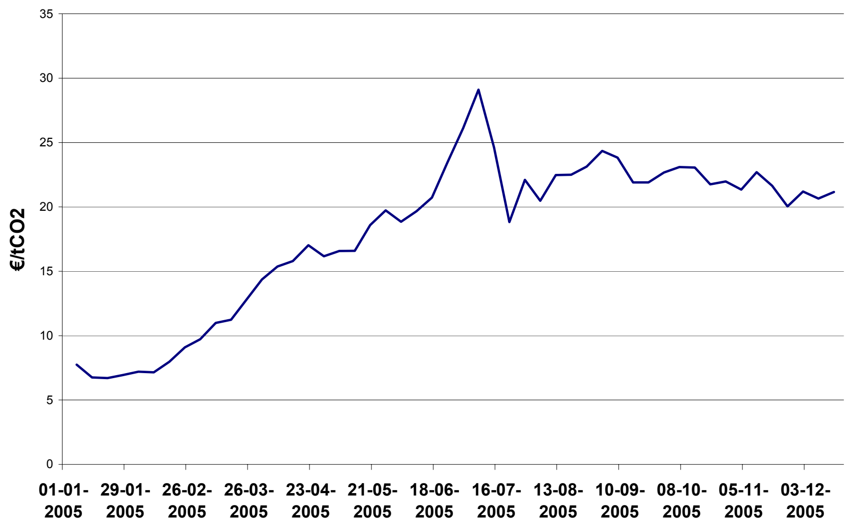
Quantitative goals: For EU-15: -8% for all greenhouse gases, burden sharing defines different national goals to fulfil this goal, for new EU member states -8% (exceptions Poland and Hungary: -6%)

Short description in bullet points:

- All 25 EU members take part. Moreover it is foreseen that Romania and Bulgaria will take part in the second period (EU-27).
- The most liquid product is the EU allowance (EUA). Other products will be CDM emissions certificates (CER) and JI emission certificates (ERU). Separate markets are not foreseen, but because of the rising number of projects and funds it will be possible to sell and buy CER and ERU. Differences in price will be due to differences in risk profiles
- One of several tools to fulfil the Kyoto commitments
- Covers CO_2 emissions of certain industry branches (steel, pulp and paper, cement, refineries) and the energy sector, opt-in of other greenhouse gases and sectors possible but still not applied
- Each member state is free to decide how to divide the national reduction goal between the sectors, especially how many allowances should be allocated initially (cap)
- There are only a few EU-rules for allocation, member states are free to use grandfathering, benchmarking, max 5-10 % auctioning, special rules for newcomers, replacements, CHP, early actions etc. in the National Allocation Plans (NAP); national allocation rules differ to a large extent from each other
- Most of the member states seem to have generous allocation rules for the first trading period 2005-2007, although there is still no overview of the total expected need. Analysts assume a shortage of 200 million tonnes for the first three years period (3 %)
- For the second period harder caps are expected in order to fulfil the reduction goals 2008-2012
- Better harmonisation of allocation rules for the second period not expected
- In Germany, the development of the next NAP (2008 – 2012) has started – the government intends to have a closure already in mid-2006.
- Currently (Sep 2005), two of the major CO_2 emitting countries (Poland and Italy) are still outside the system because they have not completed allocation. 15 countries still do not have a registry and are therefore not able to support spot market trading.
- Prices have been much higher than expected (between 20 to 30 EUR/t)

The emissions trading system that the EU introduced on 1 January 2005 utilises market forces.[35] It is the largest emissions trading scheme ever launched and there are many imperfections in the scheme. The price prognosis for the CO_2 allowances, before the system was introduced in January 2005, varied substantially from levels of €5/tonne carbon dioxide up to €20/tonne or more. Pre-trade, although very thin at the beginning, has been going on since early 2003. In the second half of 2004, prices seemed to have stabilised around a level of €8/tonne. In mid-January 2005, prices dropped below €7 for a short while, before starting to rise again. During the spring, prices rose fast and in July trades at prices above €30 were recorded. By the beginning of August prices fell below €20 before starting to rise a little again to levels around €23-24. Lately, prices have fallen slightly again. One clear conclusion can be drawn from this. There are huge uncertainties about the price level for CO_2 allowances. This was the case before the system was launched and is still the case.

Figure 17. Price for carbon dioxide emission allowances



Source: PointCarbon

There are many reasons for the price uncertainty. It is very difficult to assess how large the emission reduction needs to be. The number of allocated emissions is of course well known, but the real business-as-usual emission level is very uncertain. It is affected by factors such as economic development and the weather. Small errors (in relative terms) in the predictions of the business-as-usual levels can result in very large changes (still in relative terms) in the requirement for emission reductions. Better information will first become available when the official statistics on actual emissions during 2005 are published, which is expected in the second quarter of 2006. Better transparency and faster reporting and publication of emissions are likely to improve the functioning of the market.

The costs of emission reductions are not very well known either, which creates uncertainties about the supply. A very limited number of reduction measures are applicable due to the very short time period and the lack of banking possibilities into the next period. Furthermore, fuel price developments are important. Rising gas prices mean that fuel switching from coal to gas in the power sector needs

[35] A more extensive description of the European emissions trading scheme and the experience so far is to be found in Appendix C.

much higher prices of emission allowances to be profitable. During 2005, gas prices have risen much more than coal prices, since gas prices are often linked to oil prices through contractual arrangements. The difference in price trends between gas and coal has had a substantial effect on allowance price trends during 2005.

The prices of emission allowances have been much higher than expected beforehand. As a consequence, the price effects on electricity have also been greater than expected. This fact obviously has an effect on the competitiveness of those industries in Europe that use energy, especially electricity, as a vital input. Prices have also been very volatile, reflecting the high degree of uncertainty and the lack of transparent information to market participants. Improvement in the basic information provided to the market participants is very important to form a more stable market.

One additional important issue is that the allocations for future periods have not yet been determined. Uncertainties about whether emission reductions will now decrease future allocations may limit the willingness to reduce the emissions now and sell allowances. This is likely to provide an upward pressure on the prices of the emission allowances.

The development of the European emissions trading market

For the period 2005-2007, emission allowances for close to 6.6 billion tonnes of CO_2 have been allocated to about 11 400 facilities. Most of the allowances needed are allocated for free and the only compelling requirements for trading are the net imbalances.[36] It is thus likely that the total volume that will actually be put on the market will be much lower than these 6.6 billion tonnes, but at the same time the allowances can be traded many times.

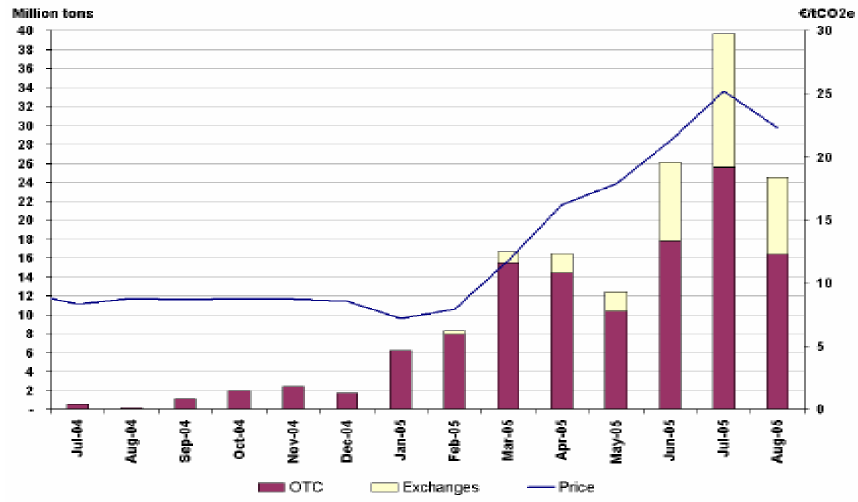
The European Emissions Trading Scheme is still at an early stage, and the market is still far from perfect. Many potential market participants have yet to enter into the market place. This is at least partly due to the fact that elements of the institutional set-up, such as the finalisation of the national allocation plans and national registers, have been delayed in some countries. Consequently, there are hurdles that hinder many players from entering the market.

Nevertheless, the market seems to have developed fairly well and a number of organised market places have been established, although the majority of the trade is still on the OTC market.[37] The traded volumes have grown steadily. In July, the total volume traded was close to 40 million tonnes, a figure that dropped to about 24 million tonnes in August which is probably mostly due to the summer holidays (see Figure 18).

[36]Any party can of course take positions in the market and trade much more than their net imbalance.

[37] Currently, emission allowances are traded on six different exchanges.

Figure 18. Trade in carbon dioxide emission allowances



Source: Total Gas & Power Monthly Brief, August 2005

It is extremely difficult to assess whether the amount of trade is large enough for the market to function well. Assuming an average trade of 30 million tonnes per month throughout the three-year period, the total volume traded would be about 1 billion tonnes, i.e. less than 1/6th of the allocated allowances. The traded volumes are limited in comparison with the total market but the market is functioning and the bid-ask spread is very small, which is usually taken as a sign of a well-functioning market.

3.5 Allocation of allowances in the European Emissions Trading Scheme

In the European Emissions Trading Scheme, most of the emission allowances are initially allocated for free to the emitters of carbon dioxide.[38] The allocation of allowances to individual installations is made at the national level. Each member state has submitted a National Allocation Plan (NAP) to the European Commission describing the principles and actual allocations made. These NAPs have then been reviewed by the Commission which has either approved the plan or requested changes. For several member states the Commission has requested either changes in the principles and/or a cut in the total level of allocated emission allowances. As of September 2005, not all NAPs have received final approval.

The emissions have previously been more or less a free good for the emitters. The free allocation of allowances can thus be seen as a way of keeping the established "property right" for emissions, and it also means that the emitters to a considerable extent are protected from large wealth losses. However, independent of the method for initial allocations, the emitters have incentives to reduce their emissions since reductions mean that they can sell their emission allowances on the market (or avoid buying). The opportunity costs of the emission allowances should be reflected in the individual company's production choices.[39] This means

[38] According to the EU emissions trading directive, at least 95 % of the allowances shall be allocated free of charge for the period 2005-2007 and at least 90 % for the period 2008-2012. The use of auctioning in the first period has been very limited.

[39] The opportunity cost is the cost of the resource in its best alternative use. For a player with emission allowances, the opportunity cost is the loss in revenue from not being able to sell the allowance if it is needed to cover emissions.

that the prices of the final output will be affected by emissions trading almost independently of the method of initial allocation. The buyers of the final output, e.g. electricity, will however not be compensated for the price increases.

Is this free allocation, or grandfathering the solution that will, or should, be chosen in the future? There are several other alternatives besides grandfathering based on historic emissions. One option is to use free allocation based on some benchmarking method. These benchmarks could either be product specific, i.e. the allocation depends on how much of the product is produced. For the electricity sector this could mean that the allocation will be granted in terms of g/kWh. As an alternative, the benchmark could be fuel-based, this means that a free allocation is given in terms of g/kWh produced depending on the fuel used. A final option is to use auctioning, i.e. to sell the allowances to the highest bidder. The different allocation methods are described and compared more in-depth in Appendix D.

Auctioning has the distinct advantage of being easy and transparent and of not creating perverse incentives. However, it also works as a CO_2-tax and may thus have considerable redistributional effects. It may also possibly affect the competitiveness mainly of heavy industries if this method is only used in one region, while competing regions use some form of free allocation. In the shorter perspective, there is also an issue of property rights. The emitters have historically had the right to emit for free and removing that right may run into legal difficulties. In the longer term, these difficulties will not be present and will certainly not apply to new installations. However, it is not self-evident that it is a good solution to use auctioning for new installations while using free allocations for older installations, since this will distort competition and may delay otherwise good investments.

Allocations using product-specific benchmarks are also likely to provide good incentives to reduce emissions. This method, as well as auctioning, means that climate protection clearly dominates other possible policy objectives. Product-specific benchmarks will, like auctioning, benefit the most environment-friendly technologies. They will, however, affect the fuel mix and may thus affect the security of supply if important European fuel sources such as lignite or coal are no longer used. Fuel-specific benchmarks will make it easier for politicians to influence the fuel mix, but the incentives to reduce emissions will be lower. Low-carbon fuels will not gain as large a cost advantage as with auctioning or product-based benchmarks. However, there will not be a negative impact for carbon capture and storage technologies.

3.6 Conclusions

Economic instruments provide the best means of achieving emission abatement at the lowest possible cost. International trade aspects are important; the instruments implemented should facilitate cooperation, exchange and global cost efficiency. In the real, non-deterministic world, systems based on tradable permits are judged superior to taxation. Strong arguments are political feasibility, global cost efficiency and the certainty of reaching the necessary reductions. Curbing greenhouse gas emissions seems to be particularly well suited for global trading. The locations of the emissions are unimportant and the opportunities for cost savings are substantial due to differing abatement costs.

The newly introduced European Emissions Trading Scheme has in its present form three fundamental weaknesses. First, it is very short sighted. The trading system only defines the period up to 2008 -12. Secondly, it is limited to the EU countries and will thus increase energy costs within EU-25. This is a major competitive disadvantage for industrial operations that use a lot of electricity, and there is a clear risk that European industry will relocate to other parts of the globe if the rest of the world declines to adopt reduction targets that add costs to fossil fuel users. If this happens, it is unlikely that EU's emissions trading system will survive. This would be an enormous setback. Thirdly, the present system covers less than 50 per cent of the total carbon dioxide emissions in EU-25. In the slightly longer term of course, all emissions must be included, especially those in the transport sector.

