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Climate change and sustainability in Europe

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Sammendrag: Dette notatet starter med å diskutere jordens klimaendringer til nå og hvilke drivkrefter som ligger bak disse endringene. Det pekes på at klimaet i tidligere tider har vært svært variabelt av naturlige årsaker, men ble roligere etter siste istid. Muligheten for at klimaet igjen blir mer variabelt er en viktig side ved klimaproblemet og kan utgjøre en større trussel enn en mer jevn temperaturstigning framover. Noen framtidige scenarier for utslipp av klimagasser og klimautviklingen drøftes deretter som bakgrunn for en kort beskrivelse av de klimaforhandlinger som pågår og de politiske valg vi står overfor på kort sikt. Til slutt skisseres de mer langsiktige utfordringene Europa står overfor som region og betydningen av klimaproblemet i debatten om en bærekraftig utvikling.

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Abstract: This paper discusses the climate history of the Earth, exploring some of the driving forces of climate change along the way. It points out that it may not be the gradual increase in global mean temperature that we have to fear the most. Rather the variability of the climate may pose an even greater threat to us. The paper outlines some possible future scenarios of climate change based on what we now think we know about the causes of climate change and possible future development in emissions of greenhouse gases. It then goes on to describe the current climate negotiations and possible political solutions in the near term, before concluding with a description of the more long-term fundamental challenges we face. The aim of the discussion is to provide a deeper understanding of the climate problem we are facing, as well as the challenges that lie ahead of us, individually as well as a region, in securing the climate aspect of a sustainable development for Europe and the world.

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Contents

- 1 INTRODUCTION 1**
- 2 REMEMBRANCE OF THINGS PAST: THE DRIVING FORCES AND HISTORY OF CLIMATE CHANGE..... 1**
 - 2.1 THE CLIMATE SYSTEM AND ITS DRIVING FORCES 2
 - 2.2 CLIMATE HISTORY 4
 - 2.3 THE HUMAN PERSPECTIVE 7
 - 2.4 DO WE SEE AN ANTHROPOGENIC SIGNAL? 9
- 3 THE WAY AHEAD..... 11**
- 4 IMPACTS..... 13**
- 5 NEGOTIATIONS 15**
- 6 THE WAY FORWARD: SOME CONCLUDING COMMENTS 16**

1 Introduction

"Sustainability" is a fuzzy concept covering many concerns and perspectives on how to build and maintain a lasting civilisation. However defined, it is nevertheless easy to agree that climate change may pose a fundamental threat to sustainable development. Not because climate change in itself will necessarily pose a direct serious threat to our well-being, at least not in our part of the world, and certainly not within a time span of a generation or so. Rather, this fundamental threat to sustainability is more related to how causes and effects of climate change are distributed among continents, nations and individuals. Because it is primarily brought about by the lifestyles and consumption patterns in the rich part of the world, and its greatest negative effects fall among the poorest of the poor people, climate change challenges the very notion of fairness, and thus sustainability, in a steadily more globalised world.

2 Remembrance of things past: the driving forces and history of climate change

Since its creation 4.6 billion years ago, the Earth has gone through enormous changes. Continents have been formed and reformed, solar output has increased some 30 percent, and the oceans and the atmosphere have been created and changed. Given these fundamental changes, it is a near miracle that life has evolved and managed to thrive over much of Earth's history.

Table 1. Earth history - some highlights

Time (Million years ago)	
4 600	The Earth was formed
3 300	First life
680	First animal
470	First fish
412	First plant
330	First tropical forest
215	First dinosaur
140	First bird
65	Dinosaurs die out
2.3	First <i>Homo</i>
0.100	First <i>Homo sapiens sapiens</i>
0.040	Eurasia invaded by <i>Homo sapiens</i>
0.015	Cave paintings in Spain and France
0.010	The end of the last ice age
0.008	First civilisations
0.004	First cities

(Adapted from C. Boyle (ed.) 1991)

Time scales of billions of years are difficult to grasp. In order to make it more 'digestible', some memorable moments in the history of the Earth are listed in Table 1.

The relatively slow start is noteworthy. It took more than a billion years before the first sign of life appeared in the ocean in the form of single cell bacteria, and almost three billion more years before the first animals were established, also in the ocean. One possible reason for this delay is that from 750 to 550 million years ago the Earth may have frozen completely over. Only after the 'snowball' melted could life extend to land areas – first with plants and then gradually with animals migrating from the ocean. It

was not until this stage that oxygen became an important constituent of the atmosphere, which at earlier stages had been dominated by CO₂ and other so-called greenhouse gases like methane. Volcanic activity and geological processes like weathering and erosion had kept the CO₂ concentration consistently high during the first period. As land areas began to team with

life, these processes were modified and a new balance between the lithosphere, the oceans and the atmosphere was created. The balances were not perfect, however, and severe climate changes in the form of extensive glaciation took place in this early part of the history of the Earth. Behind these changes were a number of driving forces, some external to the climate system, other internal.

2.1 The climate system and its driving forces

The system governing the climate on Earth consists of many sub-systems coupled together in a non-linear fashion. Important sub-systems are the atmosphere, the oceans, the cryosphere (snow and ice), the lithosphere (soil and rock) and the biosphere, see Figure 1. As such, the system is able to distort and amplify external signals affecting the various sub-systems. This is one reason why the climate is such a complex issue to study. Although we may have a good deal of knowledge about individual sub-systems, the many interlinkages with other systems operating over many time scales make it very hard to predict the overall behaviour of the global climate in response to for instance changes in emissions of the so-called greenhouse gases.

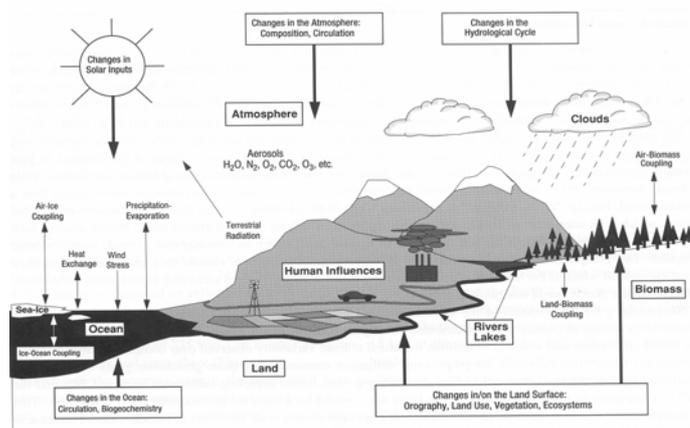


Figure 1. The climate system (Source: IPCC, 1996)

An important sub-system is of course the atmosphere itself. However, the state of the atmosphere (temperature, humidity, clouds, distribution of high and low pressure areas, etc.) is affected by and influences the state of other sub-systems. Despite this complexity, it can nevertheless be useful to list the main causes of global climate change. These driving forces operate on a number of time scales, from the very long geological time scale (millions of years) to a more 'human' and politically relevant shorter time scales (years or decades).

