European Environment Agency

Kiev report:

Final Draft Chapter:
3. Climate Change

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3. Climate change

Global mean temperature has increased by 0.6 °C (in Europe about 1.2 °C) over the past 100 years and the 1990s was the warmest decade for 150 years. Global and European mean temperatures are projected to increase by 1.4 to 5.8 °C between 1990 and 2100, with larger increases in Eastern and Southern Europe. The proposed EU target to limit temperature increase to a maximum of 2 °C above pre-industrial levels will therefore be exceeded during this century. Sea level rose by 0.1 to 0.2 meters, globally and in Europe, during the last century. It is projected to rise by an additional 0.1 to 0.9 meters by 2100. Global precipitation increased by about 2 % during the last century, with Northern Europe and Western Russia getting 10 to 40 % wetter, with a further projected increase of 1 to 2 % per decade. In summer 2002 heavy rainfalls caused a floods in central Europe. The risk of floods is projected to increase, but river management and urban planning may be contributory factors. Droughts are likely to become more frequent in other areas of Europe.

Greenhouse gas emissions in the EU fell by 3.5 % between 1990 and 2000, about halfway to the Kyoto target, assuming the use of domestic measures alone. Decreases from energy industries, the industry sector, agriculture and waste were partly offset by increases from transport. Substantial further reductions are needed to reach the national (burden-sharing) targets. Emissions in Central and Eastern European countries fell by 34 % between 1990 and 1999 and most of these are on track to reach their Kyoto targets. Emissions in some countries, however, have started to increase again as their economies recover. Emissions in the Newly Independent States fell by almost 40 %, mainly due to economic and structural change.

Many European countries have adopted National Programmes addressing climate change. Key policies and measures include carbon dioxide taxes, domestic emission trading schemes, renewable energy for electricity production (wind, solar, biomass), combined heat and power, abatement measures in industry, and measures to reduce emissions from landfills. A key proposal is for a Directive on a EU-wide emission trading scheme, which is expected to lower the compliance costs of the Kyoto Protocol.

Climate mitigation costs in Western Europe can be reduced significantly through the use of the Kyoto mechanisms (joint implementation and emission trading). Russia, which will have a significant surplus of emission allowances by 2010, will have a central role in the future market for greenhouse gas allowances. The costs of domestic measures in Western Europe are about 21 billion euro per year, while a scenario that assumes optimal banking of allowances by Russia would decrease these costs to a total of about 9 billion euro/year. Climate change policies can have significant positive effects ("co-benefits") by also reducing emissions of air pollutants and thus costs to abate air pollution.

Sequestration in land use change and forestry ('carbon sinks') can be used to meet Kyoto targets, under some circumstances, with additional allowances amounting to about 2 to 4 % of 1990 emissions for some Western European countries.

3.1. The issue

Global and European average temperature is increasing, sea level is rising, glaciers are melting and the frequency of extreme weather events and precipitation are changing. Most of the warming can be attributed to emissions of greenhouse gases from human 7activities. Climate change is expected to have widespread consequences, including an increased risk of floods, impacts on natural ecosystems and biodiversity, human health, water resources and on economic sectors, such as forestry, agriculture (food productivity), tourism and the insurance industry.

Climate change is addressed by the UN Framework Convention on Climate Change and the Kyoto Protocol, which sets binding targets for industrialised countries to reduce their greenhouse gas emissions. By August 2002, 91 countries, among them 25 industrialised countries, have ratified the Kyoto Protocol, although the US announced in 2001 it does not intend to ratify. The Protocol is expected to enter into force in 2003, after Russia will have ratified. The Protocol is a first step towards the more substantial global reductions (50 to 70%) that will be needed to reach the long-term objective of achieving 'sustainable' atmospheric greenhouse gas concentrations.

Many countries have adopted National Programmes that focus on reducing greenhouse gas emissions. Reductions in greenhouse gas emissions can be achieved through policies and measures aimed at all socio-economic sectors that emit greenhouse gases, in particular the energy and transport sector, since carbon dioxide from fossil fuels is the most important greenhouse gas.

However, even immediate large reductions in emissions will not prevent some climate change and environmental and economic impacts. Measures in various socio-economic sectors will therefore also be necessary to adapt to the consequences of climate change.

Climate mitigation costs can be reduced significantly through the use of the Kyoto mechanisms. For CEE and NIS Joint Implementation (JI) and Emission Trading will be important. In many economies in transition in Eastern Europe investments in the energy sector are needed, and greenhouse gas mitigation costs in Eastern Europe are lower than in Western Europe. Also the use of "carbon sinks" gives countries additional flexibility for the fulfilment of their Kyoto commitments. Apart from avoiding negative impacts of climate change, climate change policies can also have significant positive effects ("co-benefits") on air pollution, in terms of reduced emissions of air pollutants and reduced costs to abate air pollution (see the chapter on air pollution).

Although there have been some successes, with some countries on track towards achieving their Kyoto Protocol targets, many of the improvements have resulted from one-off changes and further action at all levels, affecting all economic sectors, will be needed if national Kyoto targets are to be met. Beyond Kyoto, the challenges of achieving 'sustainable' greenhouse gas concentrations are large, particularly if the economies and lifestyles of the Central and Eastern European countries and the Newly Independent States move towards the levels currently enjoyed by most Western European countries.

3.2. Climate change and sustainability

Signs of a changing climate have been observed on a global and European level. The clearest indicator is the considerable increase in temperature over the past 150 years. A rise in sea level and changes in precipitation and extreme weather events have also been observed in Europe during the past 50 years. Other signs include a retreat of mountain glaciers and a decrease of snow cover (IPCC, 2001a).

3.2.1 Sustainable targets for climate change

At the global level, the ultimate objective of the UN Framework Convention on Climate Change (UNFCCC) is to reach atmospheric concentrations of greenhouse gases that prevent dangerous anthropogenic interference with the climate system, but allow sustainable economic development. Achieving such 'sustainable' levels would require substantial (50 to 70 %) reductions of global GHG emissions (IPCC, 2001a, 2001c). The EU, in its sixth Environmental Action Programme, has proposed that global temperatures should not exceed 2 °C above pre-industrial levels, which means 1.4 °C above current global mean temperature (European Parliament and Council, 2002). Consistent with the

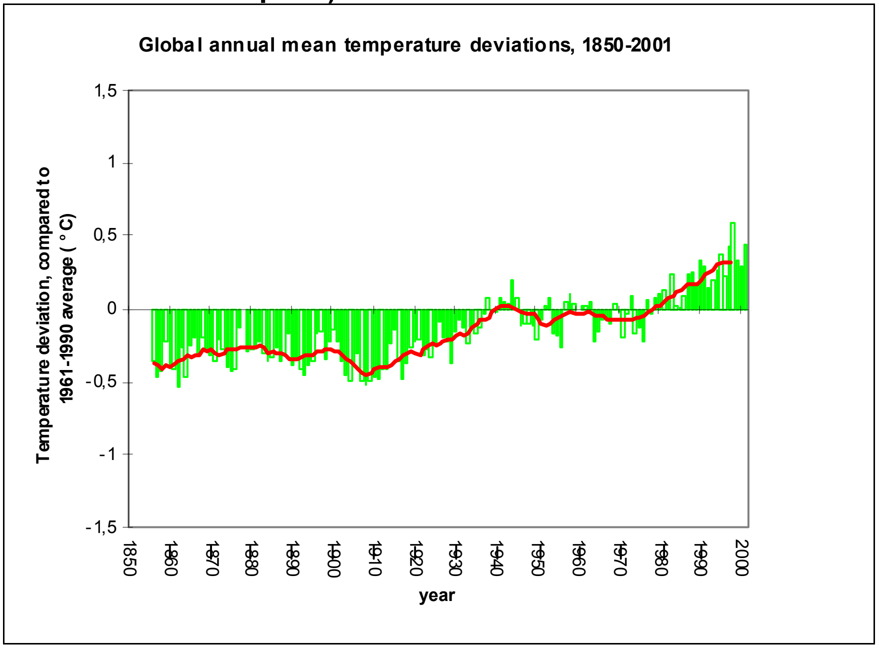
EU proposal, an additional ‘sustainable’ target has been proposed: to limit anthropogenic warming to 0.1 °C per decade (Leemans, 1998). There are no agreed ‘sustainable’ targets for sea level rise or other climate change indicators. However proposals have been made (Leemans, 1998) to limit sea level rise globally to 20 mm per decade.

Comparing these proposed indicative targets with projections of temperature increase and sea level rise (see section 2.2 and 2.3) shows that it is likely that these targets will be exceeded during the next 50 to 100 years. Achieving ‘sustainable’ levels of greenhouse gas concentrations and related climate change is likely to be one of the most difficult environmental challenges of the century.