4 Implementation - What must be done?

We[40] have to *realize* that there is no such thing as a handful of simple short-term solutions; we have to *realize* that handling the issue on a global scale will take time. Economy, energy and environment are closely interlinked, so we have to *realize* that we are implementing a major shift in the world economy that will ultimately influence everything and everybody and that a long-term perspective must be applied stretching up to 100 years. Combating climate change must and will be a part of everyday life all over the globe. Climate change is a global issue that has to be handled at the global level; "solutions" and initiatives are needed for both local and global growth.

Regimes and structures for global governance are, unfortunately, in short supply. It is now high time to take action and shoulder responsibilities on this crucial issue. Even though climate change is a global problem, we all have a responsibility to do what we can to contribute to a solution.

At present, the situation regarding climate change, the future of UNFCCC[41], Post-Kyoto, US – EU relations, the role of the growing economies among the developing countries (e.g. China, India, Brazil, South Africa and Mexico) is fairly confused. We note that at the G8 meeting in Gleneagles in July 2005 the leaders of the largest economies clearly stated that the world faces "…serious and linked challenges in tackling climate change, promoting clean energy and achieving sustainable development globally." No solution is possible if not the entire, or at least most of, the world economy is included, the Gleneagles statement can serve as a platform for a renewed global dialogue.

In this report, an adaptive burden-sharing model is suggested. It is based on the assumption than 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.

We must do all we can to set the correct price on emissions and the pricing must be as global as possible. The only possible way to do this is to make use of market forces, i.e. a global system for emissions trading must develop. Pricing will create the financial resources needed. If emissions are priced properly and the price formation process is trustworthy, i.e. it mirrors market fundamentals, it will be much easier to motivate as well as finance what each single player out there can do. The price has to be global. Otherwise, we will see a lot of second-best solutions and the comparative advantages will not be exploited. Market forces are driving the globalisation process and are some of the most powerful tools that we have. Used in the right way, they will help to minimise the consumption of

[40] Humanity

[41] The United Nations Framework Convention on Climate Change

resources and provide the best distribution of labour around the globe. An important prerequisite for such a positive development is that there is a global framework of regulations.

Emissions trading in Europe as it is conducted today is limited in many respects. Getting a majority of the world to participate in an emissions trading system is therefore vital. The disputes surrounding the Kyoto Protocol must become a thing of the past. Prestige must be laid aside. The USA and the EU have a responsibility, as the regions that release most emissions of carbon dioxide, to show joint leadership. What we need here is a reasonable and generous compromise between the developing countries' demand for fair development conditions and the industrialised countries' demand that competition throughout the world must not be distorted. It is much more important to get everyone to take part than to focus on short-term emission limits.

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. Costs will be limited by the technology available for reducing emissions to the desired level. Greater investments in research and development will accelerate technological development[42]. This is obviously a joint responsibility on the part of the political and industrial spheres. We must be open to the use of all available technology in this process. The most important technological development of the next few decades will probably be to achieve sequestration, i.e. to separate and store the carbon dioxide produced in connection with the combustion of fossil fuels.[43] Nuclear power, present and future, will also be a part of the solution. Of course, all the various forms of renewable energy must be used. The transport sector will gradually complete the transition to emission-free engines, probably via hybrid vehicles to fuel cells that use various fuels. Efficiency levels will be up as a consequence of clear market signals.

The introduction of a global regulatory framework will open up many business opportunities. This will stimulate the formation of new industries with new workplaces. It will be possible to exploit the market system to the advantage of the environment. The costs of solving the problem will have only a marginal effect on total global growth if price signals and markets are employed in a wise way. Even more important, given that we have a real and serious problem to solve, not taking action will add costs. Being forced into managing recurring crises will definitely be more costly than introducing effective market-based incentives in due time.

Curbing climate change is about combining technology, finance and policy in a wise way. If that is done by the international community, a worldwide carbon dioxide market will follow.

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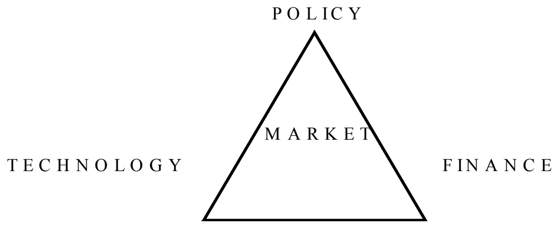
[42] Different technology options, "established" emerging and future, are described in Appendix E.

[43] The option to capture and store carbon dioxide is described in more depth in Appendix F.

Figure 19. A global carbon dioxide market



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, they have to, otherwise humanity will not be able to curb climate change.

The climate change issue has been compared with the issue of free trade. Free trade has developed gradually since the end of the second world war and has still not reached a state of full openness. The same goes for the climate change issue: we are still in the initial stages of dealing with a major problem to which solutions will be developed gradually over the next few decades. We can easily identify threats, but we can also see opportunities, and without being over-optimistic, surely we will see most of the latter given that wise political decisions are made.

An issue of outstanding importance is the future role of the international business community. 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, it 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. Business and industry can contribute important experience and know-how. Handling climate change purely or mainly in terms of "red tape" will be extremely expensive – high costs and poor results are to be expected. Today, the climate change issue is driven by politicians, public officials and NGOs that are trying to pull business into a low-emissions future. Looking forward, leading representatives of business and industry have to show leadership and instead of being pulled by society business leaders should be pushing and in a positive way integrate climate issues into the world of markets and trade on a global scale.[44]

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. All company executives,

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[44] A group of 24 company representatives, mainly chief executives, signed and handed over a statement on climate change to Prime Minister Blair in June 2005 (a part of the G8 preparation process). It is concluded that the companies involved are firmly committed to doing their part on climate change and that a coordinated and vigorous response from the G8 governments along the lines suggested is needed. The statement is to be found in Appendix G.

but primarily those on either side of the Atlantic, must commit themselves to working for a global emissions trading system. Industry should unite to facilitate joint political leadership, first of all from Europe and the USA, on this issue.

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Appendix A. Eight Questions and Answers on Climate Change and the Greenhouse Effect

1. Is Climate Change for real?

The “climate change issue” is not one but two issues:

a) Is there a climate change?

- Today, the absolute majority of scientists answer yes to this question.
- In the European Commission strategy “Winning the Battle against Global Change” it is stated: “Climate change is happening. Over the 20th century, the global average temperature has risen by about 0.6 °C, and the mean temperature in Europe has increased by more than 0.9 °C. Globally, the 10 warmest years on record all occurred after 1991.”
- This does not mean that 100 % of the scientists now support climate change as an absolute fact. There are, for example, those who say that there are short-term variations in the climate and that this has always been the case. But, they claim, this cannot be characterised as a climate change but rather as a natural part of the climate.
- In the third assessment report by the IPCC (the UN Intergovernmental Panel on Climate Change www.ipcc.ch) in 2001, a figure shows the temperature over the last 1000 years, the so-called “hockey stick”. It shows that the temperature has been more or less stable during this period until 100 years ago, when the temperature started rising. The “hockey stick” has been used as a key piece of supporting evidence which issues a strong warning to policymakers of the urgency for action on reducing greenhouse emissions. However, this is called into question by some scientists who claim that errors have been made when calculating the curve and that correct calculations show that the temperature has varied significantly during the last 1000 years and hence that the present temperature rise could fit into a pattern of natural variations. This discussion is presently ongoing and it is very difficult, or more correctly, impossible, to assess this scientific debate for non-experts.

b) if so, is it “natural” or caused by man?

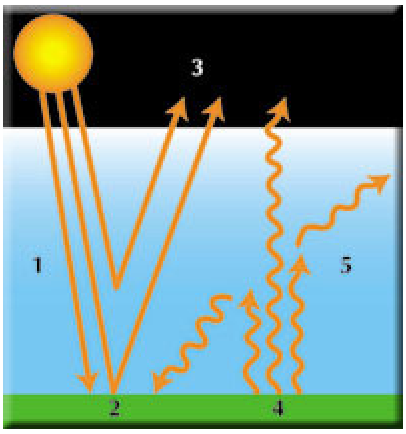
- In the European Commission strategy it is stated: “The overwhelming scientific consensus is that the cause is emissions of greenhouse gases from human activity.”
- There are, however, scientists who express their doubts on the scientific underpinning of, for example, IPCC’s conclusions. Some of these scientists claim that the scientific issue is politicized and that points of view not in line with those of the IPCC are regarded as politically incorrect and suppressed. (These scientists are sometimes labelled “dissidents”).

- Some of these “dissidents” present alternative explanations for the increased temperature, as for example some Danish scientists who claim that variations in solar activity can explain the present temperature increase (or at least part of it).

To summarize: There is more or less a consensus concerning an on-going climate change. There is also strong – but not total – support for man-made emissions as a main cause.

2. The greenhouse effect, how does it work?

A simplified explanation of the greenhouse effect is as follows (see the diagram).



1. Solar radiation passes through the clear atmosphere.
2. Most radiation is absorbed by the Earth's surface and warms it.
3. Some solar radiation is reflected by the Earth and the atmosphere.
4. Infrared radiation is emitted from the Earth's surface.
5. Some of the infrared radiation is absorbed and re-emitted by the greenhouse gases.

- Shortwave solar radiation can pass through the clear atmosphere relatively unimpeded, but long wave infrared radiation emitted by the warm surface of the Earth is absorbed partially and then re-emitted by a number of trace gases - particularly water vapour and carbon dioxide in the cooler atmosphere above. Because, on average, the outgoing infrared radiation balances the incoming solar radiation, both the atmosphere and the surface will be warmer than they would be without the greenhouse gases.
- One should distinguish between the “natural” and a possible “enhanced” greenhouse effect.
- The natural greenhouse effect causes the mean temperature of the Earth’s surface to be about 33°C warmer than it would be if natural greenhouse gases were not present. This is fortunate, for the natural greenhouse effect creates a climate in which life can thrive and humankind can live under relatively benign conditions. Otherwise, the Earth would be a very frigid and inhospitable place.
- On the other hand, an enhanced greenhouse effect refers to the possible raising of the mean temperature of the Earth’s surface above that occurring due to the natural greenhouse effect because of an increase in the concentrations of greenhouse gases due to human activities. Such a global warming would probably bring other, sometimes deleterious, changes in climate; for example, changes in precipitation, storm patterns, and the level of the oceans. The word “enhanced” is usually omitted, but it should not be forgotten in discussions of the greenhouse effect.

3. Are there alternative explanations?

In the IPCC Working Group 1 report "The Scientific Basis" it is stated:

"The possibility of a confounding explanation can never be ruled out completely, but as successive alternatives are tested and found to be inadequate, it can be seen to become progressively more unlikely."

Nevertheless, there are alternative explanations. Here is a list presented by Douglas Hoyt, a solar physicist and climatologist who worked for more than thirty years as a research scientist in the field, in the article "Alternative explanations for the recent warming" (http://www.warwickhughes.com/hoyt/climate-change.htm):

1. The sun may have warmed over the last 25 years and caused most if not all the warming as discussed.

2. The albedo (reflection properties) of the Earth has decreased (the planet is getting darker and absorbing more radiation). This will warm the planet.

3. Contrails ("global dimming") have increased in recent years and will lead to a warming on a regional and perhaps a global scale.

4. Fossil fuel combustion releases heat directly to the atmosphere and will cause a warming over the continents.

5. Urban heat islands are substantial (several degrees Celsius in many cases and larger than the predicted anthropogenic greenhouse gases warming). Placing thermometers near cities and downwind of cities may lead to a warming that is falsely attributed to greenhouse gases. Further support that urban heat islands represent half of the reported warming in the twentieth century (0.3 ˚C out of 0.6 ˚C) is provided by examining the changes in the diurnal temperature range.

6. Other explanations for the recent warming include:

- Decrease in explosive volcanic eruptions in recent years.
- Increased intensity of El Nino in the last few years.
- More carbon aerosols (soot) in the atmosphere.
- Soot on snow.
- Decreased stratospheric ozone.
- Internal changes in circulation such as the Pacific Decadal Oscillation (PDO), North Atlantic Oscillation (NAO), and Arctic Oscillation (AO).

This boils down to the following: According to the surface measurements, the climate has warmed by about 0.18 ˚C/decade since 1979. Most scientists attribute all this warming to anthropogenic greenhouse gases, but alternative explanations exist.

4. What is acceptable? How much time is “available”?

Today, the concentration of carbon dioxide in the atmosphere is about 380 ppm and increases every year by 3 ppm.

In the current debate, a 550 ppm scenario is regarded as a very ambitious but, at least theoretically, reachable target for future climate change policy. The 550 ppm scenario is associated with an estimated increase in worldwide average temperature of about 2.5-3.0 degrees. It should be noted that the uncertainties relating to these figures are significant and also that the temperature rise in the northern hemispheres is expected to be over-proportional.