External forces:

- Variations in solar output
- Variations in the orbit of the Earth
- The form and positions of the continents
- Volcanic activity

Internal forces and feedbacks:

- Changes in the Earth's albedo

- Changes in the Earth's biosphere
- Changes in the composition of the Earth's atmosphere due to weathering, volcanic activity and human activities: clouds, particles, gases

The greenhouse effect is only one of several forces determining climatic development on Earth, and it is directly related to the gas composition of the atmosphere. Why, then, is this single effect now viewed as a serious problem?

First of all, the greenhouse effect has been an important climatic force throughout the Earth's history. It works through the mechanism that certain gases – so-called greenhouse gases – allow short-wave sunlight to pass through the atmosphere but block the outgoing long-wave heat radiation from the Earth. The most important greenhouse gas is water vapour (H₂O), followed by carbon dioxide (CO₂) and methane (CH₄). Throughout the Earth's history, the greenhouse effect has been what has made the Earth's environment inhabitable. Today, the *natural greenhouse effect* increases the average temperature by some 34 °C. Without the greenhouse effect, the Earth would have been a large, uninhabitable snowball. What concerns us today is the *enhanced greenhouse effect* caused by the emission of first and foremost large quantities of CO₂ from the burning of fossil fuels since the beginning of the industrialised revolution. The effect of CO₂ and other man-made greenhouse gases is to partially block a radiation window in the atmosphere that normally allows the Earth to get rid of excessive heat. The total energy reflected from the atmosphere back down to the Earth's surface as a result of the greenhouse effect is in fact larger than the net energy received directly from the sun (see Figure 2). Another reason that the greenhouse effect is particularly relevant is that it operates on a time scale relevant to humans. Several of the other forces are only noticeable on much longer (geological) time scales.

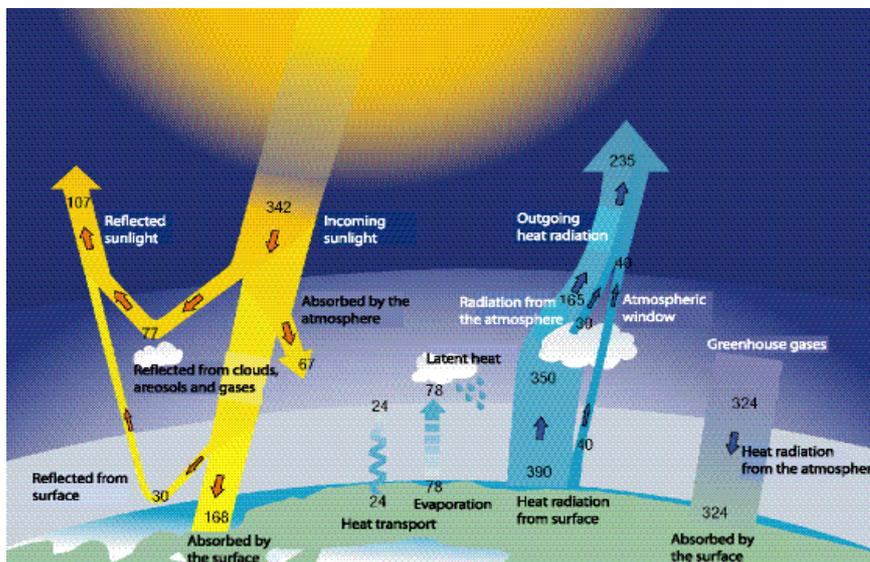


Figure 2. The greenhouse effect (Source: NILU)

Although water vapour is the most important greenhouse gas when we talk about the total greenhouse effect, it is usually disregarded when we focus on the enhanced or man-made (anthropogenic) greenhouse effect. The reason is that the content of water in the atmosphere is largely determined by climatic conditions and is not governed by the release of water to the atmosphere from human activities.

The strength of the enhanced greenhouse effect is usually measured in terms of the *radiative forcing* that the increase of the concentration of the greenhouse gases imposes on the Earth's climate system. Radiative forcing is a measure of the net energy flow at the top of the

atmosphere and is measured in W/m^2 . Figure 3 illustrates the changes in radiative forcing since the beginning of the industrialised revolution from different man-made and natural forces.

To translate changes in radiative forcing into changes in the climate, we use climate models that simulate how the different climatic sub-systems react to changes in the energy inflow. I will discuss this in more detail when I discuss possible future climate change.

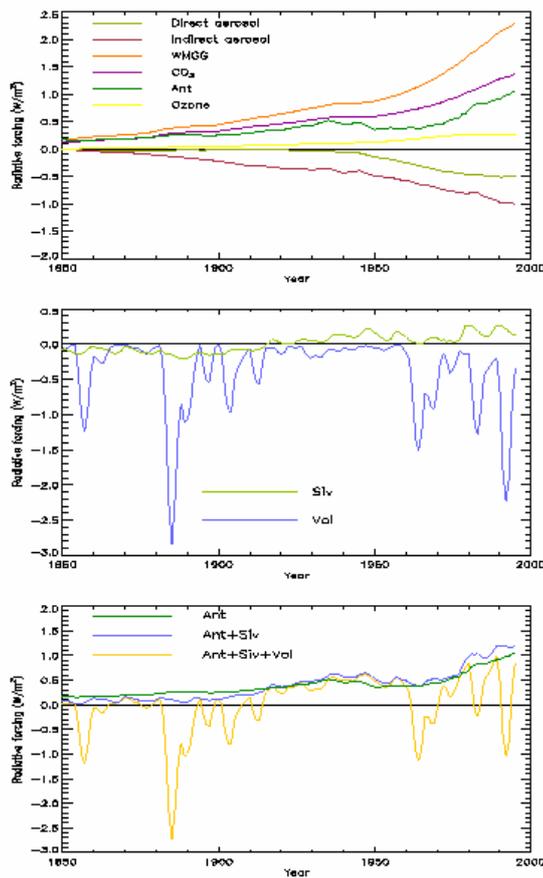


Figure 3. Changes in radiative forcing from different forces since the start of the industrial revolution. (Source: Myhre, et al., 2001)

2.2 Climate history

Changes in the driving forces and internal responses in the climate system have resulted in changes in the global climate throughout the history of the Earth. A rough indication of the climate history is illustrated in Figure 4.