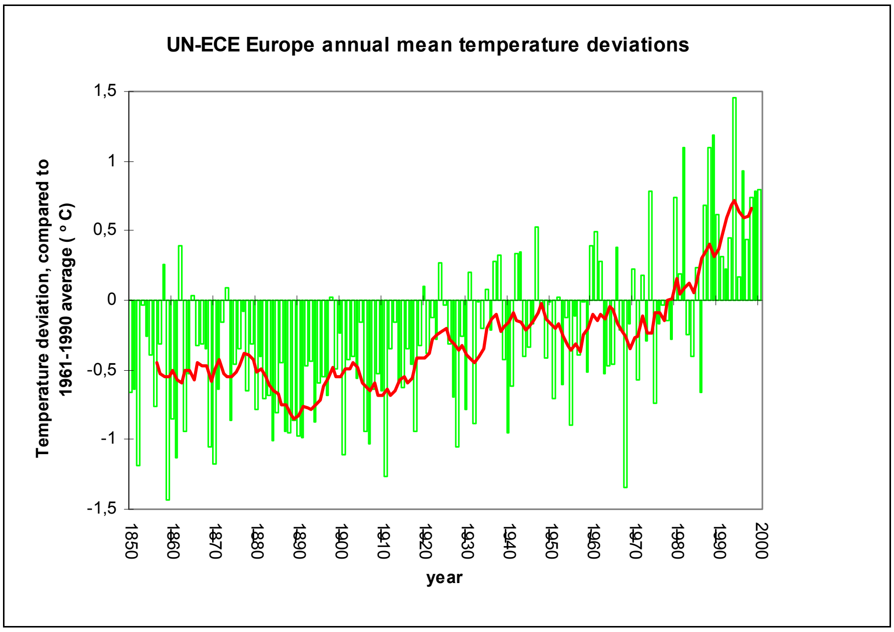
3.2.2 Temperature increase

Globally, surface air temperatures have been recorded systematically since the middle of the 19th century. There is new and stronger evidence that most of the warming observed over the past 50 years is attributable to human activities. Confidence in climate models has increased: when fed with data on past anthropogenic emissions they calculate changes similar to those that have actually been observed (IPCC, 2001a).

Figure 3.1. Observed annual average temperature deviations (Global and European)



Source: Climatic Research Centre (CRU), 2002



Source: Climatic Research Centre (CRU), 2002

Notes: Temperature is presented as the difference (deviation) from the 1961 to 1990 average (C). The bars show the annual average and the line the 10-year smoothed trend. UNECE Europe includes Siberia.

☹	Over the past 100 years global mean temperature has increased by 0.6 °C (in Europe about 1.2 °C). Global and European mean temperatures are projected to increase by 1.4 to 5.8°C between 1990 and 2100

Over the past 100 years global mean temperature has increased by 0.6 °C, with land areas warming more than oceans (

Figure 3.1). Of the past 150 years, 1998 was the warmest. The 1990s was the warmest decade since the middle of the 19th century and probably also the warmest decade of the millennium. It is likely that the increase in Northern Hemisphere surface temperatures in the 20th century was greater than during any other century in the last 1000 years (IPCC 2001a).

The data for UN-ECE Europe (which includes Siberia) show that the temperature increase up to 2001 is consistent with the global trend and amounts to about 1.2 °C over the past 100 years (

Figure 3.1). If Siberia is excluded, the temperature rise in Europe is lower.

Observations up to March 2002 indicate that in Europe (including Siberia) 2002 will probably experience a new record over the past 100 years because of an extreme warm start of the year: January, February and March were on average about 3.7° C warmer than the 1961-1990 average.

The warming in Europe has been largest over Russia and the Iberian Peninsula and least along the Atlantic coastline. The temperature changes are larger in the winter season, in line with the global trend. In the summer season southern Europe warms at twice the rate of northern Europe. Cold winters are expected to nearly disappear during the next century, and hot summers are expected to become much more frequent (Parry 2000).

According to the IPCC scenarios, global mean temperature is projected to increase by 1.4 to 5.8 °C from 1990 until 2100 (IPCC, 2001a). The range reflects the uncertainty of climate change models, but is due mainly to different scenarios for greenhouse gas and sulphur dioxide emissions over the next 100 years, based on different assumptions on population growth and socio-economic developments. On average, the temperature in Europe is projected to increase by 0.1 to 0.4 °C per decade over the next 100 years. The largest increase is projected for Eastern and Southern Europe, in particular the Iberian Peninsula, with increases of 4 to 8 °C in Siberia and 3 to 6 °C in Southern Spain by 2100, depending on the scenario (IPCC, 2001a).

Comparing these projections with the proposed 'sustainable' targets suggests that the target for absolute global temperature increase might be exceeded by about 2050, whereas the target of not more than 0.1°C increase per decade might be exceeded even earlier.

3.2.3 Sea level rise

The sea level, globally and for Europe, rose between 0.1 and 0.2 m during the 20th century (IPCC 2001a, Parry 2000). Global sea level is projected to rise by 0.09 to 0.88 m between 1990 and 2100, taking into account the full range of emission scenarios (IPCC, 2001a). Future sea level rise in Europe is expected to be similar (Parry, 2000). Due to long term movements in the earth's crust, there are regional differences, because most of Southern and Central Europe is slowly sinking (typically by 5 cm by the 2080s) and much of Northern Europe is rising out of the ocean (Parry 2000).

Comparing this projection with the proposed 'sustainable' target, suggests that the target will be exceeded during the next 100 years.

> ☹ Global and European sea level rose by 0.1 to 0.2 meters during the last century and is projected to rise by an additional 0.1 to 0.9 meters by 2100.

3.2.4 Precipitation change

Global precipitation increased by about 2 % during the last century (IPCC, 2001a), with large variations between continents and also within Europe. Northern Europe and Western Russia are getting wetter with an increase of 10 to 40 % over the last century, whereas Southern Europe is changing little or getting dryer, by up to 20 % in some parts (IPCC, 2001; ECA, 2002).

The intensity of precipitation also changed. Several different indicators show that more intense precipitation events are occurring over many areas in Mid- and Northern Europe, whereas other areas are experiencing more droughts (ECA, 2002). In addition, increasing intensities may result in extreme events like floods. In the UK, for example, the contribution of short-duration precipitation events has increased significantly during the past 40 years (Hulme et. al., 2002).

A third factor related to precipitation is its seasonal variation. Precipitation in winter has changed most (IPCC, 2001a). As a result, water losses in summer due to increasing temperatures are compensated by precipitation increases in winter, potentially leading to more severe droughts.

Climate models project a further increase of precipitation of 1 to 2 % per decade in Northern Europe for this century. In Southern Europe, especially in parts of Spain, Greece and Turkey, precipitation in the summer is projected to decrease by up to 5 % per decade, while the winters may become wetter (IPCC, 2001; RIVM, 2001).

3.2.5. Extreme weather events

Changes in the frequency and characteristics of extreme weather events have been observed in the second half of the 20th century. Climate change models project that further changes are likely in this century (IPCC, 2001a). In Europe, extremely cold winters have been less frequent in recent decades and may become rare by the 2020s, whereas hot summers are likely to become more frequent (Parry, 2000). An increase in maximum temperatures and the number of hot days was observed during the second half of the 20th century in various locations in Europe (e.g. UK, Scandinavia, Russia). In the Northern Hemisphere, including Russia and Norway, the proportion of total annual precipitation derived from heavy and extreme precipitation events has increased (IPCC, 2001). In some areas the frequency of heavy rainfalls increased despite a decrease in the total amount of precipitation. In 1995, for example, large parts of North-West Europe became flooded. Likewise, in summer 2002 heavy rainfall in the Erz Mountains in Central Europe caused a so-called 'flood of the century' in Germany, the Czech Republic and Austria.

3.3. Kyoto Protocol targets

3.3.1. Kyoto Protocol targets

Negotiations on an international convention addressing climate change resulted in the adoption of the UNFCCC in 1992. In 1997, the Kyoto Protocol was adopted which sets binding targets for industrialized countries (Annex I Parties) to reduce their GHG emissions by 5 % by 2008-2012 compared with 1990. This is generally seen as a first step towards ultimate objective of the UNFCCC. The Kyoto Protocol covers the greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF_6).

The detailed provisions of the Kyoto Protocol were finally agreed in 2001 with the *Marrakech Accords*, which give Parties flexibility in fulfilling their commitments through the flexible mechanisms *Joint Implementation (JI)*, *Clean Development Mechanism (CDM)* and *Emission Trading (ET)* and the possibility of accounting for carbon sequestered by land use, land-use change and forestry activities ('carbon sinks').