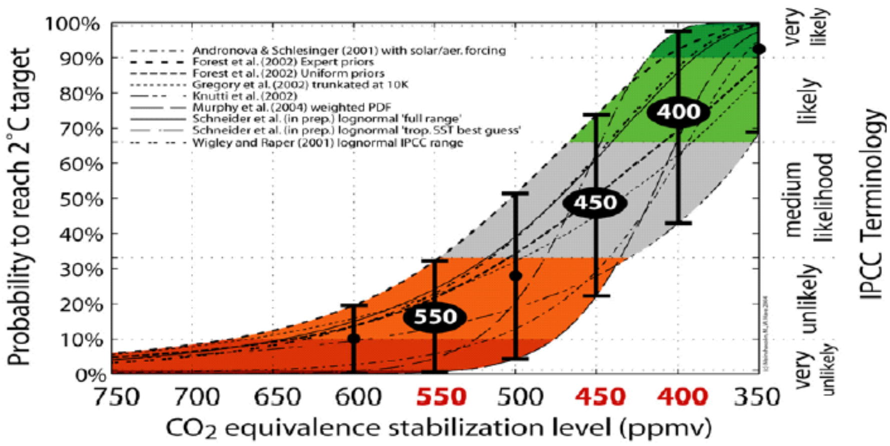
To stabilise the CO2-concentration at 550 ppm, the actual emissions of about 25 billion tonnes of CO2 per year must be limited to 30 billion tonnes in 2050 and thereafter gradually decrease to a maximum level of 10 billion tonnes per year (less than half of 1990 emissions). Because of the long time lag, the maximum concentration will not be reached until somewhere between 2100 and 2150. If, for a longer period, no serious measures to reduce emissions are taken, the later reduction path will have to entail a sharper decrease and will result in higher macroeconomic costs. To achieve the necessary emission path, the world community has to reduce its anthropogenic emissions compared to BAU scenarios drastically. The industrialized world has to accept the economic growth of the developing countries and has to give them scope for higher emissions. This means that the industrialised countries must reduce their CO2 emissions by more than 60-80% by 2050.

Sources:

- DIW-Wochenbericht 12/13 2005. pages 217-221
- http://unfccc.int/cop9/se/present/jenkins.pdf;
- http://www.climate.unibe.ch/~joos/images/ipcc95/

It should be mentioned that some voices are demanding a 450 ppm scenario in order to increase the probability of not exceeding the maximum temperature increase of 2.0 degrees that is the EU’s target. The following figure taken from the Commission Staff Working Paper “Winning the battle against climate change” [9.2.2005] shows the relation between the CO2 equivalence stabilization level expressed in parts per million by volume, ppmv, and the probability of reaching the 2°C temperature target:

Figure 4: The probability of reaching the 2°C target



Source: B. Hare and M. Meinshausen[7]

5. What options are "available"?

The options to combat climate change are:

- Reduction of emissions.
- Halting deforestation.
- Increase of up-take through re-forestation.
- Adaptation to increased temperature.

The first alternative, reduction of emissions, has totally dominated the debate in the industrial countries, although adaptation has also become a central theme recently. A number of studies have been carried out concerning the costs and potential for measures to reduce emissions of CO2. The results are normally presented as "abatement cost curves". Although these types of studies come to somewhat different results in terms of potentials and costs, the principal characteristics are the same. There is a certain amount of low-cost (or even negative cost) and medium-cost measures. However, above this level, the cost increases.

The main conclusions from this are: Below a certain reduction level (a "guesstimate": up to around 10 %) the costs for measures in different parts of society can be estimated fairly well. However, when it comes to more drastic cuts, it is difficult to estimate the costs because this involves much more fundamental changes in society.

The main reduction options

Within the EU Emissions Trading Scheme, fuel switching from coal to natural gas in electricity generation has been regarded as a fairly "cheap" measure that offers great potential for emission reduction. Another group of measures that offer low costs and great potential relate to increasing the efficiency of the energy systems of the new EU member states. Wind power – in attractive locations – and biomass for heat production also have relatively low costs. However, in terms of the fuel switch from coal to natural gas it must be emphasised that in the real world only a limited amount of the potential can be realized in the short term. The reason is that it is unclear whether the necessary amounts of natural gas can be supplied and at what price. Another reason is the risk of insufficient security of supply.

Outside the present trading system, the biggest potential is probably transportation. More efficient motor cars are in principle not just low cost measures, many of them are profitable as such. Increased energy efficiency, or simply lower consumption, in households and industry also represents an interesting category of measures.

When considering available options it is also important to distinguish between short-term and long-term potentials. Within the present EU Emissions Trading Scheme, only a limited amount of, for example, fuel switching can be realised due to the uncertainty regarding the future emissions trading system. In principle, only measures that pay off during the first trading period can be implemented. Thereby the total potential for reductions is reduced, probably drastically, causing uncertainty about what the future price of emission rights might be.

In a longer perspective, carbon capture and storage (see Appendix F) has a considerable potential.

6. What about the other five greenhouse gases?

Data and facts:

The main anthropogenic GHG is carbon dioxide, followed by methane and nitrous oxide. More limited effects but major global warming potential stems from other gases, especially from sulphur hexafluoride (SF6), which is also used in electricity installations (http://www.oekorecherche.de/deutsch/berichte/zusammenfassungen/zuHFKW.html)

Anthropogenic Greenhouse gases	Formula	Contribution to global warming	Global warming potential (CO2eq)	Lifetime in atmosphere (years)
carbon dioxide	CO_2	60%	1	50-200
methane	CH_4	20%	21	12
nitrous oxide	N_2O	6%	310	300
hydrofluorocarbons	HFCs	5%	140 – 11.700	1.5 - 264
perfluorocarbons	PFCs		6.500 – 9.200	3 200 – 50 000
sulphur hexafluoride	SF_6	<1%	23.900	3 200

Greenhouse gases	Sources
carbon dioxide	fossil fuels, erosion, deforestation
methane	rice cultivation, cattle breeding, landfills
nitrous oxide	fossil fuels, fertilizer
hydrofluorocarbons	aerosol propellants, cooling medium
perfluorocarbons	
sulphur hexafluoride	Medium and high voltage installations, windows, tyres

http://www.bayern.de/lfu/umwberat/data/klima/treibhaus_2004.pdf

The energy industry accounts for about 50% of GHG emissions, the chemical industry for about 20%, agriculture and deforestation each for about 15%.

Contribution of GHG gases:

The contribution of measures to reduce GHG depends on the marginal abatement costs and the additional emission of GHG due to economic growth. Marginal abatement cost curves have been estimated by different scientific organisations, but vary widely. Based on estimations carried out in the Emissions Prediction and Policy Analysis in 2000 by Massachusetts Institute of Technology, worldwide CO_2-reduction of 4.5 billion tonnes compared to BAU can be carried out in 2010 with an abatement cost up to 10 US$/tonne CO2. The major reduction potential is to be found outside the EU. Given the same conditions, other GHG could contribute with around than 900 million tonnes.

Note: The contribution of natural gases to the natural greenhouse effect is as follows:

H_2O (steam)	*62 %*
CO_2 (carbon dioxide)	*22 %*
O_3 (Ozone)	*7 %*
N_2O (sodium dioxide)	*4 %*
CH_4 (methane)	*2.5 %*
Other	*2.5 %*

The natural greenhouse gas effect results in a surface temperature that is 33 degrees higher than it would be without this effect. The effect of anthropogenic greenhouse gases is estimated to be 0.6 degrees or 1.8 %.

7. To what extent do different sectors in society contribute to the GHG emissions?

Within the EU-25, the CO2 emissions in different sectors depend on the industrial structure and on the fossil-based energy consumption of each member state. Within Europe, the energy sector is the largest emitter with more than 1/3 of the emissions, followed by the fast-growing transport sector with about 1/4. The industrial and the construction sector, which now accounts for 1/6 of the emissions, has been the fastest decreasing sector in recent years.

The EU-ETS covers about 50% of the CO2 emissions of the EU-25.

Within the EU-ETS, the energy sector is probably the sector with the cheapest and greatest abatement potentials. A big potential outside the EU-ETS is seen in the heating sector, i.e. with energy-efficient buildings.

Structure and changes of CO_2-emissions in EU-25 from 1990 to 2002, sector wise.

Tabelle 5

Struktur und Veränderungen der CO_2-Emissionen in der EU-25[1] von 1990 bis 2002 nach Sektoren

	Energiebedingte Emissionen					Industrieprozesse	Übrige Bereiche[3]	CO_2-Emissionen insgesamt[4]	*Nachrichtlich:* Energie und Industrie[5]
	Insgesamt	davon:							
		Energieindustrie	Industrie und Baugewerbe	Verkehr	Andere Sektoren[2]				
Sektorstruktur im Jahre 2002 in %									
Belgien	91,1	20,9	26,8	19,7	23,6	7,8	1,1	100,0	55,6
Dänemark	96,8	49,0	10,3	22,7	14,9	2,9	0,2	100,0	62,2
Deutschland	97,4	41,3	15,3	20,4	20,4	2,6	0,0	100,0	59,2
Finnland	94,6	41,6	19,0	18,4	15,5	1,4	4,0	100,0	62,1
Frankreich	94,7	14,6	20,0	35,0	25,1	4,5	0,8	100,0	39,2
Griechenland	92,7	52,2	9,6	19,2	11,6	7,1	0,1	100,0	69,0
Großbritannien	98,0	36,1	15,6	22,9	23,4	1,9	0,1	100,0	53,7
Irland	93,2	35,4	10,7	24,5	22,6	6,6	0,2	100,0	52,6
Italien	94,5	32,7	18,1	26,6	17,1	5,2	0,3	100,0	56,0
Luxemburg	92,2	2,6	22,9	53,1	13,6	7,7	0,1	100,0	33,2
Niederlande	98,9	36,1	20,3	20,5	22,0	1,1	0,0	100,0	57,5
Österreich	89,0	21,5	17,9	29,6	19,9	10,7	0,3	100,0	50,2
Portugal	91,6	36,7	14,8	29,4	10,7	7,4	1,0	100,0	58,9
Schweden	92,3	22,5	19,0	36,6	14,3	7,4	0,3	100,0	48,8
Spanien	93,1	34,8	19,0	28,1	11,2	6,5	0,5	100,0	60,2
EU-15	95,5	33,9	17,2	24,9	19,5	4,1	0,4	100,0	55,2
Estland[6]	97,9	81,5	3,4	11,2	1,8	2,1	0,0	100,0	87,0
Lettland[6]	96,3	35,1	11,8	35,5	14,0	2,3	1,4	100,0	49,1
Litauen[6]	91,7	45,3	8,8	28,6	8,9	8,3	0,0	100,0	62,5
Polen[6]	96,7	56,0	14,8	9,5	16,4	3,3	0,0	100,0	74,1
Slowakei	91,5	78,3	0,0	13,2	0,0	8,2	0,3	100,0	86,5
Slowenien[6]	94,6	38,3	14,5	23,2	18,6	5,2	0,2	100,0	57,9
Tschechien[6]	95,9	46,5	27,2	9,4	12,8	3,5	0,5	100,0	77,3
Ungarn	100,0	36,1	18,6	17,0	28,4	0,0	0,0	100,0	54,6
Summe Beitrittsstaaten[1]	96,3	53,5	16,3	11,5	15,0	3,5	0,2	100,0	73,3
EU-25[1]	95,6	36,8	17,1	22,9	18,9	4,0	0,3	100,0	57,9

Source: DIW-Wochenbericht Nr. 37/2004 page 531 to 533.

8. To what extent do different countries & continents contribute?

The worldwide efforts to combat global warming seem to be missing their targets. The OECD countries (including the USA and Australia) increased their GHG – emission levels in 2002 compared to 1990 by about 8% in relation to a Kyoto target of about – 7%. Moreover, the EU-15 has reduced its GHG emissions by only 3% but has to reduce them by a further 5% by 2008/12. All the countries with Kyoto targets (Annex-B countries) can probably reach their target (-5.3%) by using the total amount of hot air from transition countries and Russia. A participating USA with a steadily growing energy demand and emissions would cover all the hot air already in the fist commitment period. Source: DIW-Wochenbericht No. 37/2004 page 525.

Statistics for developing countries are less reliable, especially for China, and only available for CO2. Nevertheless, the developing countries China and India increased their CO_2 emissions from 1990 to 2003 by 63% and 84% respectively. China has become the second biggest CO2 emitter (3.7 billion tonnes/14% of worldwide CO2 emissions) after the USA (5.7/22%) and ahead of the EU-15 (3.3/ 13%). Source: DIW-Wochenbericht No. 37/2004 page 526.

Almost all prognoses predict increasing CO2 emissions in BAU Scenarios in all regions of the world, but the highest increase with a considerable basis is seen in Asia.

