German Institute
for Economic Research
(DIW Berlin)
Koenigin-Luise-Str. 5
14195 Deutschland
customerservice@diw.de

DIW Berlin

Weekly Report

No. 12/2005

DIW Berlin electronic edition – available online only

Volume 1/April 28th 2005

Contents

Global Climate Protection – Immediate Action Will Avert High Costs

- Delayed climate protection will accelerate climate change impacts
- Clashes of interest and doubts hampering agreement on international climate protection
- Radical transformation of energy systems required
- What price climate protection?
- The WIAGEM model
- What good is climate protection?
- Conclusion

Editorial Board

Klaus F. Zimmermann
Tilman Brück
Dörte Höppner
Claudia Kemfert
Georg Meran
Bernhard Seidel
Viktor Steiner
Alfred Steinherr
Gert G. Wagner
Axel Werwatz
Christian Wey

ISSN 1860-3343
Price: Euro 10.–
Annual Subscription Rate: Euro 300.–
www.diw.de/english/produkte/publikationen/weeklyreport

All articles are protected by copyright.

Global Climate Protection – Immediate Action Will Avert High Costs

Claudia Kemfert

The anthropogenic climate change will persist if the global volume of greenhouse gas emissions will not be reduced significantly. A dangerous and irreversible climate change will occur if atmospheric concentrations of greenhouse gases in the year 2100 exceed 450 ppm and global surface temperature is 2 °C higher than its preindustrial level. The consequence of exceeding these limits would be both more frequent and more violent extreme climate events. In order to avoid this, it is necessary to stabilize global greenhouse gas concentrations at nearly today's level.

Significant emission reduction would require the countries that are primarily responsible immediately implementing emissions-reducing measures. If climate policy measures are not introduced, global climate change damages amounting to up to 20 trillion US dollars can be expected in the year 2100.[1] If such measures are not implemented now, but only in 20 or 30 years' time, it will not be possible to prevent the rise in global surface temperature exceeding the 2 °C limit. Moreover, the costs of a climate protection policy launched today are likely to be lower than a policy initiated only in 20 years' time, which would then be based on drastic measures. The sooner a policy of climate protection is implemented, the fewer climate change damages humankind will face in future decades. The costs of an active climate protection policy implemented today would reach globally around 430 billion US dollars in 2050 and around 3 trillion US dollars in 2100. A climate protection policy that entered into force only in 2025 would imply additional costs of up to 50 billion US dollars in 2050 and 340 billion US dollars in 2100. Global climate damages of up to 12 trillion US dollars can be avoided in 2100 if active climate protection policy is implemented as rapidly as possible.

In Germany, a climate protection policy that immediately implements effective measures would cost 5.7 billion US dollars in 2050 and 40 billion US dollars in 2100. At the same time, however, climate change damages amounting to 33 billion US dollars in 2050 and 160 billion US dollars in 2100 would be avoided.

[1] The numbers specified in this report refer to the actual year and are real values of 2002.

Delayed climate protection will accelerate climate change impacts

The global earth surface temperature will increase sharply in the future as a consequence of a rise of climate-damaging greenhouse gas emissions, in particular carbon dioxide emissions. The Intergovernmental Panel on Climate Change (IPCC) has reported that an increase in global concentrations of carbon dioxide to between over 450 ppm and 1000 ppm in 2100 would lead to an increase in global surface temperature of between 2 °C (Celsius) and 5.8 °C. A temperature rise amounting to over 2 °C compared to preindustrial levels will result in significant climate change and major economic costs.[2]

A higher surface temperature will lead to a rise in the sea level.[3] If it is assumed that the combustion of fossil energy sources is not curbed, then global concentration of emissions will greatly exceed the critical level of 450 ppm of carbon dioxide concentration as early as the second half of this century, thereby generating a temperature increase of up to 5 °C over the next three centuries.[4] The consequences will be severe climate fluctuations and extreme weather events such as storms, floods caused by heavy rains, and cold and heat waves. Such extreme climate events could become both more frequent and more intense.