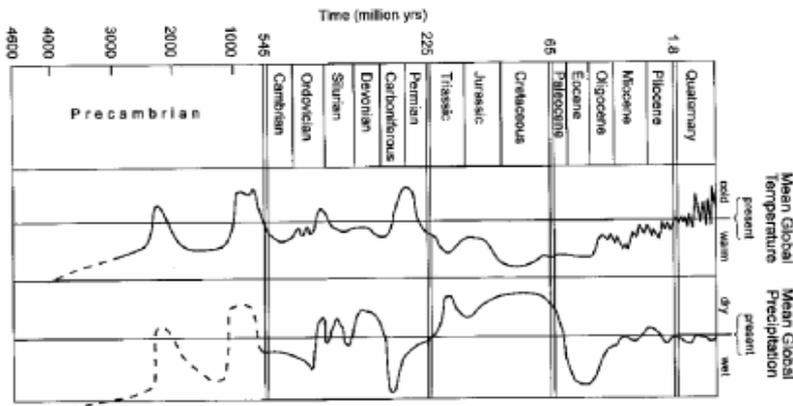


Figure 4. The climate history (Adapted from Frakes, 1979)

In rough terms, we believe that the Earth, throughout its history, has experienced at least four so-called *ice house periods*. These are periods, measured in terms of millions of years, where much of the Earth is covered by ice. Ice house periods comprise shorter *ice age periods* and *intermediate periods (interstadials)*, each measured in thousands of years. During ice ages, substantial parts of the Earth are covered by ice, while in the interstadials, the ice retreats. Between the ice house periods are *hot house periods*, where the Earth is very warm compared to today and has little or no ice cover. The first ice house period we can trace happened some 700 million years ago. Thereafter ice houses happened around 450 million years ago and 280 million years ago. The most recent ice house period, which we happen to live in, started some 2.5 million years ago – possibly because of the closure of the gap between South and North America at that time. Figure 5 illustrates the coming and going of ice ages during this last ice house period. We notice the change in frequency (indicated at the top of the figure) and amplitude of the ice ages over time; they have become longer and more severe. Lately, the ice ages have been lasting about 100,000 years with brief 10,000 year long interstadials.

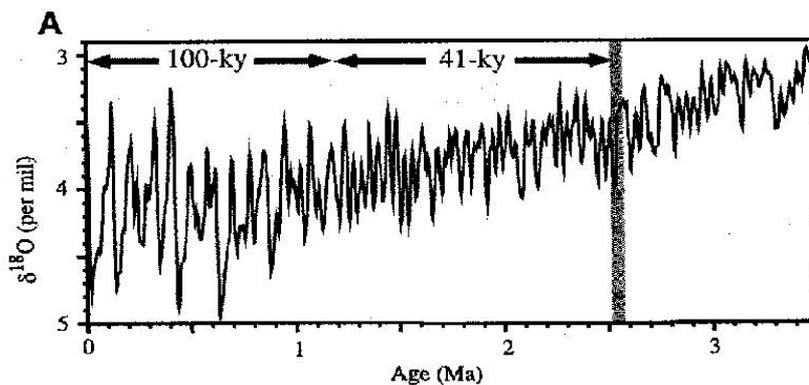


Figure 5. Ice ages during the last ice house period (Source: Clark et al., 1999)

Our knowledge about our more recent past is of course better than our knowledge about the very early history of the Earth. Not least analyses of air bubbles trapped in long ice cores from Antarctica and Greenland have greatly enhanced our ability to extrapolate climate conditions during the last four ice ages. Figure 6 shows the temperature at the Vostok site in Antarctica during the last four ice ages estimated from analyses of air bubbles trapped in the ice.

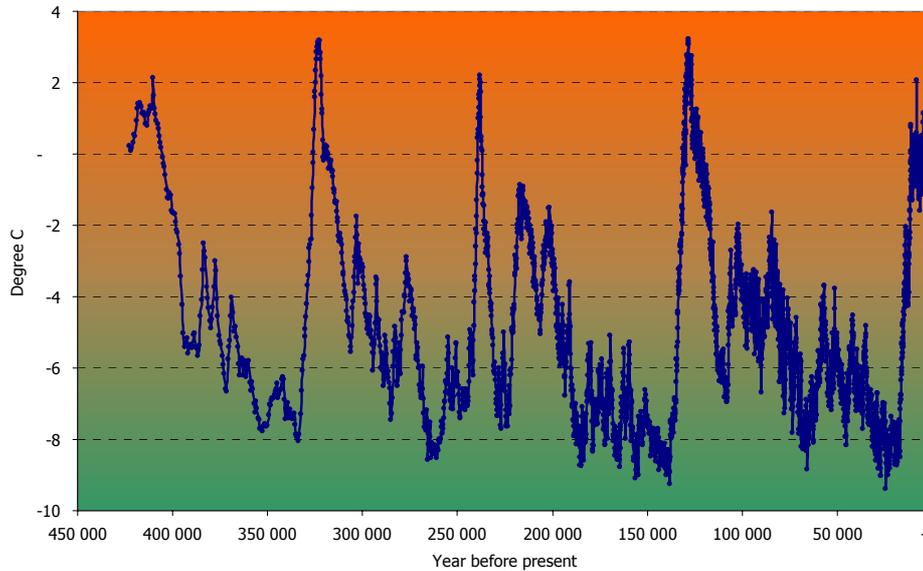


Figure 6. The last four ice ages as registered in Antarctica. (Source: Petit et al., 1999)

The recent pattern is that the Earth tends to slowly enter into an ice age, which, after some 100,000 years, abruptly ends. Then the interstadial lasts for some 10,000 years before a new decline into an ice age starts. The coming and going of ice ages during this ice house period seems to be governed by slight changes in the orbit of the Earth, resulting in changes in the amount of sunlight received during summer in the Northern Hemisphere. This small perturbation is then amplified by the feedbacks in the climate system. Figure 7 illustrates model calculations of summer solar incidence in the Northern Hemisphere over the past 200,000 years and the coming 125,000-year period, together with simulations of the extent of ice coverage in the Northern Hemisphere during the same period. Note that the present epoch is characterised by less variation in summer solar radiation than 'usual'. This has the fortunate effect of postponing the next ice age by some 40–50,000 years.