CO2 emissions in a BAU Scenario until 2020

COUNTRY/REGION		BAU Emissions ($MtCO_2$ eq)				Average Annual Change (%)		
		1990	**2000**	**2010**	**2020**	**1990-00**	**2000-10**	**2010-20**
EUROPE	**EU25**	4,243	3,931	4,301	4,632	-0.8%	0.9%	0.7%
	EU15	*3,332*	*3,329*	*3,621*	*3,904*	*0.0%*	*0.8%*	*0.8%*
	EU16-25	*912*	*602*	*680*	*728*	*-4.1%*	*1.2%*	*0.7%*
	Other Western Europe	81	87	97	104	0.7%	1.1%	0.7%
	EU Candidates	321	171	208	224	-6.1%	2.0%	0.7%
	Russia	2,372	1,513	1,855	2,097	-4.4%	2.1%	1.2%
	Ukraine	704	298	362	390	-8.2%	2.0%	0.7%
	Other Eastern Europe	409	325	375	402	-2.3%	1.5%	0.7%
OTHER ANNEX B	**Australia**	278	347	380	395	2.2%	0.9%	0.4%
	Japan	1,122	1,239	1,357	1,411	1.0%	0.9%	0.4%
	New Zealand	25	31	34	35	2.0%	0.9%	0.4%
	Canada	472	577	639	716	2.0%	1.0%	1.2%
	US	5,004	5,883	6,517	7,307	1.6%	1.0%	1.2%
DEVELOPED WORLD		**15,032**	**14,401**	**16,124**	**17,713**	**-0.4%**	**1.1%**	**0.9%**
ASIA	**China**	2,290	3,052	4,155	5,393	2.9%	3.1%	2.6%
	India	583	937	1,279	1,726	4.9%	3.2%	3.0%
	Rest of South & East Asia	906	1,695	2,399	3,243	6.5%	3.5%	3.1%
	Central Asia	492	312	379	408	-4.5%	2.0%	0.7%
REST OF WORLD	**Middle East**	576	978	1,256	1,557	5.4%	2.5%	2.2%
	Latin America	889	1,237	1,645	2,159	3.4%	2.9%	2.8%
	Africa	541	676	931	1,309	2.2%	3.3%	3.5%
DEVELOPING WORLD		**6,278**	**8,887**	**12,044**	**15,795**	**3.5%**	**3.1%**	**2.7%**
TOTAL		**21,309**	**23,287**	**28,168**	**33,509**	**0.9%**	**1.9%**	**1.8%**

Source: Eurelectric GETS 4-project

Within the EU-15, most countries seem to be unable to fulfil their burden sharing commitments, only Sweden, France, Britain and Germany are on the right path. Because of the hot air of the new member states the EU-25 still has a reserve of 71 million tonnes compared to the 2012 target. However, economic growth in the new member states may evaporate this reserve in the medium-term. Source: DIW-Wochenbericht No. 37/2004 page 527 and following pages.

Appendix B: Annex I countries

Annex I countries are the 36 industrialised countries and economies in transition listed in Annex I of the United Nations Framework Convention on Climate Change (UNFCCC or the Convention). Their responsibilities under the Convention are various, and include a non-binding commitment to reducing their greenhouse gas emissions to 1990 levels by the year 2000.

Annex B countries are the 39 emissions-capped industrialised countries and economies in transition listed in Annex B of the Kyoto Protocol. Legally-binding emission reduction obligations for Annex B countries range from an 8% decrease (e.g. various European nations) to a 10% increase (Iceland) in relation to 1990 levels during the first commitment period from 2008 to 2012. Note that Belorussia and Turkey are listed in Annex I but not Annex B; and that Croatia, Liechtenstein, Monaco and Slovenia are listed in Annex B but not Annex I.

In practice, Annex I of the Convention and Annex B of the Kyoto Protocol are used almost interchangeably. However, strictly speaking, it is the Annex I countries which can invest in Joint Implementation (JI) / Clean Development Mechanism (CDM) projects as well as host JI projects, and non-Annex I countries which can host CDM projects. This is true despite the fact that it is the Annex B countries that are subject to emission reduction obligations under the Kyoto Protocol.

Source: http://www.co2e.com

Complete list of Annex I countries:

Australia, Austria, Belorussia, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Economic Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America.

Appendix C: EU ETS Description and Experience

Political background to Kyoto Protocol

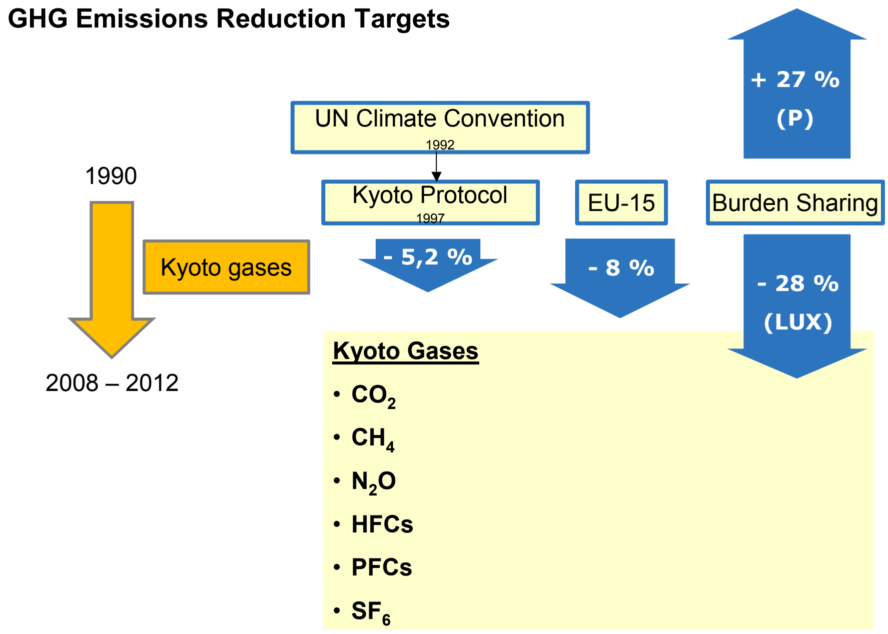
1992 United Nations Framework Convention on Climate Change UNFCCC – agreement to combat human-induced climate change
1997: Kyoto Protocol: Targets and timelines for industrialised countries.
2001: USA withdraws from ratifying the Kyoto Protocol
2001: The Marrakesh accord outlines procedures for making the Kyoto Protocol operational
2002: The European Union and all member states ratified the Kyoto Protocol
2004: Russia ratified the Kyoto Protocol triggering it to enter into force
2005: The Kyoto Protocol formally entered into force

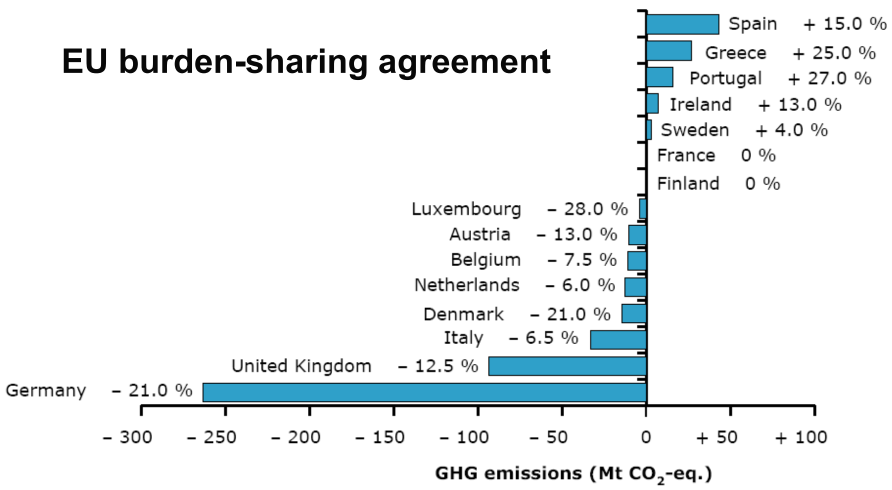
The so-called flexibility mechanisms can be used from 2008 (Emissions Trading, Joint Implementation and Clean Development Mechanisms).

A Conference of Parties (COP) is held every year. At COP 10 held in Buenos Aires in December 2004 as well as at COP 11[45] held in Montreal in December 2005, many observers hoped that the discussion about the situation post-2012 would begin. The main issue in this debate is the inclusion of the USA. However, without targets for the main developing countries China and India, the USA is not willing to join the process and, conversely, the developing countries will not accept any targets without the USA joining.

In the Protocol, the industrial countries have committed themselves to decreasing greenhouse gas emissions by 5.2 % between 1990 and the Kyoto period 2008-2012. The EU 15 took over an obligation of an 8 % reduction. The EU member states have signed a burden-sharing agreement which fixes the emission caps of every country of the EU 15. The 10 new EU Member States have also signed the Kyoto Protocol with national reduction goals (8%, exceptions: Poland and Hungary: 6%).

[45] The first Meeting of the Parties to the Kyoto Protocol (MOP) was held at the same occasion.



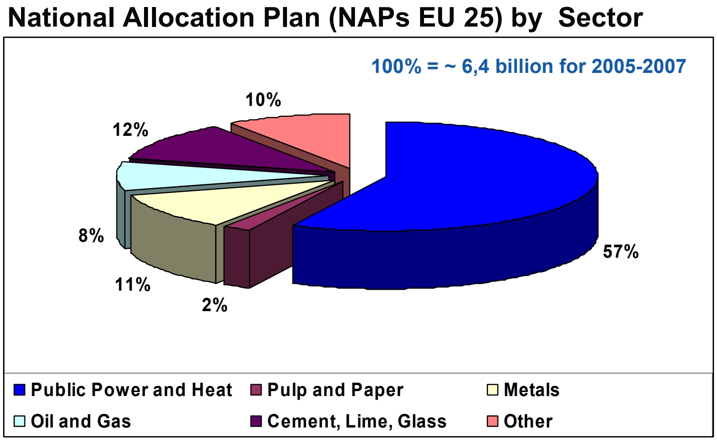


EU Emissions Trading Scheme (EU ETS) – Political Background

One of the tools for reducing greenhouse gas (GHG) emissions in the EU is a cap-and-trade system - the new EU Emission Trading Scheme (EU ETS):

- Included sectors: Power generation and heat production, pulp and paper production, oil refineries, cement, lime and glass production
- Included GHG: CO2
- Approximately 12 000 installations, 2.1 Gt CO_2/year
- ETS sectors represent roughly 45 % of the GHG emissions in the EU
- Covers all 25 Member States (27 starting from 2008)

→ By far the largest cap-and-trade scheme ever.



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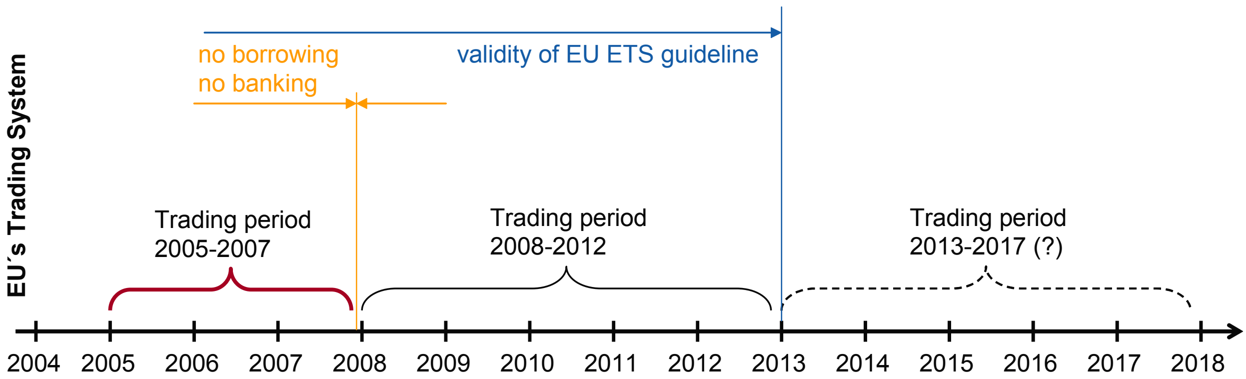
Objective of EU ETS: Emission reductions shall take place where they are cheapest.

The ETS directive entered into force on 25 October 2003:

- First compliance period 2005-2007
- Second compliance period 2008-2012
- Installation specific caps (NAPs)
- Review of scheme by July 2006



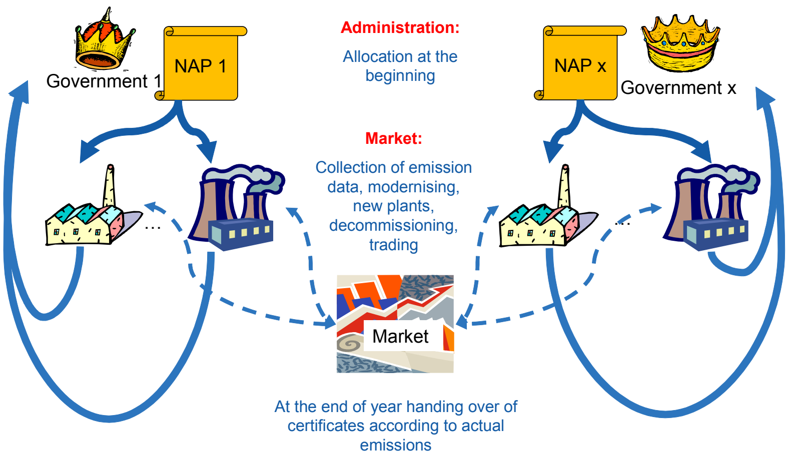
Links to use certificates from project-based mechanisms, i.e. the Clean Development Mechanism (CDM) from 2005 (close to 100 countries involved) and Joint Implementation (JI) from 2008.