Estimates of future climate change damages are highly uncertain. One of the reasons the uncertainties and margins of fluctuation regarding potential consequences are so great is that the effects are subject to temporal and spatial disparities. The positive effects of a climate protection policy pursued in Europe today, for example, will not necessarily also be felt in Europe. They could equally materialize in Southeast Asia, where exposed island nations might perhaps be spared a flood produced by a rise in the sea level. Moreover, as a result of the time delay and the long life span of greenhouse gases in the atmosphere, these potential effects will emerge in the distant future. Such uncertainties render the formulation and implementation of a constructive and determined global political strategy both complicated and arduous.

Clashes of interest and doubts hampering agreement on international climate protection

Greenhouse gas emissions and consequently greenhouse gas concentrations have been rising constantly over the last few decades.[5] Today, carbon dioxide concentrations already amount to close to 400 ppm (cf. figure 1). The main producers of greenhouse gas emissions are industrialized countries with high per capita energy consumption and high levels of emissions, such as the USA, Europe, and Japan. Meanwhile, China's energy-intensive growth has already led to this country moving into second place amongst worldwide emitters of CO_2.

The entry into force of the Kyoto Protocol means that most of the industrialized countries have now committed themselves to reducing their greenhouse gas emissions (very moderately overall) over the period 2008 to 2012. However, efforts to obtain international agreement on effective climate protection measures are proceeding sluggishly, and it appears doubtful that definite and binding emissions targets for the period following the Kyoto Protocol's first commitment period, which expires in 2012, will be implemented globally. While Germany and the European Union are pushing for binding commitments on climate protection and have themselves already adopted numerous measures, other countries reject these demands. And yet it is vital that the USA join an international climate protection agreement so as to persuade countries such as China and India – by way of good example – to also take action.

In the discussion as to when climate protection measures should be adopted, the following elements are particularly important:

Some critics do not believe sufficient proof has yet been provided that climate change is a consequence of human activity. They advocate first carrying out further climate research and observation of climate trends before investing in costly measures. The response of those in favor of climate protection is that the well-founded suspicion of anthropogenic climate change is sufficient to justify measures, almost as a kind of insurance against potential damages. In particular, they argue, the risk of irreversible damage necessitates early action.[6]

---

[2] Cf. Claudia Kemfert: 'The Economic Costs of Climate Change.' In: *DIW Berlin Weekly Report*, no. 2/2005. The scenarios presented in the two Weekly Reports diverge with respect to the temperature limit.

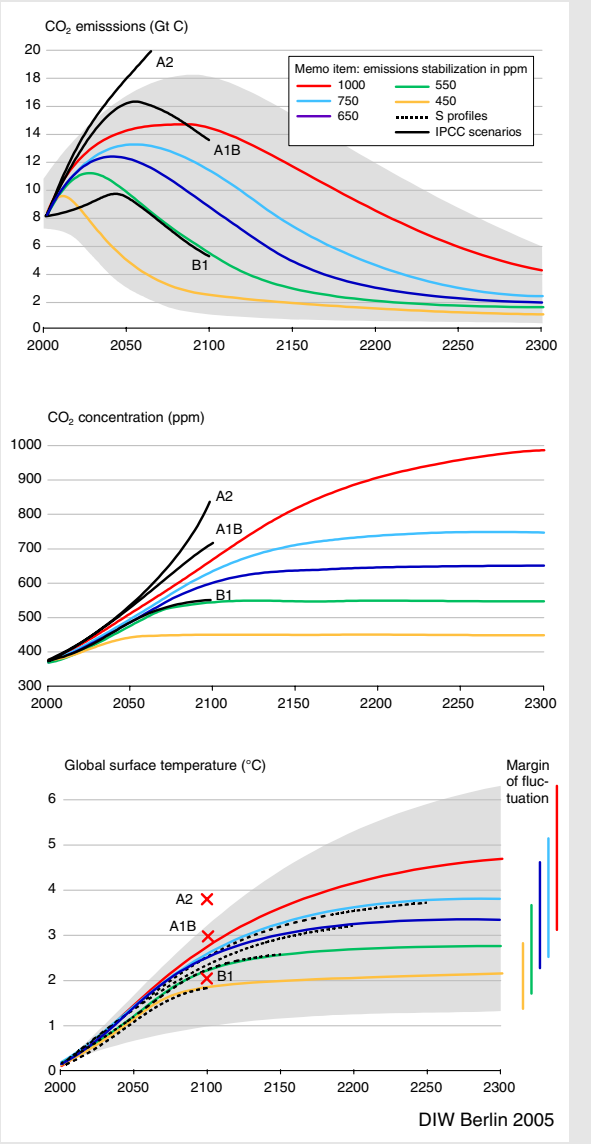
[3] Cf. Intergovernmental Panel on Climate Change (IPCC): 'Climate Change 2001. Third Assessment Report. Synthesis Report.' Cambridge University Press. Cambridge 2001.