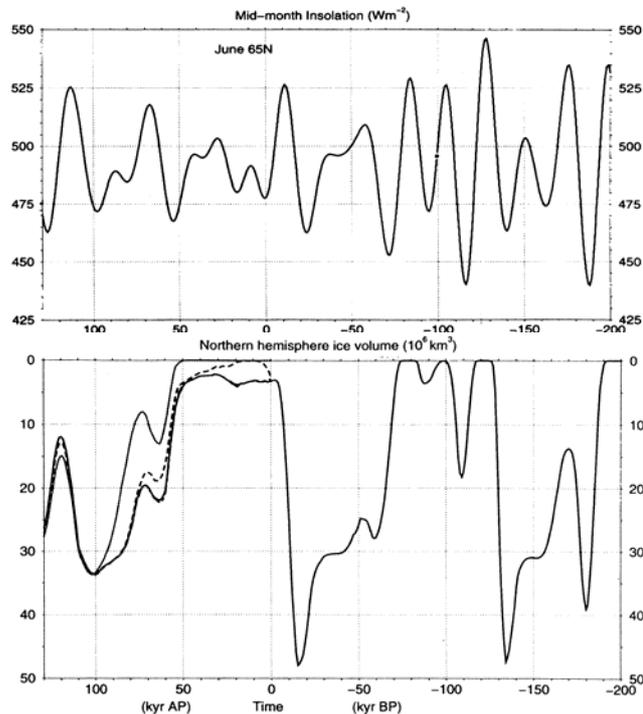


Figure 7. Solar insolation 65 °N during summer and Northern Hemisphere ice volumes. (Source: Berger and Loutre, 1998)

The projections of future ice coverage are based on three different assumptions about future concentration levels of CO₂ in the atmosphere. The lower curve reflects a very low CO₂ level corresponding to observed concentrations during ice ages (180 ppmv); the middle curve reflects concentration levels observed during previous interstadials (280 ppmv); and the upper curve reflects expected enhancements of this level due to man-made emissions of CO₂. In any case, we see that the Earth is headed for a new ice age in 50,000 years time. In this perspective, the human-induced climate problem is but a small perturbation on the cyclical development of the Earth and its climate.

2.3 The human perspective

The first humanlike animal is a few million years old, i.e. very recent in a geological perspective. It only appeared after the start of the last ice house period. *Homo sapiens* are thought to have first appeared about 400,000 years ago, certainly in Africa and perhaps in parts of Asia as well. Anatomically modern humans appeared in Africa and possibly in Asia perhaps 100,000 years ago and eventually arrived in Europe. The emergence of fully modern humans in other parts of the world is less understood, though it seems to have occurred 30,000–15,000 years ago and involved various migrations and the intermingling of different populations (see ‘human evolution’ in *Britannica Online*). Agriculture and stationary settlements seem to have appeared ca. 7,000 years ago, while the oldest remains of cities are some 4,000 years old (cf. table 1).

Thus, human development can be said to have started during the last ice age, and civilisation only got established after the end of the last ice age some 10,000 years ago. The climate conditions in our part of the world during the last ice age are illustrated in Figure 8, which shows temperatures at Greenland during and after the last ice age.

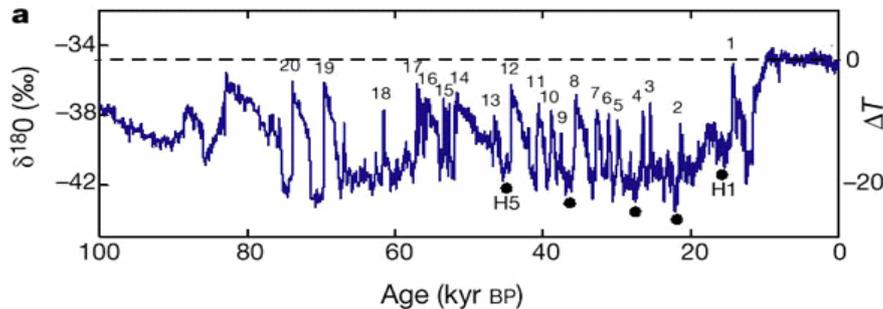


Figure 8. Climate conditions in Greenland during and after the last ice age. (Source: Ganopolski and Rahmstorf, 2001)

We note that the ice age was not a monotonous cold period. Rather it was characterised by violent, i.e. rapid and very large, climate variations driven by variability in the ocean current. During some periods the average annual temperature fluctuated by some 10–15 °C in less than a decade! This represents a change in climate corresponding to a move from Madrid to Reykjavik. And all of this happened for 'natural' reasons, i.e. without any human interference with the climate system. After the end of the last ice age, things settled down, while not becoming constant. Thus, compared to earlier variability, the post-ice age period (the Holocene) has been a relatively calm period with 'nice weather'. It is noteworthy that agriculture only emerged ca. 7,000–8,000 years ago, i.e. a couple of thousand years after the end of the last ice age and only after the climate became more benign and stable. This event, or the establishments of cities some thousands of years later, can perhaps be said to represent the start of the civilisation as we know it. Thus, our civilisation has only known a relatively calm and stable climate. Still, during this relatively calm period, civilisations have come and gone for climatic reasons.

Box 1: Are there any analogues to today's increase in CO₂ concentration?

It has generally been assumed that there would be no period in the history of the Earth where one could study the effects of a difference in emissions and uptake of greenhouse gasses similar to what is found today. However, this seems to be the case about 55 million years ago. Recent studies (Dickens, 1999, and Norris and U. Röhl, 1999) have shown some interesting changes during a short period of time where concurrently with a rapid increase in temperature (5–7 °C at higher latitudes) there was a decrease in the isotope ratio ¹³C/¹²C. The studies conclude that there was an enormous emission of methane presumably from methanehydrates (these consist of methane gas and water and are stable at low temperatures, high pressure and high methane concentrations). The total emissions are estimated to range between 1,200 and 2,000 GtC during less than 10,000 years; probably more than 600 GtC were emitted during less than 1,000 years. Both in amount and emission rates these emissions exceed the current man-made emissions. From the beginning of the emission period until the Earth returned to pre-event conditions some 140,000 years had passed. The conditions 55 million years ago were of course different from those prevailing today. One must therefore be cautious in using these results to predict effects of today's emissions. However, the results are a new reminder that our actions today may affect the conditions on the Earth for very many generations.

In this context it is instructive to take a look at a graph (Figure 9) showing CO₂ levels in the atmosphere over the last four ice ages. Combined with current and future trends in CO₂ levels, the figure gives a vivid picture of the rate of change we are currently imposing on the atmospheric composition. Already, the CO₂ concentration at approximately 370 ppmv is far above anything we have experienced over the last 400,000 years. The near vertical increase in CO₂ concentration also gives an indication of the unprecedented rate of change we now impose on the climate system.