- The Clean Development Mechanism (CDM) and Joint Implementation (JI) are project-oriented flexible mechanisms under the Kyoto Protocol.
- CDM: GHG reduction measures carried out by an industrial country in a developing country, reductions are counted as reductions in the investing country (CDM emissions certificates [CER- certified emission reductions] can be exchanged into ETS-allowances [EA] or can be added directly to the Kyoto emission rights [AAU assigned amount units]).
- JI: GHG reduction measures supported by an industrial country in an other industrial country, reductions are counted as reductions in the investing country, (and: the JI emission certificates [ERU emission reduction units] can be exchanged into ETS-allowances [EA], reductions are counted as reductions in the investing country).

- Currently, only 10 projects have been approved by national and UN authorities. This means that CDM will not play a major role during the first period (2005-2007). The international JI mechanisms have still not been fully clarified.
- EU governments intend to use 46 Mio $t_{CO2-equ.}/a$ [46] of CDM directly to fulfil the national reduction goals during the second period (2008-2012) (= 13% of the reduction or 1% of the overall emissions).
- In addition, several projects are in preparation by funds and single companies. It is almost impossible to estimate the amount of certificates it will be possible to get from the CDM and JI and at what cost.
- The CDM mechanism is too restrictive and bureaucratic to effectively include developing countries in climate policy in the long term. Moreover, it is limited to *reductions* in existing activities, e.g. no influence on fuel choice and the efficiency of new installations is included. Nevertheless, it is at present the only mechanism to open the ETS to the rest of the world. Therefore, the linking of the CDM and JI to the ETS is a step in the right direction.

Functioning of the EU ETS

The following figure presents an outline of the EU ETS. The first part is pure administration. The reduction path is determined and allocation plans are developed. The second part is the market part. The participants have the possibility to act. The system will find the most effective reduction possibilities inside the given limits.



The Second Phase (2008-2012) should lead to a reduction of EU emissions to 8% below 1990 levels and may include other industries and GHGs.

Operational measures of a market participant to fulfill obligations under ETS legislation

- Identification of installations belonging to the ETS
- Application for allowances (evaluation of historical data and data of the installation, data verification, passing the data to authorities)
- Monitoring of emissions and reporting

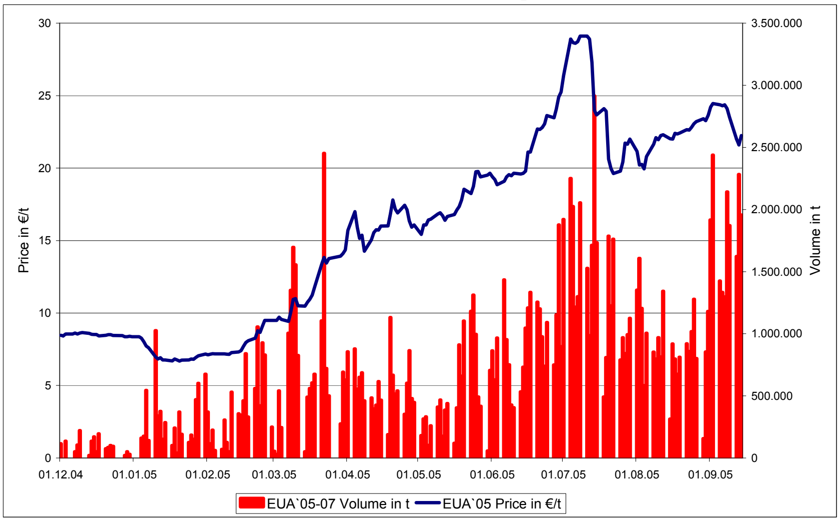
[46] The Swedish Government gives the figure 71.1 Mton/a for both JI and CDM.

- Surrender of allowances to the national authority
- Contractual rules for allowances handling related to power purchase contracts and to power plants with associated ownership
- Evaluation of own position regarding allowances (Long/Short) during the current and following period
- Portfolio management: taking the ETS into account for production planning and dispatch, hedging of the allowance position (market access necessary!)
- Financial planning: planning of the financial implications of the ETS, taking ETS into account for risk management system
- Book keeping: taking the ETS into account according to the relevant accounting standard

Market Assessment

- Utilities, gas/oil companies and a growing number of banks active.
- 7 brokers and 5 exchanges offering spot, futures and forwards.
- Traded volume 145 Mt in 2005.
- Total volume traded in 2005 expected to reach 5 times the total anticipated carbon reduction.
- OTC market represents 75% of volume traded in 2005.
- Exchange traded volume is growing as market develops.
- Spot market expected to grow substantially once registries/accounts in place.
- First phase trading has transformed from policy driven into fundamentally driven.
- Second phase trading is still pending policy and regulation.

Price and Volume Developments



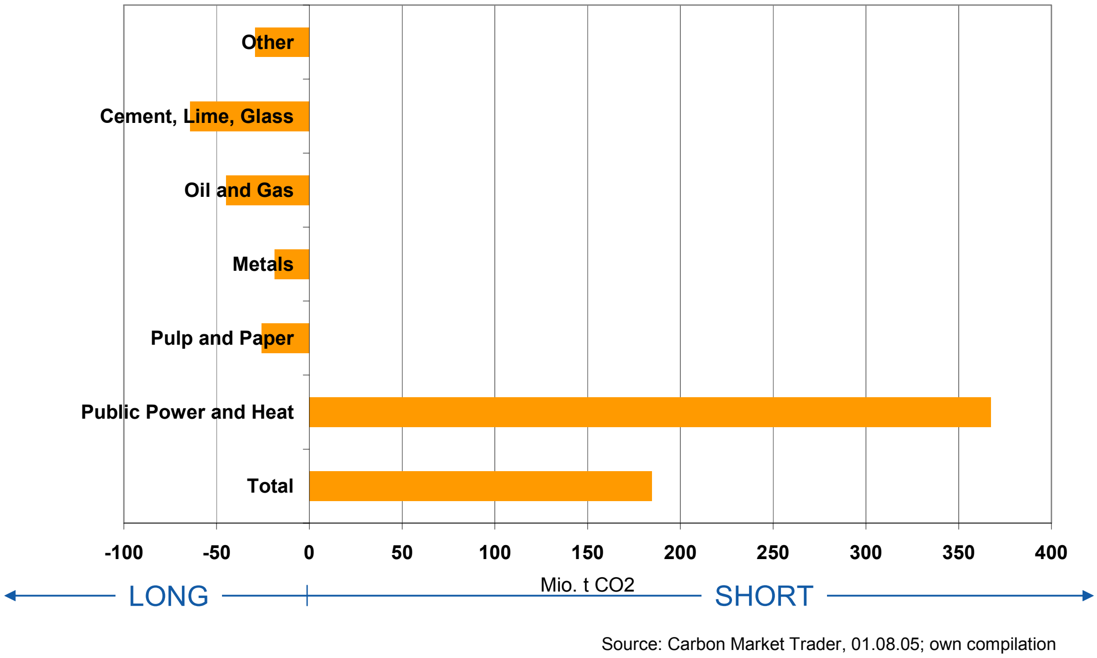
The price of CO2 allowances is higher than anticipated

Possible reasons

- Price is in principle set by marginal cost for abatement.
- Short-term reductions as a result of gas substituting coal. High gas prices give high costs for reductions.
- The trading period is very short 2005 – 2007, which means no long-term investments.
- Uncertainties about demand for EU Allowances (EUA), no reliable statistics available.
- Indications of a larger deficits of allowances than expected
- Some countries like Poland and Italy are still outside (still no valid NAPs), only 10 countries have functioning registers.

- Players with a surplus are not yet active in the market.
- Lack of knowledge about the trading system among many players.
- Certificates from the CDM not yet available, limited supply in the first period.

Estimated position for various industrial branches in over- or under-allocation of allowances



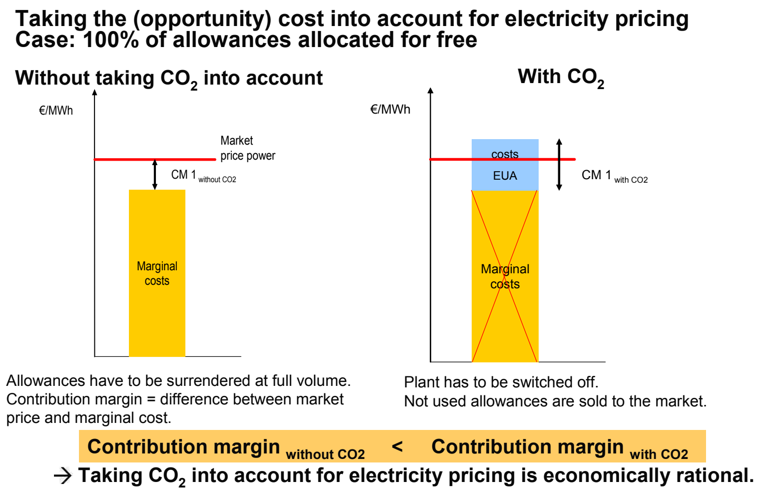
The influence on the electricity market

The intention of the EU ETS is to give CO_2 emissions a (market) price. The price shall influence the behaviour of the emitters towards lower emissions.

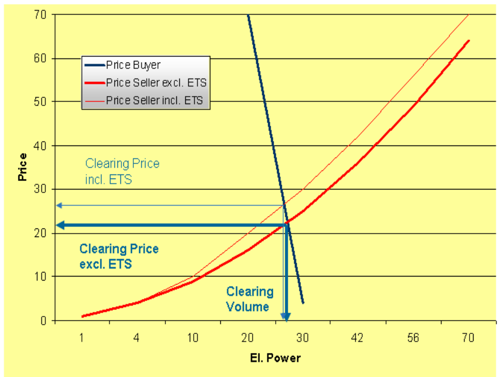
Because of the transparent wholesale market for electric power, this effect can be very easily recognised in the electricity market. For every kilowatt-hour of electric power produced in a fossil-fuelled power plant, a certain amount of EU allowances is needed. Because of their market value, this value becomes part of the marginal cost. This effect is independent of how the EUAs were allocated. The higher marginal cost has two effects:

- At a certain price of EUAs, the power plants change their position in the merit order. A power plant with higher specific emissions will lose some power generation. As a result, the emissions will decrease.

- Because of the price setting process on the power exchange, the electricity price will rise. This electricity price effect depends on the price setting units in the market area, the EUA price and other effects (fuel prices, demand, availability of power plants…).

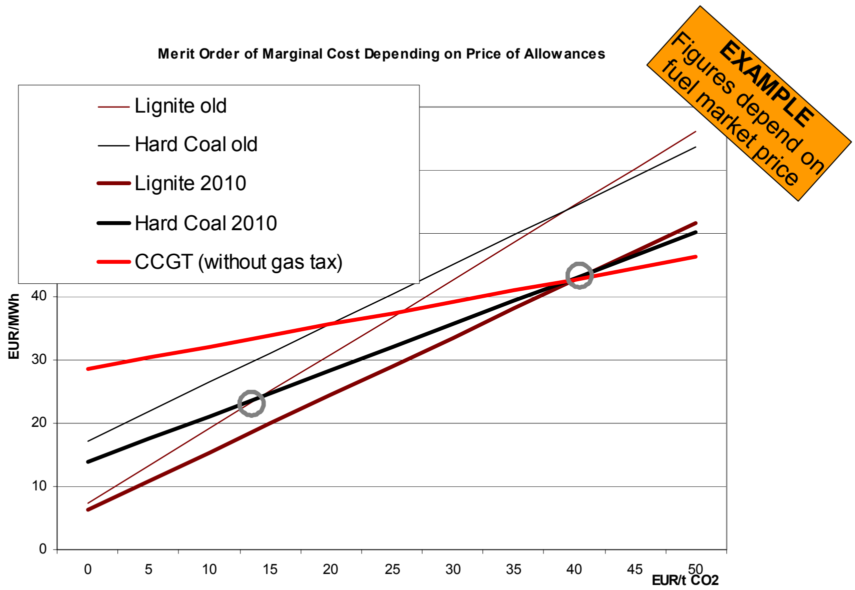


Pricing at the power exchange (EEX, Nordpool)



→ **An unavoidable price effect is a higher power market price.**

→ **The price influence depends on marginal power plants in the region and other influences (fuel prices, demand …).**



The influence of EU ETS on investments

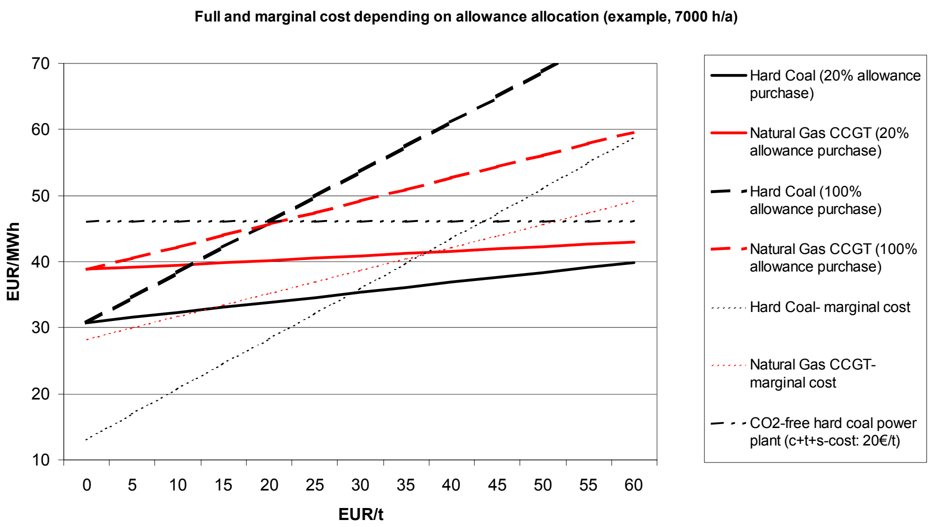
The EU ETS has a major influence on investments in new power plants. The main investment criterion in a liberalised market is the return on investment cost compared to other investments. To prepare investment decisions power companies try to forecast their own investment costs, O&M and fuel costs versus market price development.