The EU Kyoto Protocol target for 2008-2012 is an emission reduction of 8 % from 1990 levels. According to Council Decision 2002/358/EC, the EU and its Member States agreed on different emission limitation and/or reduction targets for each Member State according to economic circumstances - the 'burden sharing' agreement. According to this, some Member States have to cut their emissions, while others may increase them (Table 3.1.).

Table 3.1. EU Member States' burden sharing targets (EU Council Decision 2002/358/EC)

Member State	Commitment (% change in emissions for 2008 to 2012 relative to base year levels)
Austria	**-13**
Belgium	**-7.5**
Denmark	**-21**
Finland	**0**
France	**0**
Germany	**-21**
Greece	**+25**
Ireland	**+13**
Italy	**-6.5**
Luxembourg	**-28**
Netherlands	**-6**
Portugal	**+27**
Spain	**+15**
Sweden	**+4**
United Kingdom	**-12.5**

The Russian Federation and the Ukraine are committed to keep their 1990 emissions on the same level by 2008-2012, Norway may increase its emissions by 1%, Iceland by 10%. Switzerland and eight Eastern European Accession Countries[1] have to reduce their emissions by 8 %, Hungary and Poland by 6 %, Croatia by 5%. Other European countries do not have binding targets. Non-European countries with a commitment under the Kyoto Protocol are Australia (+8 %), Canada (-6 %), Japan (-6 %), New Zealand (0 %).The United States of America has a target of –7 %, although the US announced in 2001 it does not intend to ratify.

By 30 August 2002, 91 Parties (25 Annex I industrialised countries), responsible for 37 % of the emissions of industrialized countries in 1990, had ratified the Protocol (UNFCCC, 2002). The Kyoto Protocol will enter into force when it has been ratified by at least 55 countries, including industrialised developed countries accounting together for at least 55 % of CO_2 emissions from this group in 1990. In practice this means that Russia would need to ratify to achieve the entry into force, which is expected by the end of 2002 or early 2003.

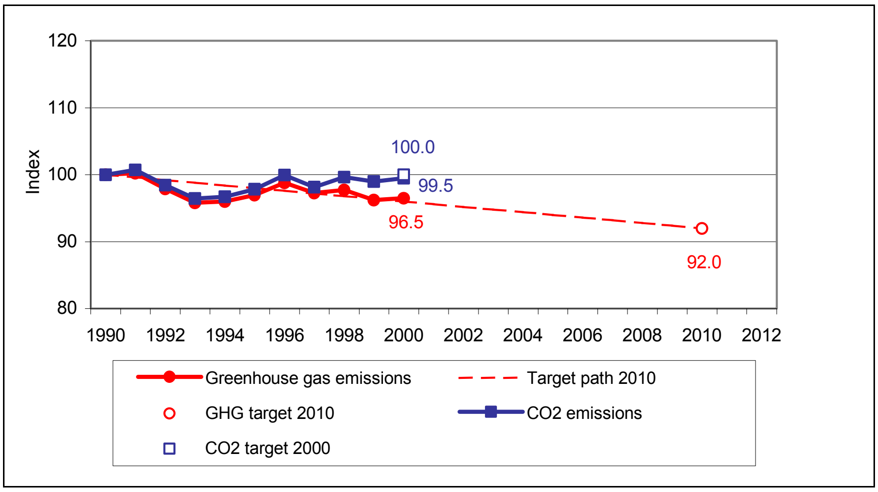
3.3.2. Progress towards targets

3.3.2.1. European Union

Greenhouse gas emissions in the EU fell by 3.5 % between 1990 and 2000. The EU is about halfway towards reaching its Kyoto target (see EEA 2002a), assuming that this will be reached through domestic policies and measures in the EU alone. The possible use of the Kyoto mechanisms and carbon sinks to meet the EU Member States' burden sharing targets is discussed in section 6.4.

[1] Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Romania, Slovakia and Slovenia

Figure 3.2 European Union GHG emissions compared with target for 2008-2012 (excluding land use change and forestry)



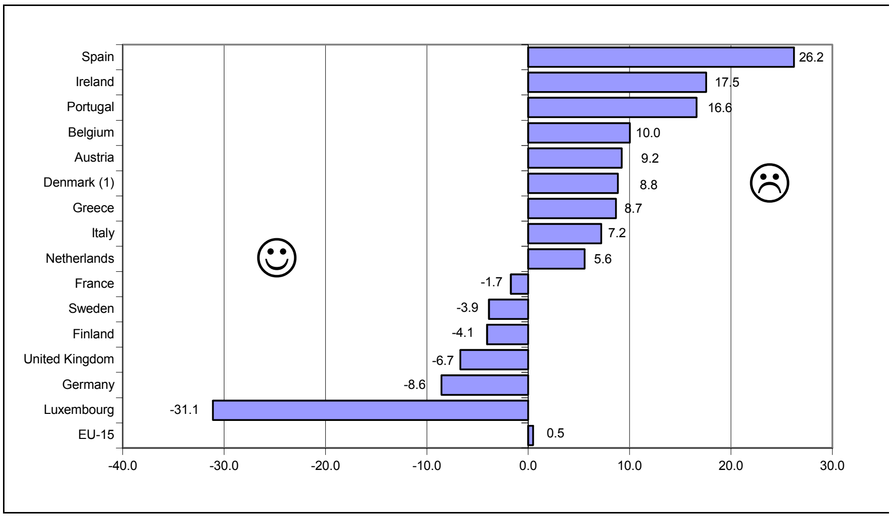
Source: EEA (2002a)

☹ EU greenhouse gas emissions fell by 3.5% between 1990 and 2000, about halfway to the Kyoto target, but substantial further reductions are needed to reach national (burden-sharing) targets.

During the past ten years, considerable cuts in emissions were achieved mainly in Germany (by 19.1 %) and the UK (by 12.9 %), while emissions increased in eight Member States. About half of the emission reductions in Germany and the UK was due to one-off factors (Eichhammer et al., 2001 and Schleich et al., 2001). In Germany, economic restructuring of the five new Länder after reunification resulted in significant emission reductions, particularly in the electricity production sector due to energy efficiency improvements. In the UK, energy markets were liberalised and electricity utilities switched from oil and coal to gas.

Figure 3.3 compares GHG emissions of EU Member States in 2000 with their linear target path for 2008-2012. Nine Member States are well above their Kyoto target path, six are below.

Figure 3.3. Distance to target indicators (in index points) in 2000 for the Kyoto Protocol and burden sharing targets of EU Member States



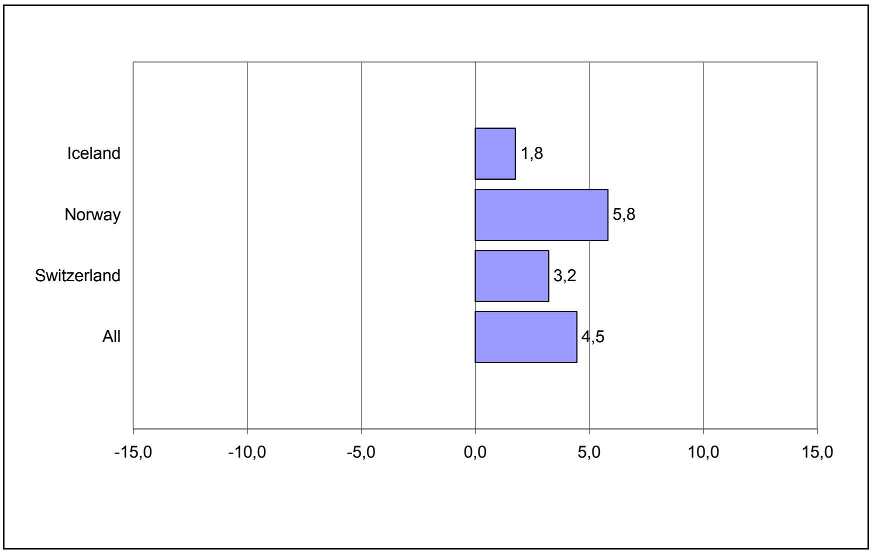
Note: The distance-to-target indicator (DTI) measures the deviation of actual emissions in 2000 from the (hypothetical) linear target path between 1990 and 2010. The DTI gives an indication on progress towards the Kyoto and Member States' sharing targets. It assumes that the Member States meet their target entirely on the basis of domestic measures.
Source: EEA (2002a)

According to the latest EU projections, total GHG emissions in the EU are expected to fall by 4.7 % from the 1990 level by 2010, assuming adoption and implementation of current, but no additional, policies and measures (EEA 2002c). This leaves a shortfall of 3.3% to the target of an 8 % reduction. Only the UK, Germany and Sweden are projected to achieve their Kyoto burden-sharing targets. The transport sector is of particular concern, with emissions projected to increase by more than 25 to 30 % between 1990 and 2010 (EEA 2002c). Substantial further action is therefore needed if the EU is to reach its Kyoto target.