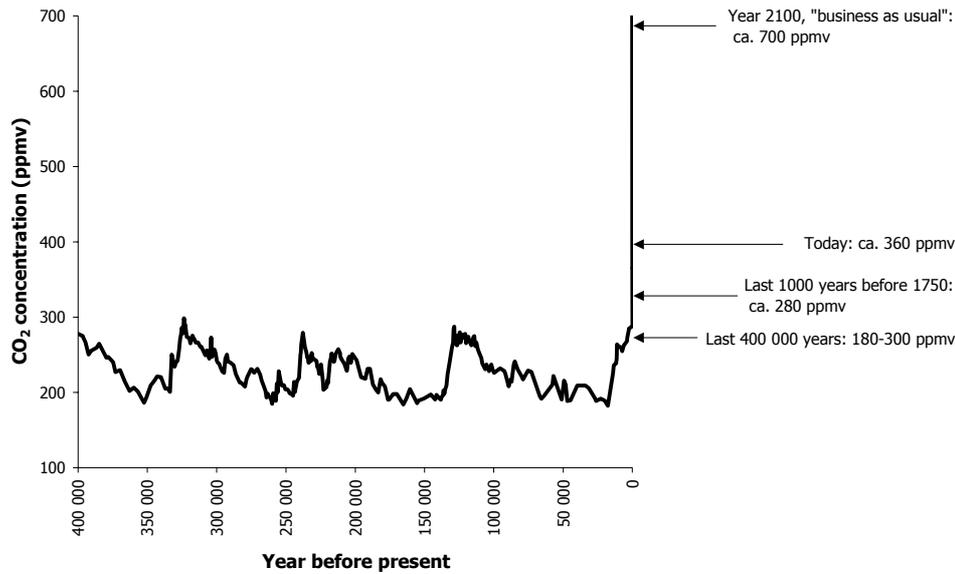


Figure 9. Concentrations of CO₂ over the last 400,000 years together with current and expected future CO₂ concentration levels. (Source: Past measurements from Petit et al., 1999)

Taken together with the increasing acknowledgement of the potential natural instability of the climate system, also in warm interglacial stages, the picture presented above provides an important piece of motivation for the current concern about climate change. The potential loss of climate stability may pose a greater threat than a more monotonous increase in temperature.

2.4 Do we see an anthropogenic signal?

As mentioned, the climate has varied also after the last ice age, although much less violently than during that period. The temperature development over the last 1,000 years in the Northern Hemisphere is illustrated in Figure 10.

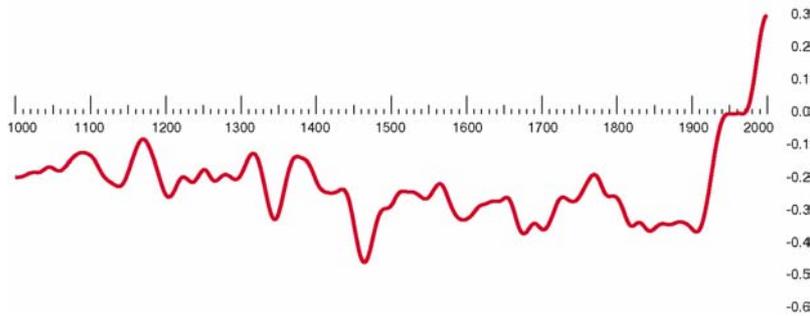


Figure 10. Temperature development in the Northern Hemisphere over the last 1,000 years. (Source: Mann et al. 1999)

The initial slow downward trend is probably mainly due to slow changes in the orbit of the Earth, but may also be affected by changes in the albedo of the Earth due to land use changes. The temperature trend is sharply broken by two steep rises in temperature from 1910 to 1945 and then again from 1976 and onwards. Analysis of temporal and spatial patterns combined with model simulations indicate that the first jump (from around 1910 to 1945) was mainly driven by natural forces like variations in the sun and (lack of) volcanic activity, see Figure 3.

The most recent jump, starting around 1976, can, however, not be explained without taking man-made emissions of greenhouse gases into account. The prevailing conclusion is therefore that the climate change of the last decades is to a substantial degree caused by man-made emissions of greenhouse gases. Figure 11 illustrates an example of a comparison between observed temperatures and model simulations with different driving forces.

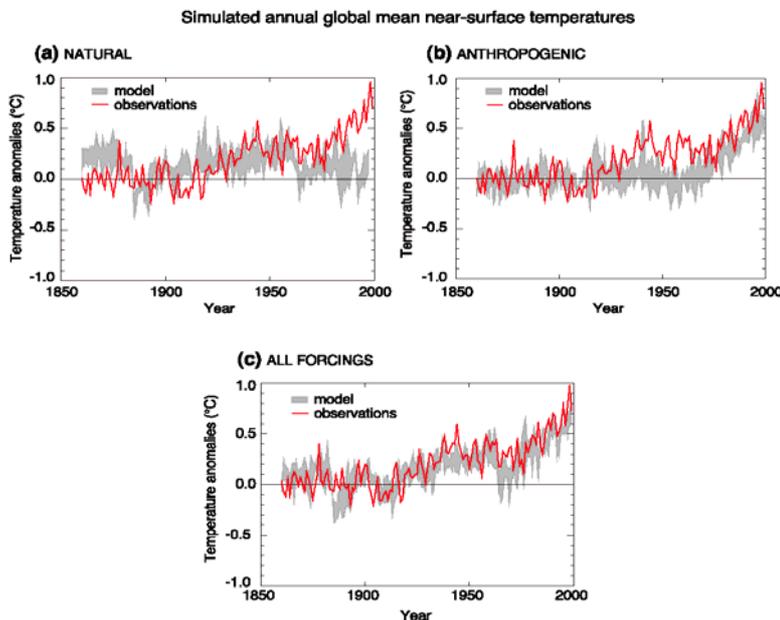


Figure 11. Do we see an anthropogenic signal? (Source: IPCC, 2001)

3 The way ahead

The climate system has a lot of inertia, in particular because of the slow to response of the ocean to external forcing. Thus, the climate development over the next few decades is, barring large surprises related to abrupt changes in the ocean currents, more or less prescribed already, and thus independent of any realistic action we can take now to reduce emissions of greenhouse gases. The development in the longer term will, however, depend on the amount of greenhouse gases we will emit, which in turn will be governed by such factors as economic and technical development, as well as population growth. Future climate change thus hinges on a number of very uncertain projections of such factors as population growth, economic growth and its composition, technological development, and social development – both at the global and local levels. There exists a wide range of possible development paths for each of these factors, which together explain the broad range of possible future emission levels. The next few figures illustrate some possible development paths based on scenario work carried out by the IPCC (IPCC, 2000). The first figure (Figure 12) illustrates some driving forces behind CO₂ emissions, while figures 13 and 14 illustrate emission levels and concentration levels, respectively.