The EU ETS creates additional cost components:

- Marginal cost as criteria for position in the merit order and annual power generation.
- Allowance purchase cost according to the allocation rules.

Unfortunately, there are significant uncertainties about future allowance price and allocation methods. Knowledge of the general political conditions is necessary to come to an investment decision. The fuel choice may be completely different in the case of a 100% auction in comparison with a case where a fuel-specific benchmark is applied.

Full and marginal cost on power plants depending on allowance allocation (Example)



Fuel choice for new installation may depend mainly on allocation mechanism and on expected market price of allowances

The uncertainties about the further development of the EU ETS and the EUA prices

Uncertainties in first trading period 2005-07

- Only 10 countries of the EU 25 have installed working registries.
- Availability of CO2 emission data is extremely weak; better information expected mid-2006 when the first monitoring reports will be available.
- Limited or no supply from CDM-projects.
- It has often been concluded that the only possibility to reduce emissions during the first period (2005 -2007) seems to be to switch from coal to gas. Because of the high prices of gas the price of CO2 allowances is also high. But ….
  - **The allocation seems to be generous compared to actual emissions,**

- Up to now, **energy companies and banks from the UK, the Netherlands and Germany are the major participants** in the market. Most of the southern and eastern European players are still not able to participate.
- Parts of the power industry (which often received under-allocations) are already active in trading while other **industrial sectors (which often received over-allocations) are still outside**.
- **Reports from analysts** who have tried to give a fundamental price forecast since the start of the system gave values ranging **between 5 and 7 €/tCO2 for the first trading period** (UBS [January 2005], Point Carbon [February 2005], ECON [March 2005]**)**.

Outlook second trading period (2008 – 2012) and post 2012

General:

As in other markets, the price is defined as the price agreed by the marginal seller and the marginal buyer. Assuming the market is efficient, this price will be equal to the intersections between the marginal abatement cost curve (MAC) and the demand for emission reductions. So the price is driven by the total expected emissions, the EU emission target and the slope of the MAC. The MAC will be influenced significantly by the availability and price of JI- and CDM-allowances.

Main uncertainties:

2008-2012:

- The amount of 'hot air' will be the key uncertainty, availability and price of allowances from JI projects in Russia and Ukraine.
- Real availability of certificates from CDM projects: EU governments intend to use 46 Mio tCO2-equ./a of CDM directly to fulfill the national reduction goals (= 13% of the reduction or 1% of the overall emissions per year).
- How much pressure will the EU member states put on the sectors participating in the European Emissions Trading Scheme to reach their Kyoto targets?
- How will allocation to the different sectors in different countries develop?

Post-2012:

- How ambitious will the emission targets be?
- Will we see harmonized allocation rules in Europe?
- What will the basic allocation mechanisms be for existing and new installations?

Appendix D Comparison of allocation mechanisms

Comparison of allocation mechanisms for existing installations (2008-2012 and >2012)

Method	Description	Practicability	Climate protection	Energy policy	Valuation
Grandfathering Fixed base period	Free allocation based on historic emissions in fixed base period (historic emissions times compliance factor)	Historic data available, simple allocation method - **but** specific historic conditions to be considered (special rules for early actions, new entrants, decommissioning, special production processes)	Strong incentive to reduce emissions because of decreasing allocation; Position in merit order influenced by specific emissions	Smooth introduction of the system, no abrupt changes. Supports a gradual transition in national energy policy Fixing of competitive situation in base period	Up to 2012 Grandfathering including the special rules to avoid competitive distortions (e.g. Early Actions) avoids economic shocks for companies and consumers and is less risky for high carbon generation technologies. Long term: Competitive distortions because of taking given historic situation as basis, special rules to avoid distortions become more and more complicated
Grandfathering Incl. updating	Free allocation based on historic emissions in rolling base period	Historic data available, simple process	Unclear signals to operators: - reduce emissions to reduce current allowance need - emit as much you can to get a better allocation in next period	Because of unclear signals allowance prices will not be taken into account for electricity prices in every case, may avoid market price effect	Destroyed market mechanism makes it difficult to find a strategy Less incentive for emission reduction.
Product-specific Benchmarking	Free allocation according to one product-specific benchmark in g/kWh times benchmark for activity level	Emission benchmark + activity level to be defined (emission level not really complicated → political decision; activity level more complicated → on basis of statistics, but how many clusters?	Most environment-friendly gets the benefit. Two mechanisms in parallel: i) Position in merit order influenced by specific emissions ii) The higher the specific emissions the lower is the percentage of cost-free allocated allowances	Promotion of gas-fired power plants; additional obstacles for coal-fired power plants, Will affect the fuel mix. Security of supply, independency from world fuel market prices and value creation inside the EU may suffer. Less possibility for politicians to influence fuel mix	Climate protection dominates energy policy. Stranded investments (coal) possible.
Fuel-specific Benchmarking	Free allocation according to fuel-specific benchmark in g/kWh times benchmark for activity level	Emission benchmarks for every fuel + activity level to be defined (definition of emission level may be complicated, how many clusters? activity level more complicated → on basis of statistics, but how many clusters? Small number of clusters and accepted benchmarks are essential!	Position in merit order influenced by specific emissions. Most environment-friendly of every fuel and/or technology gets the benefit. Limited gradient of CO2-reduction curve because fuels with higher specific emissions may remain competitive as long as position in merit order is not too bad.	Chance to maintain the fuel mix with positive effects on security of supply, independency on fuel market prices and regional value creation; Gives more time for technological development → opens time window for CCS. Possibility for politicians to influence fuel mix	Affects investment choices. Low carbon fuels benefit less. Incentives for CCS maintained. Possibility to combine competing political goals (climate protection, security of supply, power price stabilisation, employment), Avoids abrupt fuel switch, does not necessarily discriminate between technologies Risk: can only work if a few benchmarks for specific emissions and activity level can be defined; other wise too complicated.

Auctioning:	Auctioning of all allowances (theoretically on market price level, depending on timing and scope of auctions)	No specific allocation rules necessary, easy and transparent	Most environment-friendly gets the benefit, Two mechanisms in parallel: i) Position in merit order influenced by specific emissions, ii) The higher the specific emissions the higher are the purchase costs	Works like a (variable) CO2-tax, money transfer from private to public sector that creates possibility to lower other taxes. Will affect the fuel mix. Security of supply, independency from world fuel market prices and value creation inside the EU may suffer. Less possibility for politicians to influence fuel mix Long term: Increases long run marginal costs for CO2 emitting technologies → higher electricity price level to trigger new investments.	Climate protection dominates energy policy. Stranded investments (coal) possible. Fuel mix will be affected. Large distributional effects and possible high costs for economy in the short run as the competitiveness of the European economy is affected. Long-term auctioning may become main allocation method.

Comparison of allocation mechanisms for new installations

Method	Description	Practicability	Climate protection	Energy policy	Valuation
Grandfathering	Free allocation based on historic emissions	Not applicable because of lack of history			Not applicable
Product-specific Benchmarking	Free allocation according to one product specific benchmark in g/kWh times benchmark for activity level	Emission benchmark + activity level to be defined (emission level not really complicated → political decision; activity level more complicated → on basis of statistics, but how many clusters?	Most environment-friendly gets the benefit. Clear decision for fuels and technologies with lower specific emissions, Major incentive for fuel switch towards lower emissions	Will affect the fuel mix. Promotion of gas-fired power plants; additional obstacles for coal-fired power plants, Security of supply, independency from world fuel market prices and value creation inside the EU may suffer. Less possibility for politicians to influence fuel mix	Climate protection dominates energy policy.
Fuel-specific Benchmarking	Free allocation according to fuel-specific benchmark in g/kWh times benchmark for activity level Application of BAT (best available technique) benchmarks (may be with reduction factor); Application of new entrants allocation for 1, 2 or 3 periods	Emission benchmarks for every fuel + activity level to be defined (definition of emission level may be complicated, how many clusters? activity level more complicated → on basis of statistics, but how many clusters? Small number of clusters and accepted benchmarks are essential!	Important for investment decision: Position in merit order influenced by specific emissions, Limited gradient of CO2-reduction curve because fuels with higher specific emissions may remain competitive as long as position in merit order is not too bad	Chance to maintain the fuel mix with positive effects on security of supply, independency on fuel market prices and regional value creation; Gives more time for technological development → opens time window for CCS. Possibility for politicians to influence fuel mix	Affects investment choices. Low carbon fuels benefit less. Incentives for CCS maintained. Possibility to combine competing political goals (climate protection, security of supply, power price stabilisation, employment), Avoids abrupt fuel switch, does not necessarily discriminate between technologies Risk: can only work if a few benchmarks for specific emissions and activity level can be defined; otherwise too complicated.
Auctioning:	Auctioning of all allowances (theoretically on market price level, depending on timing and scope of auctions)	No specific allocation rules necessary, easy and transparent	Most environment-friendly gets the benefit. Clear decision for fuels and technologies with lower specific emissions. Major incentive for fuel switch towards lower emissions	Much higher power prices necessary to attract new investments! Works like a (variable) CO2-tax, cash for the government; promotion of gas-fired power plants; obstacle for coal-fired power plants, fuel mix will disappear most probably, security of supply, independency from world fuel market prices and value creation inside the EU will suffer	Climate protection dominates energy policy. No new coal-fired power plants.

Appendix E. Established, Emerging and Future Technologies

Established Technologies

Technology	Features	Advantages	Issues
Combined Cycle Gas Turbine (CCGT)	Technology with power ratings up to 600 MW and >58% efficiency available Suitable for Combined Heat and Power (CHP) Efficiency continues to increase through higher firing temperatures and improved fluid dynamics of turbines, 60% in reach within 10 years	Highest efficiency of fossil-fuel based commercial technologies Low CO_2 emissions per MWh_{el}, ≈500 kg Small footprint Lowest capital cost (50% of a coal plant)	High and volatile fuel price (2-3 times coal price) Security of fuel supply in Europe
Coal-fired power plants	Technology with power ratings of more than 1000 MW and >48% efficiency available Replacing old plants with new can lead to large CO_2 emissions reductions - Average world efficiency is<30% Efficiency continues to increase through higher steam parameters Suitable for Combined Heat and Power (CHP)	Fuel is widely available in Europe at relatively stable prices - no shortage expected for the foreseeable future European assets are estimated to last more than 100 years	Relatively high CO_2 emissions per MWh, 700- 1000 kg/Mwh_{el} for new plant, >1100 for old
Fluidized bed combustion	Fuel is burned in a bed of solid particles at an even and low temperature The FB,CFB is only a different kind of boiler, the power cycle is conventional World leading technology for all medium-sized boilers	Very good fuel flexibility, High reliability Market leading technology for everything but the largest power plants Built-in SOx and NOx reduction abilities	Technology still developing Cannot compete with pulverized fuel burner boilers at very large sizes

Technology	Features	Advantages	Issues
Nuclear power	New capacity investments are planned or under way in several countries, incl. Bulgaria; Finland; France; Poland and Romania. Generation III technology incorporates passive safety systems, meaning even higher reactor safety than previously An international R&D programme has been launched to develop the Generation IV nuclear reactor technology, to be deployable by 2030	Very low CO_2 emissions No shortage of fuel is expected for the foreseeable future - At double today's uranium fuel prices, resources can be estimated to last several hundred years	Public Acceptance High capital costs Long-term radioactive waste management
Hydro power	Hydro power assets in Europe are well developed, and the efficiency is high - Significant unexploited resources (50-70 TWh) exist in the Nordic region - Sweden and Norway have decided to keep the relevant rivers unexploited	Very low CO_2 emissions Excellent controllability makes hydro valuable as balance power capacity Can be used for storage	Variation in precipitation Public acceptance of dams
Bio-fuelled power plants	Thermal power plants based on bio-fuels emit no net CO_2, as long as consumption of bio-mass does not exceed natural production Bio-fuel markets and supply chains are immature in several countries Bio-fuels can be co-fired with coal in existing plants to varying degrees Waste-to-energy transforms a problem into an asset Suitable for CHP	Very low CO_2 net emissions Can contribute to alleviating problems with waste management	Relatively high fuel cost and limited use of the fuel potential Competition for bio-mass from paper & pulp industry and, in the future, transportation High temperature corrosion and slagging-fouling restrict efficiency.
Wind power	>5-10% of generation in several countries Large growth world-wide, 20-30% per annum Development of large off-shore parks is increasing 4 MW generators are available, with 5 MW prototypes on the way	Very low CO_2 emissions	Relatively high cost for avoided CO_2 Uncontrollable nature of generation leads to extra costs for balance power Network stability with high installed capacities Local public acceptance ('NIMBY' syndrome)

Emerging Technologies (examples)

Technology	Features	Advantages	Issues*
IGCC – Integrated Gasification Combined Cycle	Gasification of coal is used to create a product gas that is burned in a gas and steam combined thermal cycle to produce electricity Several large scale demo plants in operation around the world.	Potentially high efficiency Good control of SOx, NOx, and other pollutants Can be combined with transport fuel production and / or CO_2 removal	Limited reliability of plants Actual efficiencies lower than conventional steam cycles
Pressurised fluidised bed combustion	Combustion of solid fuels in a fluidised bed at elevated pressure, acting as a combustor in a gas turbine, producing electricity. A steam turbine is added to form a combined cycle Several demo and commercial plants in operation around the world	Potentially higher efficiency than conventional steam cycle plants Large fuel flexibility	Reliability of plants and efficiency not as high as anticipated Commercial availability uncertain
Geothermal power	Uses naturally occurring geothermal heat for co-generation In the EU, Italy has significant electricity generation (5 TWh_{el}).	High utilisation factor possible Very low CO_2 emissions	Geographically limited Combination of high drilling costs and lack of methods for geology assessment from surface constitutes economic risk

* In general, and not surprisingly, all future technologies currently have an issue with high costs.