3.3.2.2. Iceland, Norway and Switzerland

Greenhouse gas emissions in Iceland, Norway and Switzerland fell slightly during the first half of the 1990s. During the second half, emissions increased significantly in Iceland and Norway, but hardly changed in Switzerland. In total, between 1990 and 2000, greenhouse gas emissions increased in Iceland (by 6.9 %) and Norway (by 6.3 %) and decreased in Switzerland (by 0.9 %). All these countries are some percentage points above their linear Kyoto target (Figure 3.4).

Figure 3.4 Distance-to-target indicators (in index points) in 2000 for the Kyoto Protocol of Iceland, Norway and Switzerland

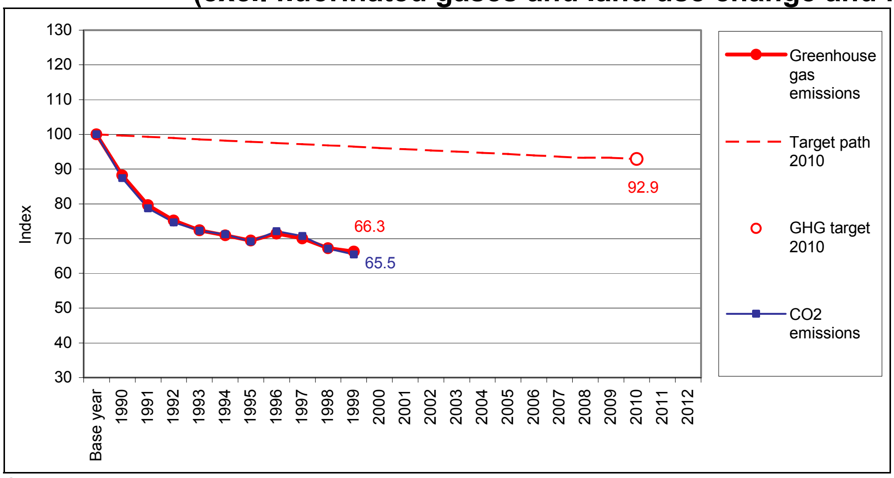


Note: The distance-to-target indicator (DTI) measures the deviation of actual emissions in 2000 from the (hypothetical) linear target path between 1990 and 2010. The DTI gives an indication on progress towards the Kyoto and Member States' sharing targets. It assumes that countries meet their target entirely on the basis of domestic measures.
Source: UNFCCC

3.3.2.3. Accession countries

In the 10 East European accession countries (AC-10), greenhouse gas emissions fell by 33.7 % between the base year[2] and 1999, see
Figure 3.5. The reductions were due mainly to the transition to a market economy and economic restructuring during the first half of the 1990s. During the second half, emissions in Slovenia, the Czech Republic, Poland and Hungary increased, while those in the other countries stabilised or continued to fall.

Figure 3.5.Greenhouse gas emissions in Eastern European Accession Countries (AC10) compared with Kyoto target for 2008-2012 (excl. fluorinated gases and land use change and forestry)

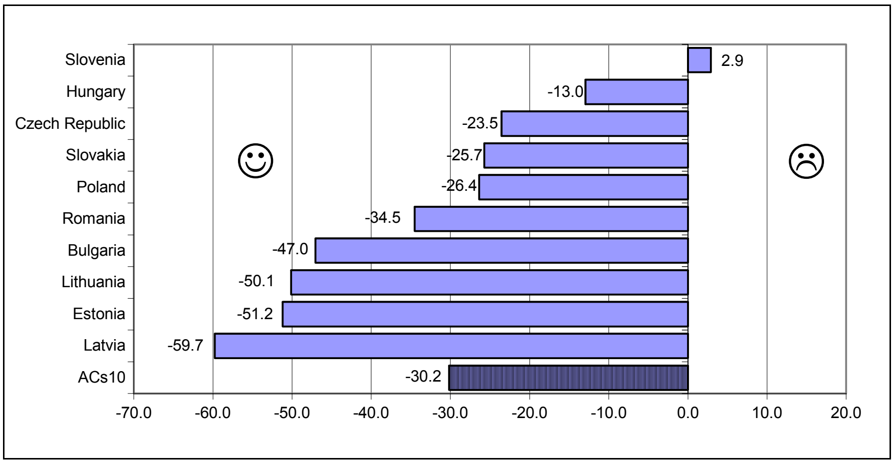


Source: EEA (2002a)

[2] Article 4.6 of the UNFCCC allows countries undergoing the process of transition to market economy some flexibility in choosing the base year. For Bulgaria the base year is 1988, for Hungary the average from 1985-1987 and for Poland 1988.

Total AC-10 greenhouse gas emissions in 1999 were far (30.2 %) below their linear Kyoto targets (Figure 3.6.). Only in Slovenia were they above the linear Kyoto target. For other Central and Eastern European countries no data is available.

Figure 3.6.Distance-to-target indicators (in index points) in 1999 for the Kyoto Protocol of Eastern European Accession Countries (AC10)



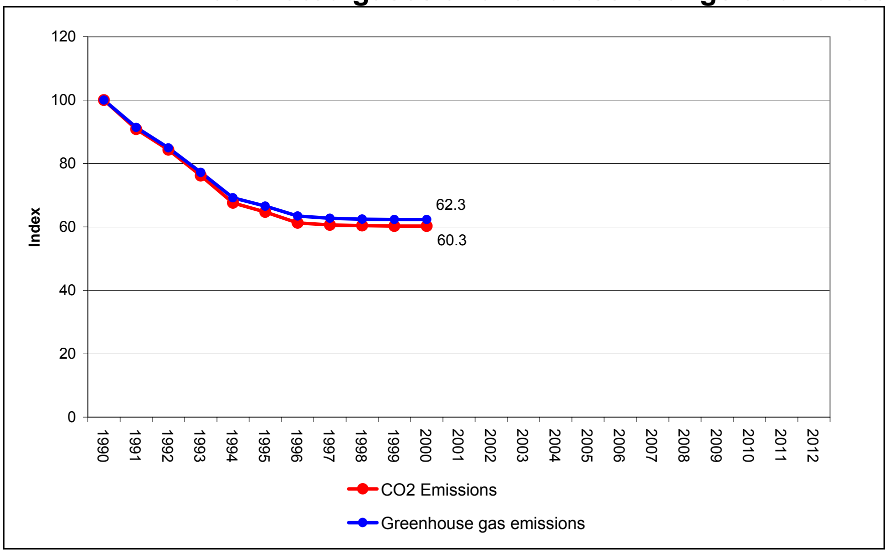
Note: The distance-to-target indicator (DTI) measures the deviation of actual emissions in 2000 from the (hypothetical) linear target path between 1990 and 2010. The DTI gives an indication on progress towards the Kyoto and Member States' sharing targets. It assumes that countries meet their target entirely on the basis of domestic measures.
Source: EEA (2002a)

☹ Greenhouse gas emissions in ten Central and Eastern Europe countries fell by 34% between 1990 and 1999 and most countries are well on track to reach their Kyoto targets, but emissions have started to increase again in some countries.

3.3.2.4. NIS

Greenhouse gas emissions in the NIS fell by almost 40 % between 1990 and 2000 (Figure 3.7). As with the accession countries, this was due mainly to economic and structural changes following the collapse of the Soviet Union.

Figure 3.7 GHG emissions in Newly Independent States (NIS) (excl. fluorinated gases and land use change and forestry)



Source: UNFCCC

Within the NIS, only the Russian Federation and the Ukraine have Kyoto targets. Both countries are far below their linear Kyoto target path and emissions are expected to be substantially under their Kyoto target by 2010. This will generate significant surpluses of emission allowances in these two countries (see also section 6.2 on flexible mechanisms).