[4] Ibid.

[5] Cf. Hans-Joachim Ziesing: 'Worldwide climate protection policy – still no visible success.' In: *DIW Economic Bulletin,* vol. 41, no. 10, October 2004; Hans-Joachim Ziesing: 'Carbon Dioxide Emissions in Germany. Stagnating in 2004.' In: *DIW Berlin Weekly Report*, no. 9/2005; Hans-Joachim Ziesing and Franz Wittke: 'Primärenergieverbrauch in Deutschland von hohen Energiepreissteigerungen und konjunktureller Belebung geprägt.' In: *DIW Berlin Wochenbericht*, no. 7/2005.

Figure 1

Temperature and Emissions Trends under Different Scenarios[1] (IPCC)



1 Scenario A2: low per capita economic growth.
Scenario A1B: balanced use of fossil fuels and alternative energy sources.
Scenario B1: high GDP and population growth, but stronger growth again in service and information sectors.
Sources: IPCC (2001).

Another argument in favor of postponing the implementation of climate protection measures is that technical progress will make such measures cheaper in the future. It would therefore be better, the argument goes, to invest today in appropriate research measures. The response to this argument is that technical progress and cost reductions might be achieved most effectively if the technology is not developed in the research laboratory, but in practice via 'learning by doing.' Moreover, measures adopted at a later date would have to be much more drastic and implemented over a much shorter period time in order to achieve the necessary level of atmospheric greenhouse gas concentrations.[7]

Advocates of early measures point out that the climate system reacts to human intervention only after enormous time delays. It is therefore necessary, they argue, that we start with climate protection measures today if we are ever to succeed in stabilizing the concentration of greenhouse gases at today's levels. Immediate action could substantially mitigate the foreseeable climate change damages.[8]

However, without clear-cut allocation of the costs of climate change and specification of the advantages of climate protection, it will be very difficult in political terms at international level to push through explicit emission reduction measures that apply to the years following the expiry of the Kyoto Protocol's first commitment period in 2012. In particular, it will not be easy to win over those countries that refuse point blank to implement active climate protection policies. Many of these countries argue that climate protection measures are too expensive today and that postponement would open up the possibility of more economical options for reducing greenhouse gas emissions.

Radical transformation of energy systems required

It will only be possible to stabilize greenhouse gas concentrations at today's level by the year 2100 if the energy system is completely restructured and the energy demand for fossil fuels drastically reduced (cf. figure 2).[9] At the same time, the share of renewable energy sources such as wind, biomass, and solar energy would have to be substantially increased.