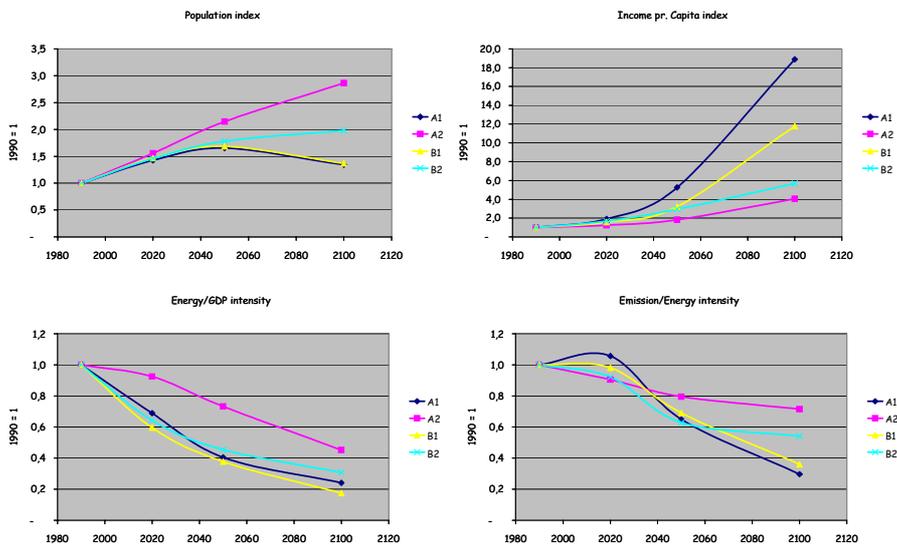


Figure 12. Factors behind emission growth (Source: IPCC, 2000, CICERO)

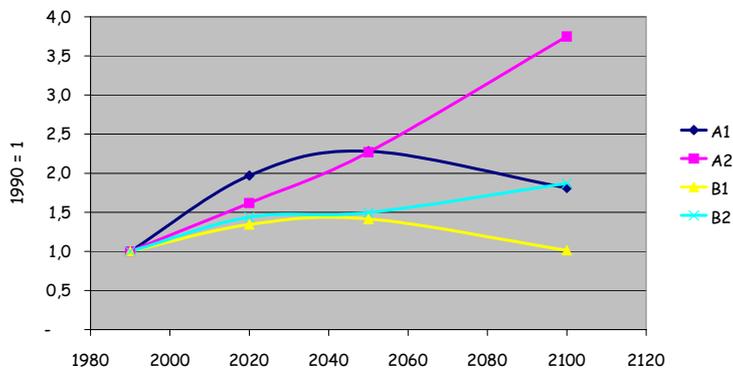


Figure 13. CO₂ emission scenarios (Source: IPCC, 2000, CICERO)

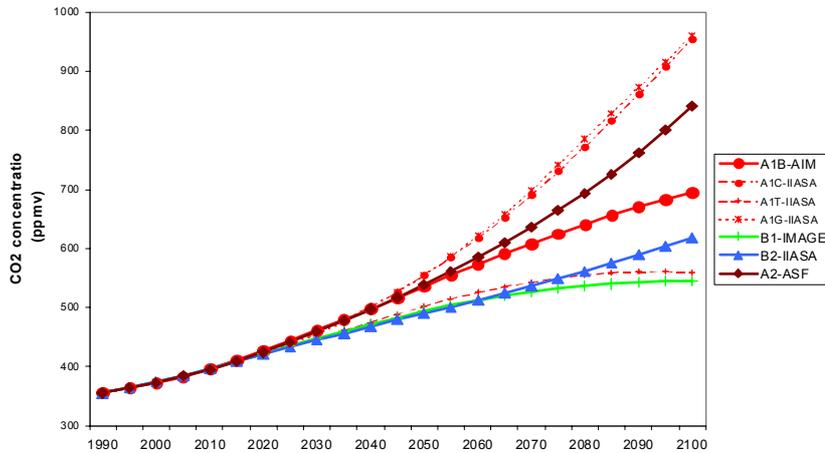


Figure 14. CO₂ concentration scenarios (Source: IPCC, 2000, CICERO)

The concentration levels of greenhouse gases can then be translated into changes in radiative forcing levels. Using climate models, these changes can again be transformed into climatic scenarios – first at a global level and then downscaled to regional and local levels. Finally, it then becomes possible to indicate some of the relevant impacts of these changes to society (Figure 15).

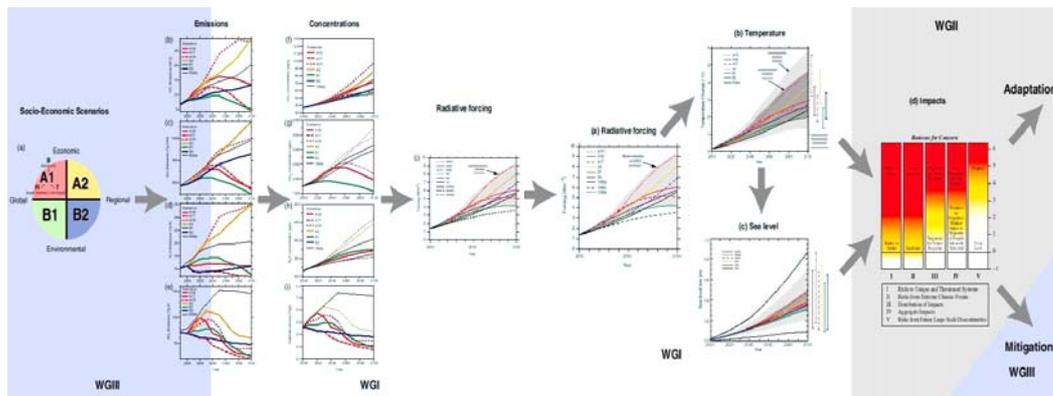


Figure 15. From economic development to climate impacts (Source: IPCC, 2001)

The average global climate impact of these development paths is, of course, uncertain – in part because of the complexities and our restricted understanding of the climate system. Our best estimate at the moment is that the global average temperature will increase by between 1.4 and 5.8 °C by the end of this century. This is illustrated in Figure 16.