3.4. Sectoral emissions

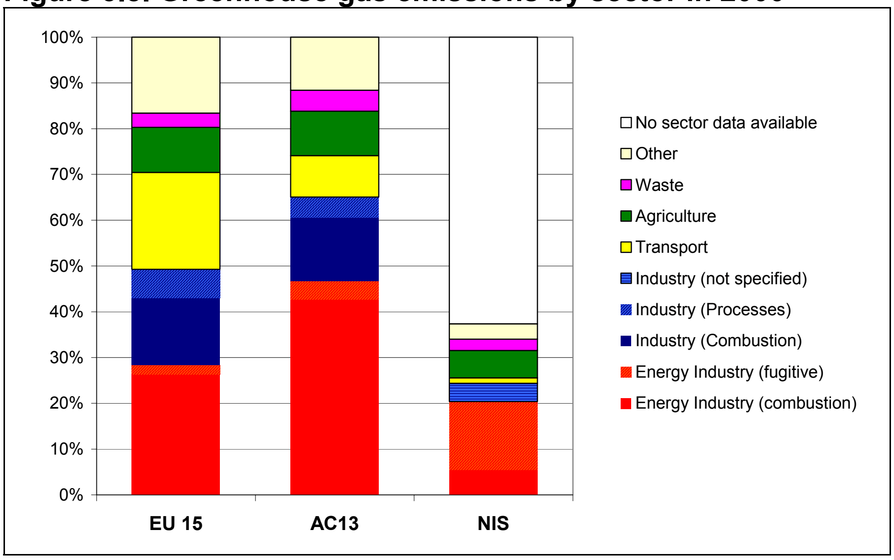
3.4.1 Overview

Total greenhouse gas emissions in the EU are about 4 000 million tonnes of CO_2 equivalent per year (24% of the total for industrialised countries), in EFTA countries about 110 million tonnes (less than 1% of the total of industrialised countries), in the AC10 about 830 million tonnes (5 % of the total of industrialised countries) and in the NIS about 2 900 million tons (17 % of the total of industrialised countries). CO_2, the most important greenhouse gas, contributes about 82 % of total GHG emissions in WE, about 79 % in Eastern Europe (AC10) and about 75 % in the NIS.

Figure 3.8. shows that:

- Combustion in the energy industries, industry, transport and "other" (mainly heating in commercial and residential areas) – is the dominant source of GHG emissions in all of Europe.
- Emissions from energy industries (electricity and heat production) are more important in the AC10 and the NIS, partly because of the lower share of other sources such as road transport.
- In WE, transport contributes with about 20 % to total GHG emissions, whereas in CEE (AC10) the contribution is considerable less, since there is less road transport in these regions.
- Although data for the NIS is limited, fugitive emissions from energy industries appear to contribute significantly to total emissions. This is caused mainly by methane leakages in the natural gas transport systems.

Figure 3.8. Greenhouse gas emissions by sector in 2000



Note: Data for NIS countries are incomplete: for 62% of the reported emissions the sectors are not known.
Source: UNFCCC

😐	In the EU, decreases in emissions from energy industries, the industry sector, agriculture and waste management were partly offset by increases from transport.
😐	In the Eastern European Accession Countries (AC10) emissions from energy industries, the industry sector, agriculture and waste management decreased also, while emissions from transport fell between 1990 and 1995, but increased significantly thereafter.

3.4.2. Energy industries

Energy industries (electricity and heat production, refineries, mining and distribution of energy carriers) are the most important source of greenhouse gases in Europe, contributing 29 % of total emissions in WE, 47 % in AC10 and 20 % in the NIS.

In the EU carbon dioxide emissions from electricity supply fell by 55 million tonnes (per year) or 5 % between 1990 and 1999, due mainly to switching from coal to gas in the UK and efficiency improvements in Germany, while consumption of electricity increased by 19 % (EEA 2002a). The increase in combined heat and power generation in several Member States and increasing wind power generation in Denmark and Germany also contributed to the reductions. Significant reductions of fugitive emissions from methane (by 34 %) were a result of reduced coal production, better control of coalmines and reduction of leaks in the natural gas distribution system.

In the Eastern European Accession Countries (AC10**)** emissions from energy industries fell considerably, by about 28 % or 150 million tonnes of CO_2 equivalent (per year), between 1990 and 2000 due to a decrease in electricity demand and the restructuring or close-down of heavily-polluting and energy-intensive industries. Fugitive methane emissions also decreased significantly, by about 14 million tonnes of CO_2 equivalent or 29 %. No data are available on trends in emissions from energy industries in the **NIS**.

3.4.3. Industry

The industry sector is the second largest source of greenhouse gas emissions in Western and Central Europe. Combustion of fossil fuels is the most important industrial source: about 70 % of the total in the EU and about 75% in the Accession countries (AC10). Information for the NIS is not available. CO_2 emissions from the production or use of mineral products (e.g. cement production) is the other main source, followed by nitrous oxide emissions from the chemical industry, mostly from adipic and nitric acid production and the use of fluorinated gases used for various purposes in industry as substitute for ozone-depleting substances banned by the Montreal Protocol.

In the EU, annual CO_2 emissions from industry fell by 55 million tonnes (per year) or 8 %, mainly as a result of economic restructuring and efficiency improvements in German manufacturing industry after reunification. Large reductions (59 million tonnes per year or 56 %) were achieved in nitrous oxide emissions from the chemical industry, because of specific measures at adipic acid production plants in Germany, the UK and France (EEA 2002a). Emissions of fluorinated gases increased by 36 % between 1990 and 2000, while emissions of hydrofluorocarbons (HFC) increase with 94 %, although during recent years large reductions of HFCs emissions were achieved in the UK. It is expected that emissions of fluorinated gases will further increase drastically (EEA 2002c).

CO_2 emissions from industrial processes in the Eastern European Accession Countries (AC10) fell by 5 million tonnes per year (14 %) between 1990 and 2000. There was no reduction in nitrous oxide emissions. No information is available on emissions of fluorinated gases. No data are available on trends in emissions from industry in the NIS countries.

3.4.4. *Transport*

The transport sector contributed more than 20 % of overall GHG emissions in the EU in 2000. In Eastern Europe (AC10) emissions from transport are the third largest contributor (about 10 %), with a far smaller share in the NIS. Road transport is the largest source. CO_2 from fuel combustion is by far the most important GHG, followed by N_2O, mostly generated as a by-product in catalytic converters.

Of particular concern in the EU is the increase of 128 million tonnes per year (18 %) in CO_2 emissions from transport over the past ten years, due to a growing volume of traffic, both passenger car and freight transport, and no substantial improvement in energy use per vehicle-km for the whole vehicle fleet. However recent years show a decreasing trend in CO_2 emissions per vehicle-km for new passenger cars, due to an agreement to reduce such emissions with European and other car manufacturers. Only Finland achieved slight emission reductions and the UK and Sweden managed to limit growth to less than 10 % from 1990 to 2000. Although only responsible for 0.6 % of GHG emissions, nitrous oxide emissions from transport increased after the introduction of the catalytic converters in most WE countries. CO_2 emissions are expected to increase by about 25 to 30 % between 2000 and 2010 (EEA 2002c).

Emissions in the Eastern European Accession Countries (AC10) fell by 19 % between 1990 and 1995, but increased significantly thereafter. Emissions in 2000 were only about 5 % below the 1990 level. Economic growth and the continued shift towards road transport will further increase emissions significantly. Although CO_2 is currently the main (98 %) GHG emission from the sector), nitrous oxide emissions are expected to increase rapidly due to the growing penetration of cars with catalytic converters.

Transport is a smaller contributor to greenhouse gas emissions in the NIS. However large increases are expected as the number of cars and transport demand rises.

3.4.5. *Agriculture*

Agriculture contributed about 10 % of overall GHG emissions in all three groups of countries in 2000. Nitrous oxide emissions from agricultural soils (due mainly to the application of mineral nitrogen fertilisers) and methane emissions from enteric fermentation (mainly from cattle) are the largest sources.

In the EU, nitrous oxide emissions fell by 4 % from 1990 to 2000 mainly as a result of a decrease in the use of nitrogen fertilisers. Methane emissions from ruminant animals fell by 9 % between 1990 and 2000, due to falling cattle numbers and changes in manure management (EEA 2002a). Methane emissions may fall by 18 to 40 % by 2010 compared with 1990 due to a further reduction in livestock numbers and changes in manure management (EEA 2002c).

In the Eastern European Accession countries (AC10) relatively large reductions of methane emissions from enteric fermentations were achieved (46 %), due to falling cattle numbers. Nitrous oxide emissions do not show a clear trend and in 2000 were at about the same level as in 1990. No data are available on trends in emissions from agriculture in the NIS.

3.4.6. *Waste*

The waste sector only contributes about 3 to 5 % of total greenhouse gas emissions in the different country groups within Europe. The main source is methane resulting from solid waste disposal on land (landfills).