But alternative fuels will have to play an important role in the realm of transportation as well, and especially

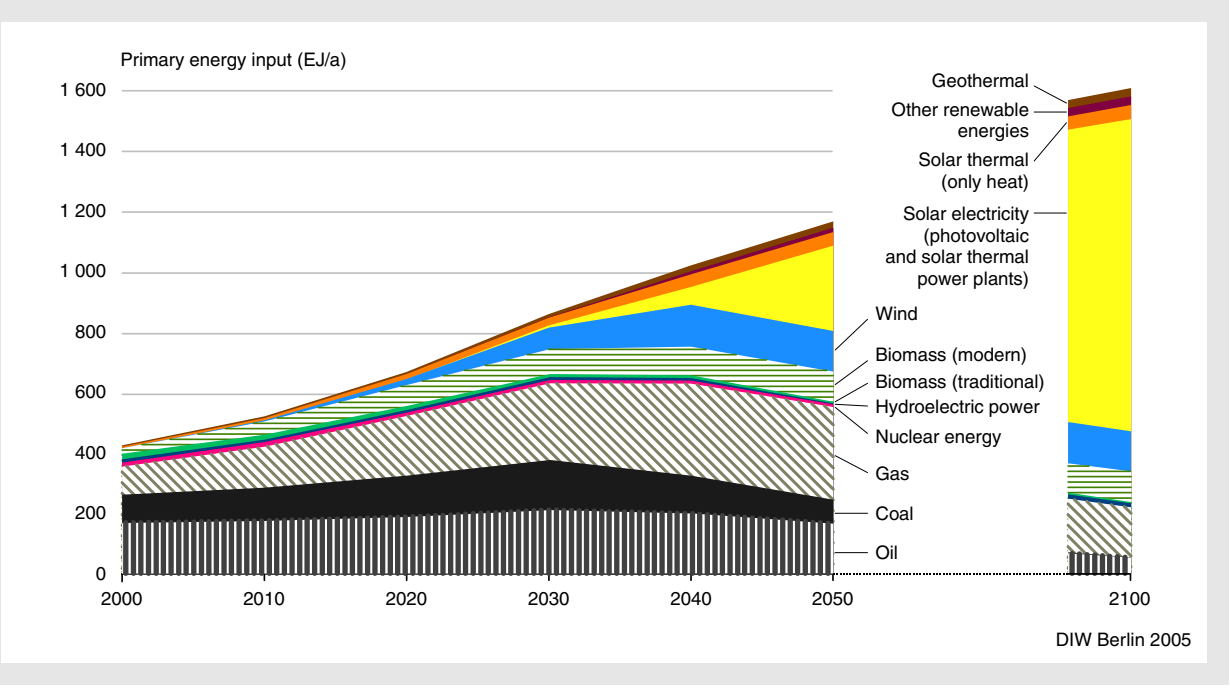
[6] Björn Lomborg: 'Global Crisis, Global Solutions.' Cambridge University Press. Cambridge 2004. The discussion has been summarized in the Copenhagen Consensus. Cf. *www.copenhagenconsensus.com*, data from 16 March 2005.

[7] W. Nordhaus: 'Modelling Induced Innovation in Climate Change Policy.' In: A. Grübler, N. Nakicenovic, and W. Nordhaus (eds.): 'Technological Change and the Environment: Resources for the Future.' Washington, D.C. 2002, pp. 97-127.

[8] Stefan Rahmstorf: 'Rote Karte für die Leugner.' In: *Bild der Wissenschaft*, no. 1, 2003, pp. 56-61.

[9] Cf. German Advisory Council on Global Change (WBGU): 'Welt im Wandel: Energiewende zur Nachhaltigkeit.' Berlin 2003, pp. 94-98.

Figure 2
Change in Global Energy Mix (Example Path) by 2050/2100



Source: German Advisory Council on Global Change (2003).

in the area of individual, motorized transportation.[10] Numerous policy options are available to this end. In addition to economic instruments such as emissions trading, ecological taxes, and international kerosene tax, other potentially promising measures to reduce greenhouse gas emissions in the long term might give financial incentives in favor of climate-friendly technology such as renewable energy for electricity production or alternative fuels for transportation.

What price climate protection?