Future Technologies (examples)

Technology	Features	Advantages	Issues*
Carbon dioxide separation and storage (CCS)	Carbon dioxide and other pollutants from combustion of fossil fuels are captured The captured CO2 is compressed to a liquid state and pumped into geological formations, similar to those containing oil and gas	CCS is one of the most powerful tools to reach climate goals	Large scale capture demonstration needed Demonstration of storage technique to address acceptability issues needed
Wave power	Extraction of mechanical energy of waves and subsequent conversion to electricity in generator	Relatively high utilisation rate, comparable to off-shore wind power Very low CO_2 emissions	Limited reliability Requirement for equipment to survive storms renders equipment expensive
Photovoltaics (Solar cells)	Direct conversion of solar radiation to electricity High costs and low energy density limit economic application to niches where electricity grid connection is not available	Primary energy available everywhere Low CO_2 emissions	Low utilisation factor Low energy density of solar radiation Limited efficiency of solar cells
Fuel cells	Converts chemical energy, for example natural gas, to electricity	Potentially high efficiency Can use bio-fuels like bio-gas and bio-methanol Potentially low or very low CO_2 emissions, when using renewable fuels	Reliability and lifetime
Hydrogen (H_2)	Not a primary energy source, but an energy carrier, similar to electricity! CO_2 emissions depend on which method is used for hydrogen production	Allows storage, which makes H_2 potentially suitable for transportation applications	Inefficiency of distribution system, due to basic properties of H_2 Many required technologies are quite immature
Fusion	Thermonuclear fusion, where atomic nuclei are fused together at ultra-high temperatures, can give access to vast amounts of energy No one has demonstrated sustain-ed fusion with positive net energy production France has recently been appoint-ed to host an international deve-lopment collaboration on fusion.	Abundance of fuel Potential for high energy density and utilisation rate Potentially very low CO_2 emissions	Principle not demonstrated Several decades will be needed to develop a commercial technology, after demonstration Short-term radioactivity

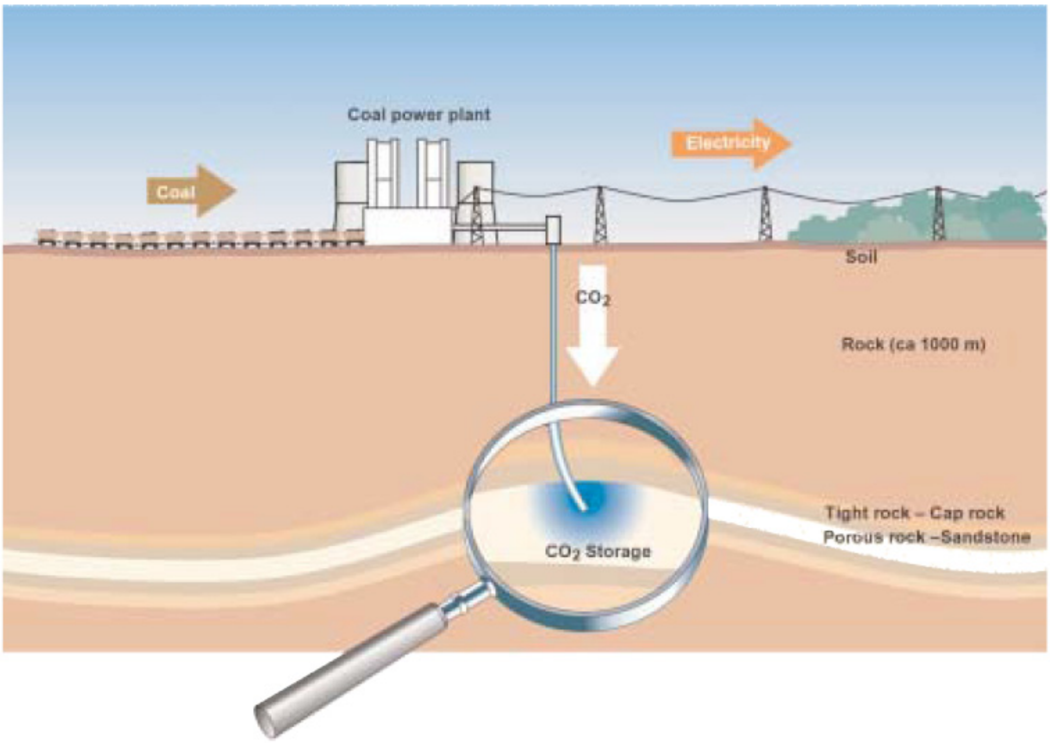
* In general, and not surprisingly, all future technologies currently have an issue with high costs.

Appendix F. Carbon Dioxide Capture and Storage (CCS)

A number of options exist that can reduce the carbon dioxide emissions from the energy system. These include improved energy efficiency and switching to renewable and nuclear energy. However, policies based on these options will, at best, only partly solve the problem.

Carbon dioxide capture and storage technologies constitute another promising option that can drastically reduce these emissions. The idea is to capture carbon dioxide from a coal-fired power plant, transform it into a liquid, and permanently store it deep underground. The storage sites (repositories) are of the same kind as those where oil and gas are extracted – i.e. porous rock formations with a sealing cap on top. To accomplish this, action now has to be taken to ensure that technologies are developed and deployed on a large scale over the next few decades. Several initiatives on carbon dioxide capture and storage are currently underway all around the world.

Figure 20 Principles of Carbon dioxide Capture and Storage – The CO_2-Free Power Plant



Carbon dioxide capture programmes chiefly involve research and development activities in combination with cost cutting. Carbon dioxide transport and storage has already been demonstrated and even commercially introduced in enhanced oil recovery, EOR. Further activities are ongoing on new transport and storage applications, as well as on scaling up the commercially available technology and verifying the capacity of the storage sites to permanently store the carbon dioxide. The largest efforts are being made in Europe under the EU research framework programmes, in Northern America, in Australia and in Japan. North American and European activities are also taking place in northern Africa and in China. Several national and international bodies support the largest programmes and initiatives. Vattenfall has taken a position in the forefront in Europe. Efforts relating to transport and storage are focused on verifying the integrity of the storage sites and the enduring capability to retain the carbon dioxide underground without leakages, neither in the short term nor the long term. Efforts relating to capture technologies are focused on further engineering research and development to reduce costs.

Worldwide research on capture technologies

The cost of capture is the main part of the estimated total cost penalties for the capture, transport and storage of carbon dioxide. Capture is also the technical part that has the largest improvement potential. Carbon dioxide can be captured from power plants using technologies that have been developed and proven in other applications in, for instance, the petrochemical, food and chemical industries. However, optimisation of the integration of these technologies in power plants and a significant equipment scale-up is required. Carbon dioxide only makes up a small part of the flue gas emitted from a power plant. Typically, flue gases emitted from power plants contain about 3–15 per cent of carbon dioxide, depending on the fuel and power plant process.

Three different approaches for carbon dioxide capture

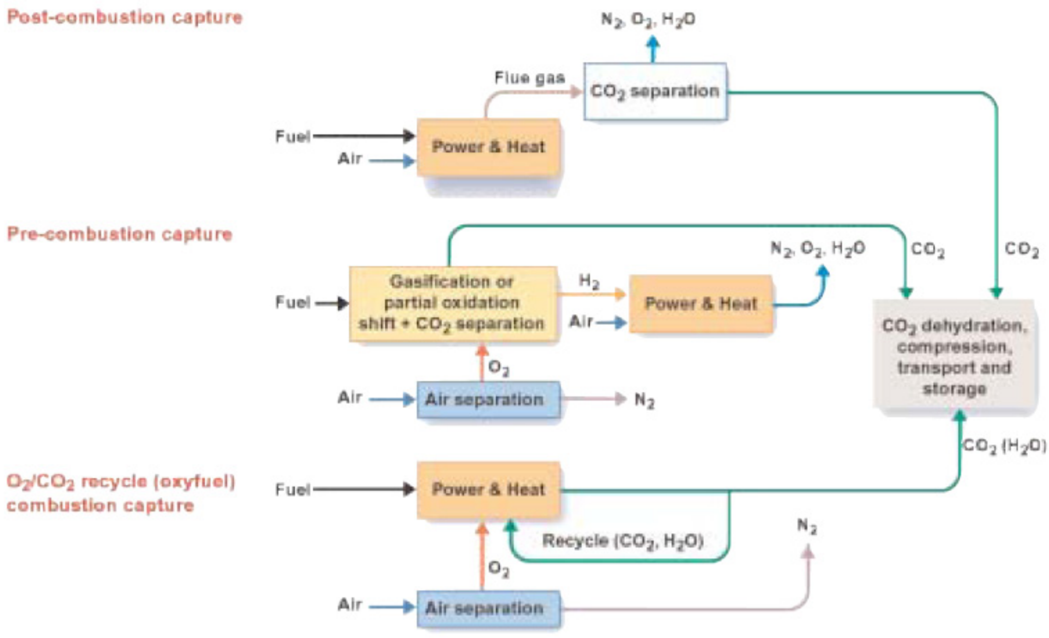
There are three main approaches for carbon dioxide separation from power plants:

1. The flue gas cleaning approach or post-combustion capture where the carbon dioxide is separated from the power plant flue gas.

2. The hydrogen/syngas approach or pre-combustion capture where the fuel, coal or natural gas, is processed to produce a gaseous fuel consisting of mainly hydrogen and carbon dioxide. The carbon dioxide is then separated from this mixture before the hydrogen is combusted in the power plant. Combustion of hydrogen results in a flue gas consisting of water vapour only.

3. The oxygen combustion approach including technologies where the nitrogen is excluded from the combustion of the fuel, resulting in a flue gas with carbon dioxide and water vapour as the main components. It is then easy to condense the water vapour and get an almost pure carbon dioxide product stream.

Figure 21: Schematic view of three different approaches to CO_2 capture



Worldwide research on transport and storage

Carbon dioxide can be stored in depleted oil and gas fields as well as in saline aquifers. This kind of injection has no other purpose than preventing the carbon dioxide from reaching the atmosphere where it contributes to global warming. Formations of this type are able to permanently store carbon dioxide since their capability to store oil and gas has been proven.

Research efforts are presently underway in most regions where oil and gas is extracted today. Research is also being carried out in the northern part of the European Mainland since the ground has the right properties even though little oil and gas have been found here. Such formations have been used for many years to store natural gas and other gases, both as reserve and buffer storages. In Germany alone, more than 40 such storages exists. Under the entire city of Berlin, a gas storage with a capacity of 1.4 billion cubic metres is at hand in a sandstone formation just like the ones proposed for carbon dioxide. Several test operations of just storing carbon dioxide are in progress. Since 1996, a total of 1 million tonnes of carbon dioxide have successfully been injected at the Sleipner platform into the Utsira formation in Norway. Carbon dioxide is also being captured from natural gas and being injected into another similar formation. By the end of 2006, injection will also start at the Norwegian Snöhvit platform. In the middle of 2004, a project started to inject 1.2 million tonnes of carbon dioxide annually at In Salah in the Sahara Desert in Africa.

Appendix G

STATEMENT OF G8 CLIMATE CHANGE ROUNDTABLE

CONVENED BY THE WORLD ECONOMIC FORUM

IN COLLABORATION WITH HER MAJESTY'S GOVERNMENT, UNITED KINGDOM

9 JUNE 2005

Introduction

As leaders of major global companies representing a broad range of industries, we share the belief that climate change poses one of the most significant challenges of the 21st century. With linkages to other important issues, such as the need to ensure economic growth, alleviate poverty, and provide access to adequate supplies of energy, climate change is an issue that demands the attention of governments, business, and civil society throughout the world. We fully support the efforts of the Prime Minister to elevate attention to the issue in the G8 process and welcome this opportunity to contribute.