In the EU, substantial reductions (26 %) in methane emissions were achieved (from 1990 to 2000) as a result of landfill emission control measures (EEA 2002a), through early implementation of the Landfill Directive. Similar trends can be observed in the Eastern European Accession Countries (AC10), where methane emissions fell substantially (by 27 %) between 1990 and 2000. Methane emissions from the waste sector may decline much further by increasing use of methane and energy recovery and the diversion of biodegradable waste from incineration to composting or anaerobic treatment.

3.5. Impacts and adaptation

Climate change is expected to have significant impacts in Europe. Generally, the south and the European Arctic are the most vulnerable areas. Impacts have been assessed in various studies (IPCC, 2001b; Parry, 2000) and can be expected in the many areas on:

- Hydrology and water resources (see also chapter…)
- Land and soil resources (see also chapter…)
- Forestry and agriculture (see also chapter…)
- Natural ecosystems and biodiversity (see also chapter…)
- Economic sectors
- Human health

3.5.1. Hydrology and water resources

Total annual flow and its variation through the year are likely to be affected by climate change. Changes in precipitation are expected to increase annual flow in northern Europe and decrease in the countries around the Mediterranean Sea. In mountainous and continental regions more precipitation will fall as rain instead of snow. These effects will increase the risk of floods and summer droughts. More intense precipitation events may affect large areas, as in the 'flood of the century' in 2002 in Mid-Europe. Many large towns and industrial areas are in the catchments of large rivers. For example in Germany about 17 000 people were evacuated and many cities along the rivers were severely damaged, with estimated costs of about 15 billion Euro (Die Zeit 2002). Landslides are likely to increase due to sudden and strong precipitation and endanger human settlements (as occurred in Italy in 2000). The demand for water for irrigation will increase, but availability will be reduced during the summer.

Adaptation will involve measures both on the demand and the supply side and will require the development of management systems that allow short-term actions, as well as measures affecting urban planning and building standards.

3.5.2. Land and soil

Climate change will affect land and soil directly and indirectly (through impacts on land use). Changes in the use and management of land are likely to have bigger effects on soils than climate change itself. Nevertheless, climate change is likely to result in the deterioration of soil quality. Likely effects include salinisation, peat loss and erosion by wind or water. Mediterranean forest soils are already facing a loss of carbon through wildfires, which are likely to increase.

Adaptation will require the development of policies to preserve the quality of land and soil and promote a sustainable use of land, for example through afforestation.

3.5.3. Forestry and agriculture

A higher CO_2 concentrations in the atmosphere is likely to lead to an increase in net productivity in most European forests and agricultural systems. However there will be regional differences, depending mainly on water availability. For example, productivity in the forestry sector in Germany may fall (by up to 9 %) at forest sites where drought stress increases. However, where precipitation is not the limiting growth factor, forest productivity may increase by 5 % (Lindner et al. 2002). The risks of climate change will be considerably higher and less manageable in countries that already suffer significantly from drought stress, such as the Mediterranean countries. In agriculture, increasing temperatures are likely to result in a reduction of the growing period of crops like cereals. In contrast, warming could lead to a lengthening of the growing season for root crops as sugar beet. An unclear, but important issue is how pests and diseases will be affected by climate change. Both are expected to increase but it is not yet known to what extent. Agricultural systems and forests are vulnerable to extreme weather events, such as droughts, storms or fires, which are likely to increase with climate change.

Adaptation measures will require more flexibility of land use, crop production and farming systems.

3.5.4. Natural ecosystems and biodiversity

Climate change is expected to affect ecosystems and biodiversity, though it is difficult to attribute changes that have already occurred to climate change alone. The impacts may threaten the habitats of some plant and animal species, which may lead to their extinction if they are not able to adapt or migrate. For example, wintering shorebird and marine fish diversity is seriously endangered by a loss of coastal wetlands. Ecosystems that thrive in the warm humid conditions of northern Iberia may appear in northern France and the southern British Isles. The tree line has already moved upwards and this is projected to continue in many mountainous regions.

Adaptation measures will have to protect endangered species, and include monitoring the productivity of other species, changes of which may disrupt ecological balances.

3.5.5. Economic sectors

3.5.5.1. Coastal zones

The increased risk of flooding, erosion and wetland loss in coastal areas will have impacts on human settlements, industry, tourism and agriculture. Southern Europe appears more vulnerable (Parry 2000). Management systems that safeguard human activities and preserve coastal ecosystems will be need to be developed; these should including measures to lessen flood peaks and keep floods away from property.

3.5.5.2. Insurance

The insurance industry is already facing growing property damages due to more extreme weather events, such as windstorms or flooding. Worldwide economic losses from catastrophic events have increased more than tenfold during the past 50 years, although only a part of this increase can be linked to climatic factors (IPCC 2001b). Properties at risk in some regions of Europe may become uninsurable. Adaptation measures include risk transfer into wider financial markets and generally better cooperation between stakeholders.

3.5.5.3. Tourism

Climate change is likely to have significant consequences on tourism, both positive and negative. Higher temperatures are likely to change summer destination preferences since outdoor activities in northern Europe may be stimulated, while summer heat waves in the Mediterranean region may lead to a shift of tourism to spring and autumn. Higher temperatures will also result in less reliable snow conditions and affect winter tourism. Regional policies will have to respond to changes in tourism patterns, for example new destinations may need specific infrastructure.

3.5.6. Human health

Climate change is likely to have considerable effects on the spread of vector-, food- and water-borne infections. Some vector-borne diseases may expand their range northwards. For example, there is some evidence that the northward migration of tick vectors in Sweden is due to the observed warming. An increase of heat waves, accompanied by a rise of urban air pollution, can cause an increase in heat-related deaths and periods of illness, but winter mortally is likely to be reduced. Adaptation measures should include specific public health programmes and the development of pan-European surveillance systems that allow the early detection of infectious diseases.

3.6. Policy responses

Most WE countries will need additional efforts to fulfil their commitments under the Kyoto Protocol, while most Accession countries and the NIS expect to be below their Kyoto targets. Most European countries will need to prepare for climate change by selecting and implementing appropriate adaptation strategies. WE countries are expected to reduce GHG emissions primarily by domestic action, policies and measures, although the Kyoto Protocol gives Parties additional flexibility in fulfilling their commitments by the use of flexible mechanisms and 'carbon sinks'.

Programmes, policies and measures addressing climate change, mainly for the period up to 2008-2012, are described in the next section while the possible use of the flexible mechanisms and sinks is analysed separately. In addition the costs and benefits of climate change policies are analysed.

A long-term climate change strategy for the period after 2012 will be also needed. Projections show that emissions are expected to increase, particularly in the transport sector, if no additional efforts are undertaken. Also the massive nuclear decommissioning, which is anticipated to take place after 2010, will challenge climate policy responses. Future climate change policy will require structural changes of the economy to bring down emissions in the long run. The expansion of the use of renewable energy and the increase of energy efficiency will need to be a focus of such a future climate change policy, as well as adaptation measures in a wide range of socio-economic sectors.

3.6.1. National Programmes

☺ Many European countries have adopted National Programmes addressing climate change. Key policies and measures include carbon dioxide taxes, domestic emission trading schemes, promotion of renewable energy (wind, solar, biomass) and combined heat and power, abatement measures in industry and measures to reduce emissions from landfills.

Many European Countries have adopted and partly implemented programmes that address climate change. The *energy sector,* the largest contributor to GHG emissions, is a focus of policies and measures in many countries:

- **Energy and** CO_2 **taxes.** Several countries (Denmark, Finland, Germany, Italy, The Netherlands, Norway, Sweden and the UK) have introduced or increased taxes on energy use and/or CO_2 emissions.
- **Carbon dioxide emission trading scheme in the UK.** The UK is the first country in the world to set up a domestic emission trading scheme for the basket of six Kyoto gases. Companies may voluntarily take on legally binding obligations to reduce their emissions from 1998-2000 levels. The government is making up to £ 215 million available over 5 years to participating companies.

- **Promotion of renewable energy.** In WE, many countries have adopted legislation to further increase the share of renewables. The rapid expansion of wind power (38 % per year in the EU between 1990 and 99), driven by Denmark, Germany and Spain, was the result of support measures including 'feed-in' arrangements that guarantee a fixed favourable price for renewable electricity producers. Germany and Spain are leading countries in the growth of solar (photovoltaic) electricity, mainly as a result of a combination of 'feed-in' arrangements and high subsidies (EEA 2002b). Biomass for electricity and heat production have also expanded significantly in some countries, especially in Finland, Sweden, Austria and the Baltic countries (EEA 2002b).
- **Promotion of Combined Heat and Power (CHP).** Several countries have promoted the use of CHP plants by regulatory, economic and fiscal policies. A particularly high penetration of CHP was achieved by 1998 in Denmark (62.3 %), the Netherlands (52.6 %) and Finland (35.8 %) (European Commission 2002).