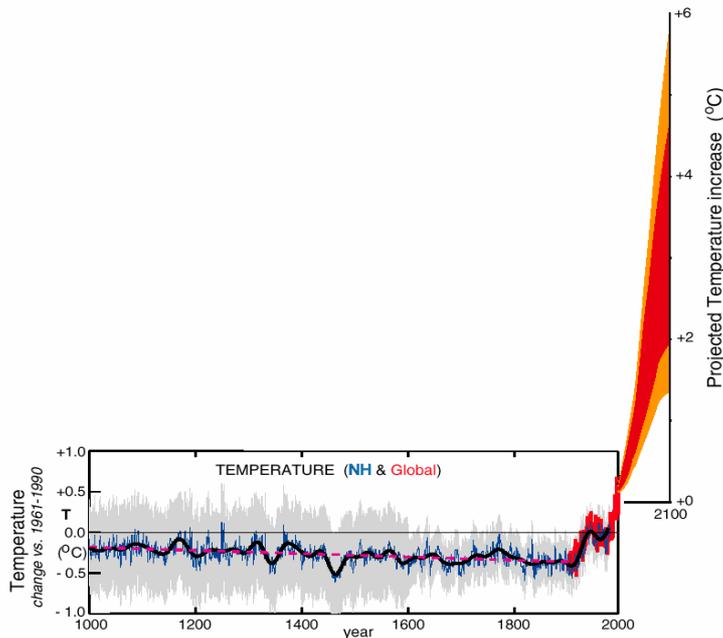


Figure 16. Historic and future temperatures (Source: IPCC, 2001, Mann et al., 1999)

In Figure 16, the projected increase is linked to the temperature development the last 1,000 years. Two remarks are in order regarding this result. First, the expected temperature increase is more or less off the scale with respect to what we have experienced over the last millennium. (Still the temperature variation is very much smaller, by an order of magnitude, than the variability that took place regionally during the last ice age). Second, the uncertainty range for future temperatures is quite large. However, this uncertainty mainly results from uncertainty in socio-economic and technological assumptions and only to a lesser extent from uncertainty in the climate models.

4 Impacts

The change in the global climate is expected to manifest itself as a warming, mostly in the Northern Hemisphere and over land areas. Also, the temperature increase is expected to be largest during winter, with a particularly large increase in minimum night temperatures. Precipitation is probably going to increase in already humid areas, while dry areas may experience more frequent droughts. The sea level will increase, mainly due to thermal expansion of the oceans, but also because of increased run-off from land-based glaciers and ice sheets. This is in simple terms the global picture as it emerges when we disregard the possibility of a surprise in the form of a change in climate regime to a more violent and variable climate. What stands out as perhaps the most worrisome from this picture is the expected increased water shortage in already dry areas. The global picture is detailed somewhat more in Box 2 where also some of the remaining climatic uncertainties are listed.

Box 2: Projected changes and remaining uncertainties (based on IPCC, 2001)

Projected changes in extreme weather and climate events:

- Higher maximum temperatures and more hot days over nearly all land areas (very likely).
- Higher minimum temperatures, fewer cold days and frost days over nearly all land areas (very likely).
- Reduced diurnal temperature range over most land areas (very likely).
- Increase of heat index, i.e. temperature and humidity over land areas (very likely).
- More intense precipitation events (very likely).
- Increased summer continental drying and associated risk of drought (likely).
- Increase in tropical cyclone peak wind intensities (likely).
- Increase in tropical cyclone mean and peak precipitation intensities (likely).

Remaining uncertainties:

- Discrepancies between the vertical profile of temperature change in the troposphere seen in observations versus those seen in models.
- Large uncertainties in estimates of internal climate variability from models and observations.
- Considerable uncertainty in the reconstructions of solar and volcanic forcing.
- Large uncertainties in anthropogenic forcing associated with the effects of aerosols.
- Large differences in the response of different models to the same forcing.

The uncertainties are even greater at a regional level. At a European level, the southern part of the region is probably going to experience the most dramatic effects, provided the North Atlantic Drift does not react violently to a changing climate (something which is not expected, but may not be totally disregarded). The recent ACACIA study (Perry (ed.), 2000) indicates in more detail that the following changes with regard to future climate change in Europe will be most important:

- The general pattern of future change in annual precipitation over Europe is likely to be widespread increases in northern Europe, somewhat smaller decreases across southern Europe, and small or ambiguous changes in central Europe. Most of Europe gets wetter in the winter season (increased precipitation between 1 and 4 per cent/decade). In summer, there is a strong gradient of change between northern Europe (increased precipitation of up to 2 per cent/decade) and southern Europe (decreased precipitation up to 5 per cent/decade).
- The global mean sea level is expected to rise by between 13 and 68cm by the 2050s. These estimates make no allowance for natural vertical land movements. Owing to tectonic adjustments following the last glaciation, there are regional differences across Europe in the natural rates of relative sea level change.

- It is *very likely* that frequencies and intensities of summer heat waves will increase throughout Europe, likely that intense precipitation events will increase in frequency – especially in winter – and that summer drought risk will increase in central and southern Europe, and *possible* that gale frequencies will increase.

These changes in climatic conditions can then be translated into likely impacts on ecosystems and abiotic systems. However, what remains to be explored are the actual consequences for local societies and sectors that depend on the functioning of ecosystems and man-made infrastructure – in short our *vulnerability* to climatic change. This vulnerability depends not only on the climatic change and its impact on biotic and abiotic systems, but also on the ability of these systems and society as such to adapt to the rate of change imposed by climatic change.

5 Negotiations

So, in broad terms the climate change challenge facing humanity is in the short term to adapt to more or less prescribed climatic change, in terms of both relatively slow changes in mean values and more acute exposure to extreme events. In the longer term the task is to avoid driving the climatic system into a more violent and variable regime.

How serious are these threats? The answer to this question depends, of course, on the scale we use for measuring damage and benefits. The flooding in Poland in 1997, and again this year, represents damages in the order of several percent of GDP. Damages like this are certainly important and represent a significant drag on economic development, but are hardly the doom of civilisation. So while climate change may be a burden on industrialised countries, it is, at least in the coming hundred years, no threat to our societies as such. Things are different for some of the developing countries. Here, weather-related events are capable of undoing decades of economic development within a short time span. A worsening of the conditions for development is indeed a serious threat for these countries, which provide a home for the majority of people on Earth, and certainly those in greatest need for development. If climate change makes a narrowing of the gap between rich and poor people more difficult than it is today, this represents in my mind a real threat to sustainability. The most important reason for taking mitigating actions against climate change is therefore to enable a long-term development where the riches of the Earth becomes more evenly distributed than they are today. Only of secondary importance is, in my mind, the avoidance of climate-related damages in rich countries.