Model calculations carried out using the WIAGEM simulation model[11] (cf. box) show that stabilizing emissions at the level of 450 ppm of carbon dioxide equivalents would have a global cost of 430 billion US dollars in

[10] Cf. Dominika Kalinowska: 'Alternative Kraftstoffarten im Straßenverkehr.' In: *DIW Berlin Wochenbericht*, no. 5/2005.

Box

The WIAGEM model

The WIAGEM model was developed to provide a means to determine the long-term economic effects of climate change and climate policy. It combines a dynamic trade model with simplified climate and ecosystem models.

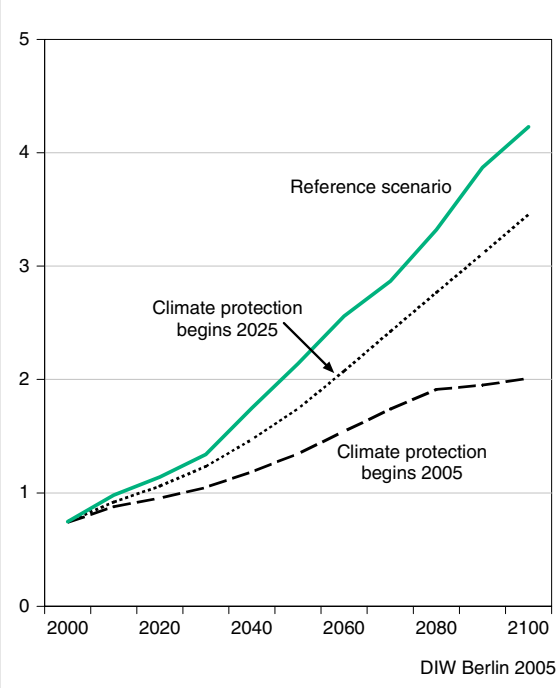
The model simulates economic events over a time span of 100 years (until the year 2100) for the world regions of Africa, Asia, Europe, Japan, Latin America, Middle East, and USA. The integration of an economic model with a climate model and an ecosystem model enables the quantification in economic terms of the effects of variations in the temperature and the sea level. By precisely modeling the energy markets for fossil energies and the potential replacement of these by renewable energy sources, it becomes possible to assess the effects of a transformation of the energy system.

In addition, the model integrates the economic costs of changes in human health, the ecosystem, and spending on climate damages before and after the occurrence of extreme climate events. This allows a detailed estimation of the economic losses induced by climate change.

Figure 3

Temperature Increase Compared to Preindustrial Levels

Temperature increase in °C



Sources: WIAGEM model simulation; DIW Berlin calculations.

2050 and around 3 trillion US dollars in 2100 (cf. figure 3). These are costs that would arise if the appropriate measures were implemented immediately. In addition to the concrete elements of climate protection policy at domestic level, such measures also include what are known as flexible instruments, such as the Clean Development Mechanism (CDM), Joint Implementation (JI), and emissions trading. In Germany, a climate protection policy of this kind would cost 5.8 billion US dollars in 2050 and 40 billion US dollars in 2100. Climate damages amounting to 33 billion US dollars in 2050 and 160 billion US dollars in 2100 could be avoided in Germany alone on the basis of this climate protection policy (cf. table).

Apart from the need to begin implementing climate protection measures today, it is also necessary to make targeted investment in research and development so as to develop more economical ways of reducing greenhouse gas emissions in the future.[12] If, for example, investment were made today in research into the possibility of a 'CO_2-free power plant,' this technology could be used at low cost in the long term.

Another scenario proceeds from the assumption that climate protection policy is not implemented until 2025. In this case, a total of 3.3 trillion US dollars (2002 prices) would have to be spent globally in 2100. This postponement alone would engender additional costs of around 340 billion US dollars. The increase in costs would be a result, first and foremost, of the fact that over time ever more drastic measures will be required to achieve the target. Moreover, in a scenario of this kind, investment in research into new technology would be made only later. As a result, the associated cost savings would also only be realized at a later date. An additional finding under this scenario is that if measures to reduce greenhouse gas emissions are adopted only in 2025, it will then no longer be possible to achieve the temperature target of a maximum increase of 2 °C by 2100; instead, global surface temperature will rise by 3.5 °C by 2100 (cf. figure 4).