Regarding *transport,* with emissions projected to rise significantly, some policies and measures are in place in several countries. For example, Sweden is promoting less fuel-consuming cars, and the promotion and development of inter-modal transport, rail transport and public transport are an important part of Finnish transport policy.

Few policies and measures are in place to reduce GHG emissions in the *agricultural sector*. Some policies and measures may help to reduce emissions as a side effect rather than directly. For example in Finland, an agro-environmental support programme aimed at decreasing nutrient inputs to surface and ground waters is being implemented by about 90 % of farmers, which is expected to reduce nitrous oxide emissions as a side effect.

In *industry,* large reductions of nitrous oxide emissions can be achieved by measures in the manufacture of adipic and nitric acid. Emission reductions ranging from 45 % to 75 % are projected in the UK, Germany and France from such measures.

Large reductions may be achieved in the *waste* sector by implementing the Landfill Directive, leading to reductions of methane emissions up to 80 %.

3.6.2. European Union

☺ In the EU several common and coordinated policies and measures have been developed, including an agreement with car manufacturers to limit emissions of CO2 emissions from new passenger cars and a proposal for a directive on a EU-wide emission trading scheme

In the EU, common and coordinated policies and measures have been developed in several sectors, for example the Green Paper on the security of energy supply and the White Paper on a common transport policy (European Commission 2001a, European Commission 2001c, European Parliament and Council 2002).

In June 2000, the EU established the European Climate Change Program (ECCP) to help identify the most cost-effective additional measures to meet the Kyoto target and national burden sharing targets. Several measures are at an advanced stage of preparation, including Directives on:
- An EU emission trading scheme (see section 6.3)
- Promotion of renewable energy
- Combined heat and power
- Bio-fuels
- Energy performance of buildings
- Energy efficient public procurement
- Fluorinated gases.

In the transport sector the agreement with the car manufacturers (ACEA agreement) that was agreed in 1999 is expected to limit significantly the increase of CO_2 emissions from road passenger transport.

An important new EU policy instrument for the mitigation of climate change is the proposed Greenhouse Gas Emission Trading Scheme (European Commission 2001b). The scheme is limited to CO_2 and to energy-intensive sectors. The proposal covers about 46 % of the EU CO_2 emissions. A first phase will be established for the period 2005 to 2007. The scheme is expected to lower the compliance costs of the Kyoto Protocol for the European Union significantly (by 35%) compared with Member States meeting their commitments without trading across borders. The price for allowances for one tonne of CO_2 is estimated to fall in a range of € 20 to € 33 (European Commission 2001b).

3.6.3. Emission trading and Joint Implementation

The Kyoto Protocol and the Marrakech Accords provide for three flexible mechanisms, which Parties may use to facilitate compliance with their commitments:

- By *Joint Implementation (JI)* industrialized countries may conduct emission reduction projects jointly. The mechanism invites especially Western economies to invest in projects to reduce GHG emissions in countries in transition in Eastern Europe and the Russian Federation. The achieved emission reductions units are transferred to the investing Party, which can use them to fulfil its reduction commitments.
- The *Clean Development Mechanism (CDM)* invites industrialised countries to invest in projects to reduce GHG emissions in developing countries. According to the reduction achieved, certified emission reduction units are issued which industrialised countries can use to fulfil their commitments.
- *Emission trading (ET)* allows industrialised countries to trade emission allowances among each other.

The three flexible mechanisms are expected to become important instruments for reducing compliance costs by channelling investments into cost-effective greenhouse gas mitigation options. *Joint Implementation* is particularly interesting for cooperation between Western and Eastern European countries. In many countries in transition in Eastern Europe, investments in the energy sector are needed. At the same time greenhouse gas mitigation costs in Eastern Europe are mostly lower than in Western European. Such projects could also help accession countries to integrate into the EU (Fernandez and Michaelowa 2002). During a pilot phase for project-based activities to reduce GHG emissions under the UNFCCC, more than 80 *Activities Implemented Jointly* projects have been reported in Eastern Europe, including many cooperative projects between Sweden and the Baltic countries Latvia, Estonia and Lithuania (UNFCCC 2002).

Russia and Ukraine will have a central role in the future market of greenhouse gas allowances. Both have relatively large emissions (Russia about 3 040 million tons of CO_2 equivalent in 1990), which fell until 1996 due to economic restructuring (Russian emissions by approximately 35 % (DIW, 2002)). By 2010, Russian emissions are projected to be far below the Kyoto target, which is to keep emissions at the 1990 level. Consequently, Russia is likely to have a significant surplus of emission allowances in 2008 to 2012, which is often referred to as 'hot air', since use of this could mean that there would be no real (physical) reduction of emissions. Estimates of the total 'hot air' available by 2010, including from Eastern European Countries and Russia, range from 750 to 1 340 million tonnes of CO_2 (Grüttner 2001a). In addition, if Kazakhstan agrees a Kyoto Protocol commitment, this could lead to substantial additional 'hot air'. Russia has a substantial potential for further emission reduction through improvements in energy efficiency. Following negotiation in Marrakech, Russia is allowed to account up to additional 605 million tons of CO_2 during the first commitment period for forest management activities, which means in practice a potential increase in the amount of 'hot air' available from Russia.

The *green investment scheme* that is currently being developed may help to avoid trading in 'hot air', which would fail to result in real emission reductions. The scheme aims to use funds from the flexible mechanisms to invest in reformation of the Russian energy sector. It could create a framework to make Russian 'hot air' both economically effective and environmentally legitimate by ensuring investment in real emission-reduction projects (Moe et al. 2001).

Following the US withdrawal from the Kyoto Protocol and with the additional flexibility to account for carbon sinks for Russia, projected prices in the future GHG market have dropped from about 3 to 27 US$ to about 0 to 8 US$ per tonne of CO_2 (Grüttner 2001b, den Elzen and de Moor 2001, Vrolijk 2002). Russia, as the main supplier of GHG allowances, has an economic interest in reducing the supply of its allowances by banking them to the next commitment period after 2012, which would lead to a reasonable price in the first commitment period (see also chapter air pollution - check). However, prices would be difficult to control, because these will depend on economic growth and future emissions by 2010 in Russia and other East European countries and the extent to which WE countries use domestic policies and measures, flexible mechanisms and carbon sinks to meet their targets.

Altogether, the effect of the Kyoto Protocol after Marrakech is estimated to bring emissions to 0 to 3 % under 1990 levels (den Elzen and de Moor 2001).

3.6.4. Carbon sinks

😐 Sequestration in land use change and forestry ('carbon sinks') can be used to meet Kyoto targets, under some circumstances, with additional allowances amounting to about 2 to 4 % of 1990 emissions for some Western European countries.

Terrestrial ecosystems contain large carbon stocks that amount to about 2 500 Gt C globally (IPCC, 2001c). In the past, land management has often resulted in the depletion of carbon pools, but in many regions, like WE, carbon pools have now stabilized or are recovering (IPCC 2001c). Recent calculations indicate that terrestrial carbon sinks may turn into a source of CO_2 in the second half of the 21st century (Cox et al. 2000).

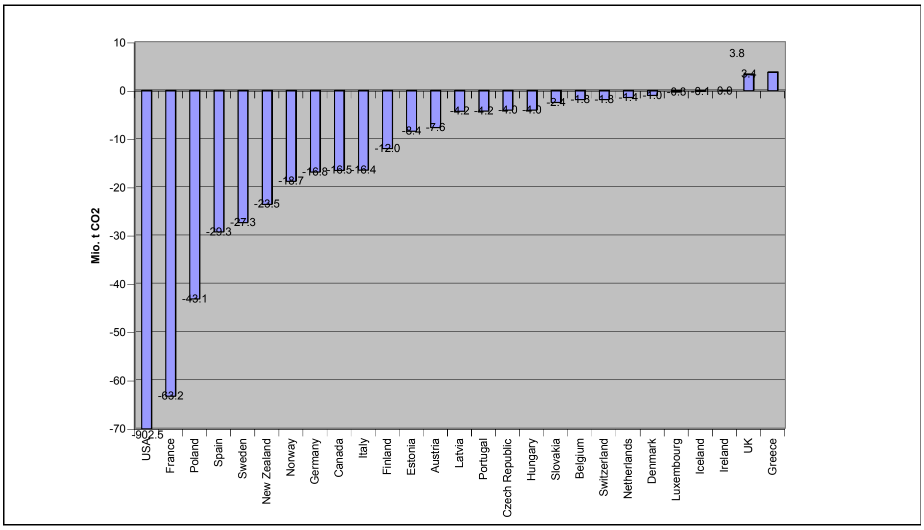
Management of land may also lead to considerable carbon uptake and consequently mitigate climate change by lowering CO_2 concentrations in the atmosphere. However, the effectiveness and security of such sequestration may only be temporary.