We recognize we have a responsibility to act on climate change. Many of us are significant users of energy or produce products whose use results in substantial emissions of greenhouse gases; some of us have assets or investments that will be adversely affected by changes in climate; all of us face the prospect of increased regulation in one form or another. We also know that small costs today can become material costs in the future, with significant impact on bottom line performance, shareholder value, and brand reputation.

Our companies have begun to act in a variety of ways, ranging from inventory and disclosure of greenhouse gas emissions to development of new product lines that release less carbon to the atmosphere. Many of us are participating in voluntary emission reduction programs or mandatory emissions trading markets. Some are launching new financial instruments that consider risks and new profit opportunities relevant to climate change. Others have committed to significant purchases of renewable energy or are actively exploring new investments in other low carbon technologies such as nuclear power. We acknowledge, however, that there is a need for further, substantial efforts to reduce greenhouse gas emissions.

We also note that business and government cannot solve the climate change problem alone. Consumers, too, have a vital role to play, in so far as they will determine whether actions undertaken by business to introduce low carbon practices or offer new "climate friendly products" will be met with a viable market. Indeed, that is the premise underlying Article 6 of the UN Framework Convention on Climate Change (ratified by 189 states), which obligates governments to educate and inform consumers. Market-based solutions to climate change will work best when there is an informed base of consumers who understand the implications of their consumption and buying choices – and when they are given the right price signals.

Key Principles

From a business perspective, we believe there are a few key principles that should guide future strategy for climate change mitigation:

- Policies and action should be based firmly on good science and rational economics.
- Policy frameworks that use market-based mechanisms to set clear, transparent and consistent price signals over the long term offer the best hope for unleashing needed innovation and competition.
- Solutions must be global -- participation of all major emitters is essential.
- Climate change mitigation must not be viewed in isolation from other highly important challenges, such as ensuring access to energy, expanding availability of clean water, alleviating poverty, and achieving economic growth in emerging markets.
- Undertaking a system-wide, integrated approach to the problem and its solutions is critically important – to identify where greatest leverage exists for mitigation from the beginning of the production cycle through to end-users and consumers.

Science

The science of climate change has been strengthened through three cycles of five-year assessments by the Intergovernmental Panel on Climate Change (IPCC), as well as many national and regional studies. For many of our companies, the IPCC has become the primary source of information on the science of climate change. These companies feel that maintaining IPCC's credibility and independence is essential, and that the IPCC deserves full and sustained support from the G8 governments.

It is our understanding that IPCC sees increasing confidence in models and historical data that show global warming is both already underway and attributable, in significant part, to human activity. We agree that the science is sufficiently compelling to warrant action by both the private and public sector, and we acknowledge that, because of the cumulative nature and long residence time of greenhouse gases in the atmosphere, action must be initiated now.

The above said, it is difficult for companies to determine the scale of needed investment without a clear definition of the problem's dimensions, including the thresholds (e.g. greenhouse gas concentrations) that must not be crossed in order to minimize adverse consequences. In our view – because the problem is a broad societal and long-term issue -- governments must take responsibility for defining these boundaries, considering as well the technical, financial, and political feasibility of various solutions. Toward that end we urge the G8 governments to:

- Focus more resources and attention on assessing the potential scale and magnitude of adverse effects on human health, natural ecosystems, and regional and global economies. Identifying needs for near-term adaptation measures is particularly important.

- Strengthen the global observation systems that are essential to improve our understanding of the changes that are now underway or may evolve in the future (e.g. sea level rise, sea/ice cover).
- Move expeditiously to adopt climate stabilization targets that will define the scope and scale of mitigation needed in the years ahead.

Policy Framework

To establish clear, transparent, and consistent pricing signals, the policy framework for addressing climate change must meet a number of objectives. We summarize these below, together with some specific ideas (highlighted in bold) for the G8 governments to consider.

1. Create long term value:

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 carbon capital projects whose life cycle may often be in the 25-50 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 emissions credits and the value of investment in low carbon infrastructure in emerging markets.

We must adjust our thinking about actions to reduce emissions of greenhouse gases – to see them as adding real, long term value, not simply imposing costs. This is a primary benefit of market-based approaches and should be reflected in an enduring policy framework supporting all low carbon technologies. Creating lasting shareholder value is particularly important.

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 emissions 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.

2. Unleash technological innovation through performance-based incentive programs:

Properly designed emissions trading programs can and will induce companies to reduce their emissions of greenhouse gases. However, the primary effect of such mechanisms is to promote efficiencies in energy use or manufacturing processes; they are less likely to stimulate major technological change or breakthroughs. Therefore, a continuing emphasis on other public and private sector programs to stimulate the development and commercialization of new low carbon technologies is required.

Technology-specific government support is essential for basic research that offers long-term prospect of success but remains too risky to attract private sector investment. This is especially relevant in areas where technological breakthroughs have not yet been achieved.

For more near-term applications, however, where the goal is rapid commercialization and deployment of technologies that are nearly "ready to go", governments should avoid picking winners and losers. Here, regulatory or incentive programs designed to support the power of innovation will function much more productively if they are technology-neutral and performance-based – i.e. establishing the goals, but giving business maximum flexibility to achieve them.

It is also important for such programs to consider a life-cycle approach – to encourage business to identify the stages of design, production, distribution, use, and disposal/reuse where technology innovation can provide greatest reduction in greenhouse gas emissions at least cost, and then optimize that across the full cycle. Additionally, performance-based standards must be balanced with other societal goals (e.g. safety, employment growth) and be consistent and stable, both over time and across geographical areas that are defined by similar market characteristics or common business operations.

- We urge the G8 governments to emphasize performance-based standards in new initiatives aimed at rapid commercialization of low carbon technology.
- Ensuring compatibility with other societal objectives is equally important, together with the ability to optimize greenhouse gas reductions across product life cycles.

3. Facilitate greater investment in low carbon economic growth in emerging markets:

Emerging markets offer substantial opportunities for private investment to support low carbon economic growth, in concert with other sustainable development goals. Ways must be found, however, to reduce the risks that pose significant barriers to private investment – especially at a time where significant quantities of private investment capital appear to be available.

Good governance is key, together with the same kind of market-based policy instruments and technology incentive programs discussed in the preceding sections. A partnering approach involving business, governments, and relevant international financial institutions and focused, initially, on a small group of specific countries across a range of continents could create important precedents that would have application worldwide.

- The G8 governments should step up collaborative efforts with emerging market nations to streamline and encourage low carbon investment, with particular focus on technologies that can be replicated across different regions.

- The G8 nations should engage in a major new partnership with China, India, Brazil, South Africa and Mexico to establish appropriate frameworks to facilitate private investment in low carbon infrastructure, consistent with local and regional objectives for expanding access to affordable energy, providing greater mobility, assuring availability of clean water, and meeting other sustainable development goals. Such a partnership could aim for implementation of specific projects within each of these countries or it could focus on rapid introduction of specific technologies (e.g. renewable energy or carbon capture and storage) across several or all of them. Strengthening local research and innovation capacity should also be a key objective.

One financing tool that already exists -- the Clean Development Mechanism (CDM) established by the Kyoto Protocol for promoting low carbon investment in developing countries -- offers significant promise. However, in the view of many of our companies, the CDM process has become overly complex, time consuming, and expensive. A governance approach matched to the scale of the task, together with the resources needed to implement it, is lacking. There is uncertainty about the long term value of CDM credits beyond 2012. Very few projects have been approved, and we are concerned that business interest may decline considerably. To realize the full potential of this mechanism, major reforms are needed.

G8 governments that have ratified the Kyoto Protocol should launch immediately a consultative process with the UNFCCC to engage experienced global businesses in an assessment of the CDM, with the goal of implementing measures to streamline the process substantially by the end of 2005.

Additionally, we pledge our full support for the Joint Implementation (JI) mechanism established by the Kyoto Protocol. JI offers significant opportunity to advance cooperative solutions to the climate change problem and a model that could be applied well beyond its original focus on Annex 1 countries (developed countries, as defined in the Kyoto Protocol).

4. Establish common metrics:

Many companies have taken the lead in establishing benchmarks for reporting and/or measuring corporate performance in reducing greenhouse gas emissions. Some common baselines have been developed, most prominently the protocol developed by the World Resources Institute and the World Business Council for Sustainable Development, the Global GHG Register hosted by the World Economic Forum, and the soon-to-be completed ISO standard 14064. However, there is an emerging risk that national, regional, and/or sectoral protocols will diverge substantially, complicating the task of comparing corporate performance both within and across various industry sectors. The problem may become particularly acute in some G8 nations where multiple agencies have promulgated different standards.

Transparency, comparability, and simplicity of reporting metrics is crucial to the ability of investors and other stakeholders to assess value derived from actions to mitigate climate change. Greater harmonization can reduce transaction costs substantially. These issues will become even more important as the complexity and volume of corporate action increases. Therefore, we urge the G8 governments to:

- Work toward convergence of existing greenhouse gas reporting processes and systems.

This could take the form of an assessment of greenhouse gas reporting requirements promulgated by national and sub national agencies, with the goal of identifying and implementing appropriate reforms. Consideration could also be given to the development of a forum or board to establish a common approach for greenhouse gas reporting, similar to the International Accounting Standards Board currently in place to measure financial performance. In either case, it should be emphasized that the objective is to build upon the considerable amount of good work already done in this area.

We also note a need for common metrics in two other areas. One is energy efficiency. Benchmarking energy efficiency across national borders would greatly facilitate identification of new climate change mitigation opportunities. The other concerns trans national measurement of the overall health and recovery of the planet. As we move forward to implement solutions, it will be important to monitor and track their impact on a global basis.

5. Utilize the power of procurement and supply chain drivers:

Government and industry jointly represent massive buying power in the global economy. Their requirements for energy efficiency, for example, can have a major impact on greenhouse gas reductions, while at the same time stimulating the economies of scale that will create products and services whose application will yield benefits extending far beyond procurement/supply chain pathways. Integrating climate change mitigation more widely in government procurement – and doing it in ways that would create large market value by harmonizing standards across national boundaries – would provide industry with much greater motivation to invest in innovation. Such a commitment, matched by a private sector commitment of similar scale focused on supply chain purchasing, would create cascading effects throughout the global economy.

- Business and the G8 governments should work together to establish a practical toolkit for integrating climate change into their global supply chain requirements.
- Business and government should commit to use such a common framework and encourage its use in stages of supply chains where optimal effect on greenhouse gas emissions can be achieved.

Conclusion

Business and governments can – and must – work together on climate change mitigation. Working together, we can identify and implement policy measures that will create meaningful and effective solutions, while at the same time ensuring long term value for shareholders. With properly designed programs and incentives, we can unleash the power of the market to accelerate the deployment of low carbon technologies, engaging both producers and consumers alike. And with the right kind of focus on both the needs and aspirations of emerging markets, we can ensure that a truly global solution to the problem is achieved.

We are firmly committed to do our part on climate change. A coordinated and vigorous response from the G8 governments along the lines suggested above will allows us to do even more.

G8 Climate Change Roundtable

Participating Companies

ABB, Fred Kindle, CEO

Alcan, Travis Engen, President and CEO

BP, John Browne, Group Chief Executive

British Airways, Martin Broughton, Chairman

BT, Ben Verwaayen, CEO

Cinergy, James E. Rogers, Chairman, President & CEO

Cisco, Robert Lloyd, President, Operations, Europe, Middle East, Africa

Deloitte, John Connolly, CEO, UK and Global Managing Director, Deloitte, Touche Tohmatsu

Deutsche Bank, Tessen von Heydebreck, Member of the Board of Managing Directors

E.ON Ruhrgas, Burckhard Bergmann, CEO, Member Executive Board of E.ON

EADS, François Auque, Head of Space Division

EdF, Pierre Gadonneix, Chairman and CEO

Eskom, Reuel J. Khoza, Non-Executive Chairman

Ford, William Clay Ford, Chairman and CEO

HP, Mark Hurd, President and CEO

HSBC, Sir John Bond, Group Chairman

Petrobras, Jose Eduardo de Barros Dutra, President and CEO

RAO UESR, Anatoly B. Chubais, CEO

Rio Tinto, Paul Skinner, Chairman

Siemens, Klaus Kleinfeld, President and CEO

Swiss Re, Jacques Aigrain, Deputy CEO

Toyota, Katsuhiro Nakagawa, Vice Chairman

Vattenfall, Lars G. Josefsson, President and CEO

Volkswagen, Bernd Pischetsrieder, Chairman of the Board of Management

List of most common abbreviations

AAU	Assigned Amount Units
BAU	Business As Usual
CCS	Carbon Dioxide Capture and Storage
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CO_2	Carbon Dioxide
COP	Conference of the Parties to the UNFCCC
EA	ETS- Allowances
ETS	Emission Trading System
EU	European Union
EUA	EU Allowances
GDP	Gross Domestic Product
GHG	Green House Gases
JI	Joint Implementation
MOP	Meeting of the Parties to the Kyoto Protocol
NGO	Non-Government Organisation
OECD	Organisation For Economic Co-Operation and Development
UNFCCC	United Nations Framework Convention on Climate Change
NAP	National Allocation Plan
IPCC	Inter Governmental Panel on Climate Change

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