How do we face up to this challenge? Today at the international level we see hectic activity around the negotiation table.

The starting point of the current international negotiations can be traced back to the UN conference on environment and development that took place in Stockholm in 1972 (United Nations Conference on the Human Environment, UNCHE). This marked the first instance when climate change was recognised as a potential problem on the international political arena. Through pressure from the scientific community, the Intergovernmental Panel on Climate Change (IPCC) was established in 1988 with the mandate to assess the current scientific knowledge about climate change and suggest remedies. The first assessment report appeared already in 1990 and led to the UN Conference on Environment and Development in Rio de Janeiro in 1992. There, the UN Framework Convention on Climate Change (UNFCCC) was signed, recognising – although in a non-binding fashion – the need for industrialised countries to somehow control their emissions of greenhouse gases. The Convention entered into force a couple of years later without much discussion, and led to the Kyoto process, which produced the Kyoto Protocol in 1997. Here, binding targets for future

emission of greenhouse gases were established for the industrialised countries, together with three so-called flexibility mechanisms: emissions trading, Joint Implementation and the Clean Development Mechanism. Negotiations on the regulatory frameworks for these mechanisms, as well as issues of the use of carbon sinks and compensation and technology transfers included in the Convention, broke down in late 2000 in The Hague. In the spring of 2001, the Bush administration in the US withdrew from the Kyoto process altogether. The negotiations begun in The Hague nevertheless continued in Bonn in the summer of 2001, where a political agreement on a somewhat watered-down Kyoto Protocol was reached among all countries except USA. This may allow the protocol to be ratified by enough parties to enter into force in a couple of years.

While this is encouraging, it is important to be aware that, first of all, renewed disagreement about technical details in the Kyoto Protocol may still derail the protocol from ever entering into force. Second, the protocol will by itself not affect the climatic development in any perceptible manner (see Figure 17 for an illustration of the effect of a protocol that includes the USA). Without USA, global emission reductions will be virtually nil. The problems experienced in the negotiations of the Kyoto Protocol may be an indication of how far we have yet to go before important segments of our civilisation take the climatic problem seriously.

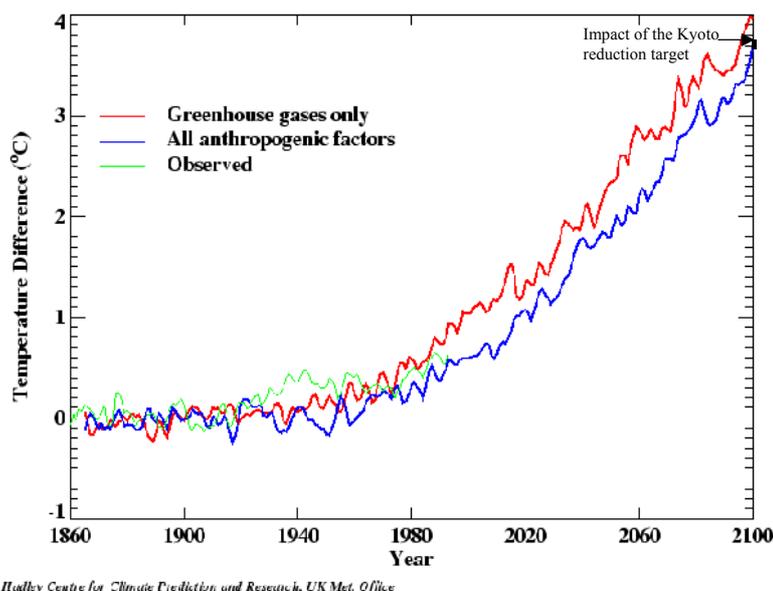


Figure 17. The climatic effect of the Kyoto Protocol including USA. (Source: Wigley, 1998)

6 The way forward: Some concluding comments

However, what is nearly certain is that the climate problem will not disappear – rather it is likely that it will be more forcefully felt in the years to come. Which option then remains for finding a path towards a solution to the climate problem?

Climate change is a complex issue, spanning coupled, non-linear bio-physical systems, economic concerns, and societal processes and responses, all taking place within an environment of uncertainty and playing out over many time scales. At the bottom of this is, however, a fundamental issue all too familiar to human kind: the sharing of limited resources.

To avoid unnecessarily harmful climate change (whatever that is), we have to accept the limited capacity of the atmosphere to store greenhouse gases. The problem is complicated both by the time lag involved, in that today's emissions will mainly affect future generations, but also by the fact that those most vulnerable to climate change, namely the poor majority of the Earth, are not the ones responsible for the bulk of the emissions. (They may be in the future, but that is another story.) Thus, the climate issue is but one of many issues to be faced in the general conflict over how to share the limited resources of the world among the rich as well as the poor. In particular, underlying the response of the rich world to the problem of climate change is the question of solidarity between those who have reaped the benefit of a fossil fuelled period of economic growth and those who will not be able to follow this path because of the climate consequences. We cannot secure a sustainable future without tackling this overriding problem.

The current state of affairs in terms of emissions, technology, and not least negotiations clearly shows that important countries and segments of countries have yet to recognise the reality, the long-term and lasting nature, and the ethical dimension of the climate problem. One might argue, although with less and less credibility, that human activity at present does not affect the climate. Few would, however, argue that a continuing increase in greenhouse gas emission would not have an eventual future impact. While some might argue that the overall impact will be benign, this is at best only true for a few already well-off regions of the world, and certainly not true for regions where the majority of people live. Some might argue that we are better off learning more about the issue before acting. However, the enormous size of the task makes it intuitively clear that we had better start with mitigating and adapting action sooner rather than later. While it is true that we have some time before our cleaner oil reserves run out and we are forced to rely on coal energy, common sense should dictate that we use this time to develop the technology, the regulatory mechanisms, and the understanding of the climate issue that we will need to tackle the global challenge in the long term. Thus, the current period should be a time for developing the necessary tools that we will have to apply tomorrow. This implies at least three tasks: First, we will have to educate the public about the challenges we will face in the future so that the necessary policy measures will be seen as legitimate. Second, we will have to create incentives for developing economically viable non-fossil based technologies, possibly with interim carbon capture and storage solutions. And third, we will need to design national climate policies that allow for regionally, and ultimately globally, cost-effective solutions.

This is particularly important in the light of creating incentives for abatement – incentives that could be carried over to developing countries. Thus by informing the public, developing technology, and designing effective policy, Europe can contribute to the sustainable development of the world as a whole.

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