What good is climate protection?

In the absence of climate protection policy, the year 2100 could bring climate change damages amounting to up to 20 trillion US dollars (at 2002 prices). If climate protection policy were introduced in 2025, the damages in 2100 could amount to up to 15 trillion US dollars. Under these conditions, the damages incurred as a result of climate change would be much higher in the second half of this century than if climate protection policy were initiated today. For if this were the case, then damages amounting to 2.5 trillion US dollars could be avoided in 2050, and damages of up to a hefty 12 trillion US dollars could be averted in 2100. Moreover, in view of the long life span of greenhouse gases in the atmosphere, an active climate protection policy that commences at a later date would not succeed in reducing climate damage to the required extent. According to this thesis, climate damages can thus only be avoided if the implementation of far-reaching climate protection policy commences immediately.

Conclusion

The IPCC and the German Advisory Council on Climate Change (WBGU) believe that if by the year 2100 global

[11] Claudia Kemfert: 'An Integrated Assessment Model of Economy-Energy-Climate – The Model WIAGEM.' In: *Integrated Assessment*, 2002, vol. 3, no. 4/2002, pp. 281-299.

[12] Cf. Claudia Kemfert: 'Induced Technological Change in a Multi-regional, Multi-sectoral Trade Model.' In: *Ecological Economics*, Special Issue, 2005 (in press).

Table

Costs of Climate Protection and Climate Damages in 2002

Billion US dollars[1]

	Cost of climate protection				Climate damages			
	Climate protection commences							
	2005		2025		2005		2025	
	2050	2100	2050	2100	2050	2100	2050	2100
Japan	59.54	415.70	66.09	463.01	182.80	467.83	522.97	2 124.31
China	11.63	81.20	12.91	90.45	35.71	91.39	102.16	414.98
Asia[2]	12.31	85.97	13.67	95.75	37.80	96.75	108.15	439.32
USA	137.67	961.19	152.81	1 070.59	422.68	1 081.74	1 209.23	4 911.93
Canada	5.53	38.58	6.13	42.97	16.97	43.42	48.54	197.16
Europe	16.03	111.88	17.79	124.62	49.20	125.92	140.76	571.75
of which: Germany	5.77	40.30	6.41	44.89	17.72	45.35	50.70	205.94
Russia	9.03	63.02	10.02	70.19	27.71	70.92	79.28	322.02
Latin America	108.00	754.07	119.88	839.89	331.60	848.64	948.66	3 853.46
Africa	30.74	214.63	34.12	239.06	94.38	241.55	270.02	1 096.84
Others	40.25	281.05	44.68	313.04	123.59	316.30	353.57	1 436.23
Total	430.73	3 007.29	478.11	3 349.57	1 322.45	3 384.46	3 783.34	15 368.00

1 Discounted to 2002. — 2 Asia: Not including Japan or China.
Sources: WIAGEM model simulation; DIW Berlin calculations.

concentrations of carbon dioxide have risen above 450 ppm and, by association, global surface temperature has increased by over 2 °C, then the human-induced impact on the climate will have attained a dangerous level. Model simulations show that if emissions mitigation does not commence until 2025, these target values will be exceeded. It will only be possible to achieve the target of a maximum temperature increase of 2 °C by 2100 if active climate protection policy starts today.

The economic costs of climate change are substantial. However, if active climate protection policy starts today then, notwithstanding climate costs of around 3 trillion US dollars, hefty damages of up to 12 trillion US dollars could actually be avoided in 2100; this amounts to around 5% of the estimated global GDP for 2100.[13] If active climate protection policy does not commence until 2025, then climate damages amounting to 15 trillion US dollars must be expected for 2100.

The costs of a well-timed active climate protection policy would amount to around 430 billion US dollars in 2050 and around 3 trillion US dollars in 2100. If, however, climate protection policy were not initiated until 2025, the result would be additional costs of up to 50 billion US dollars in 2050 and 340 billion US dollars in 2100. But the rise in global surface temperature would then amount to 3.5 °C in 2100 (compared to preindustrial levels), which would lead to much more substantial climate change damages. In Germany, climate protection policy would cost 5.8 billion US dollars in 2050 and 40.3 billion US dollars in 2100. In Germany alone, this policy would prevent climate damages amounting to 33 billion US dollars in 2050 and 160 billion US dollars in 2100.

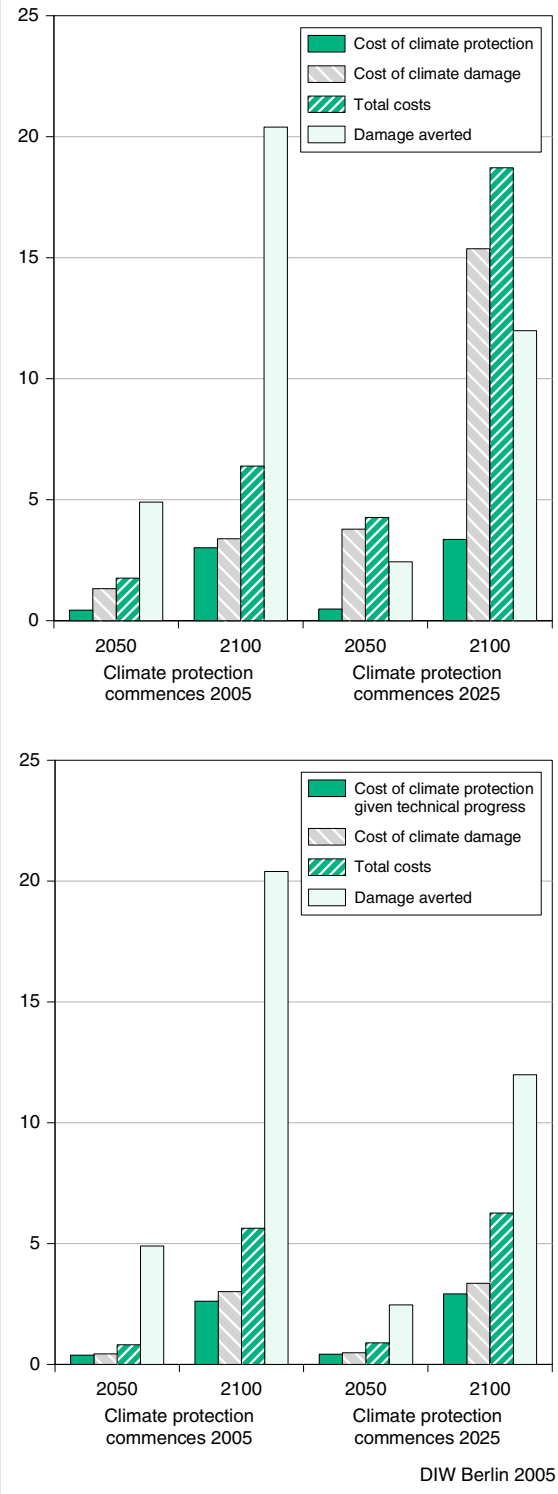
These are the reasons why a long-term, target-oriented climate protection policy should be implemented

[13] Different IPCC scenarios are based on different assumptions about the growth of the national economies. Cf. Intergovernmental Panel on Climate Change (IPCC): 'Emission Scenarios.' Geneva 2000, pp. 360-580.

Figure 4

Cost of Climate Protection Action and Inaction with Technical Progress

Billion US dollars



Sources: WIAGEM model simulation; DIW Berlin calculations.

as rapidly as possible at both national and international level. Currently, significant effort is still required at global level even only to achieve the moderate goals of the Kyoto Protocol. At the same time, targets and policies must be formulated for the years subsequent to the first commitment period (2008 to 2012) so as to avoid long-term climate damages in a cost-effective manner.