Under the Kyoto Protocol, carbon sequestration from deliberate afforestation, reforestation and deforestation (ARD) as well as from other land use, land-use change and forestry activities (revegetation, forest management, cropland management and grazing land management since 1990) can be used to meet the targets. The extent to which Parties can account for carbon seque*stration by specific land-use, land-use change and forestry activities is limited to the first commitment period (2008-2012). The extent to which forest management activities can be used is subject to an individual cap for each Party. The Clean Development Mechanism projects that enhance the uptake of carbon are limited to ARD activities and may not exceed 1 % (annually) of a Party's base-year emissions.

Figure 3.9. shows the emission/removal estimates from land-use change and forestry for the year 2000. There are large differences between countries. The US shows the largest uptake of about 900 million tonnes of CO_2. The UK and Greece have net emissions from sinks. Within the EU, the largest CO_2 uptake occurs in France (about 36 million tonnes),

followed by Spain (43 million tonnes). The amount of removals that can be accounted for under the Protocol will be lower than the removals currently reported in Figure because of the limits agreed for several activities and because only activities initiated after 1990 can be accounted for.

Figure 3.9. Reported emissions / removals of GHGes from land-use, land-use change and forestry for the year 2000

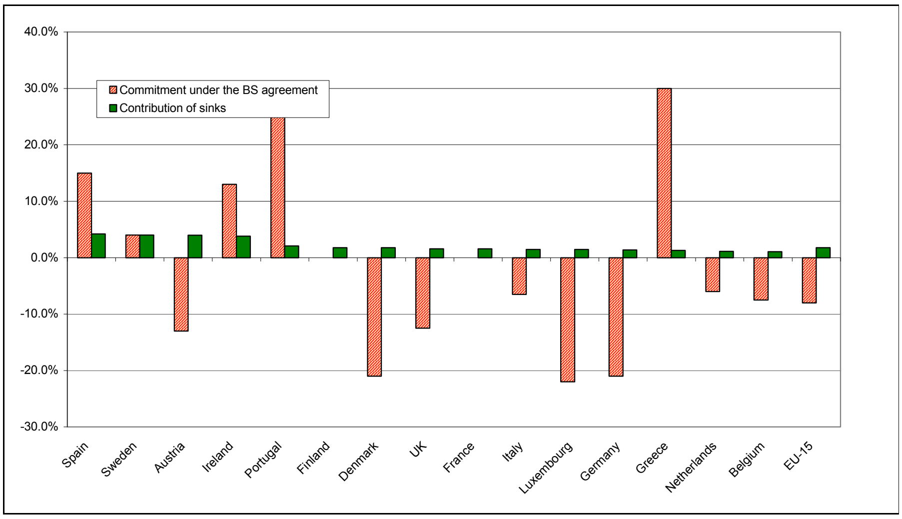


Note: Positive values indicate a net emission, negative values a net uptake of CO2. Several Annex I Parties have not reported inventories on land-use change and forestry or not complete inventory data.
Source: UNFCCC, Submitted GHG Inventories by Annex-I Parties for the year 2000

Comprehensive methods for estimating changes of carbon pools under the Protocol are currently being developed by IPCC. Projections for the relevant carbon pool changes during the first commitment period are therefore difficult to perform with the existing inventory data.

The *maximum potential* of the contribution of sinks may be estimated. However, this does not imply that Parties will actually use the maximum potential.
Figure **3** compares the maximum contributions from all potential carbon removal activities with the EU Member States targets under the burden-sharing agreement. With the use of carbon sinks, Spain can increase its emissions target of an allowed increase of 15 % by approximately 4.2 %. Similarly Sweden can increase its emissions target of an allowed increase of 4 % to 8 % by using all of its potential for sinks. In Austria and Ireland sinks could contribute about 4 % (of base-year emissions) to the achievement of their burden-sharing target. For the rest of EU, the maximum sink potential is less than 2 % of base-year emissions. Most EU countries have not yet provided estimates for the carbon sink potential of their agriculture activities which are therefore not included in Figure 3.10. which could further increase the contribution of sinks to the achievement of the Kyoto targets.

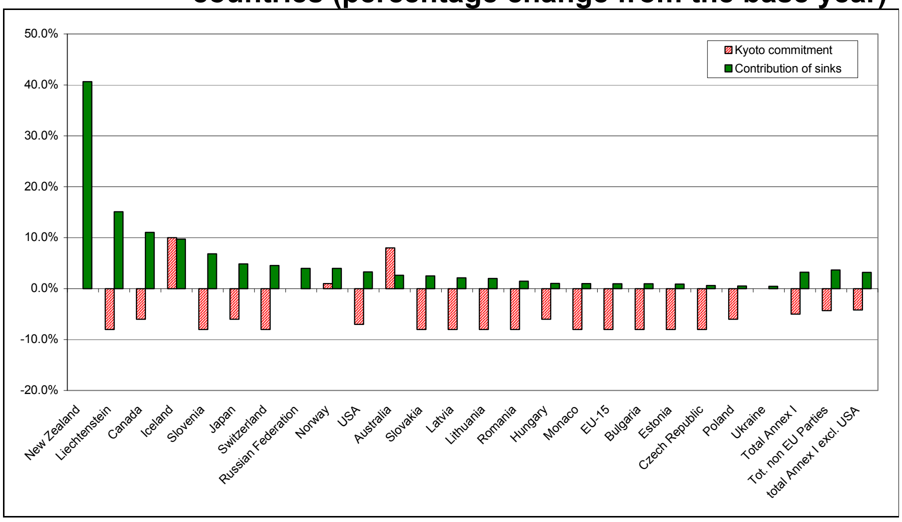
Figure 3.10.Comparison of potential contributions from land use, land-use change and forestry with burden sharing targets for EU-15 (percentage change from the base year)



Source: Data for ARD activities, forest management and additional activities were taken from Parties' submissions to UNFCCC, FAO data and country specific data were used for calculation of the debit compensation. Agreed caps were considered. Estimates include the maximum contribution of sink CDM projects. This contribution was calculated on the basis of base year data from 2002 inventory submission.

For some Non-EU Parties, sinks could contribute to a much larger extent to the achievement of the Kyoto targets (Figure 3.11.). In New Zealand, sinks would allow for an emission growth by 40% above the stabilizing target if maximum potentials were used. For Canada potential effects from removals are considerably larger (11%) than the reduction target (-6%). For Iceland and Norway potential credits from sinks can also considerably increase the allowed emission growth, but Norway took the decision not to use sink credits from agricultural activities and forest management. Japan, Switzerland and Russia can potentially increase their emissions by 4 to 5 percentage points. For most Accession Countries (with the exception of Slovenia) sinks will not contribute significantly to achieving emission targets.

Figure 3.11. Comparison of potential contributions from land use, land-use change and forestry with targets for non-EU industrialised countries (percentage change from the base year)



Source: Data for ARD activities, forest management and additional activities were taken from Parties' submissions to UNFCCC, FAO data and country specific data were used for calculation of the debit compensation. Agreed caps were considered. Estimates include the maximum contribution of sink CDM projects. This contribution was calculated on the basis of base year data from 2002 inventory submission. For CDM potential it was assumed that CEE and NIS countries will not use the CDM.

3.6.5. *Costs and benefits of climate-change policies*

3.6.5.1. Costs

☺ Climate mitigation costs in Western Europe can be reduced significantly through the use of the Kyoto mechanisms (joint implementation and emission trading).

The costs of climate change mitigation can be reduced significantly through appropriate policy instruments. The use of flexible mechanism, such as the Kyoto mechanisms or the planned emission-trading scheme for the EU, are expected to help considerably to implement policies in a cost-efficient manner.

A recent study (van Vuuren et.al., 2002) has estimated the costs of achieving the Kyoto targets for WE and analysed the spin-off benefits of climate change policies on air pollution (see also chapter on air pollution). One scenario in the study assumed that the Kyoto targets would be achieved by using only domestic action in WE, which implied a 5 to 6 % decrease of CO_2 emissions by 2010 from 1990 levels. Measures would include a number of the policies and measures mentioned above, including the improvement of energy efficiency, the substitution of coal by gas in electricity production and measures in some end-use sectors. Measures in the transport sector would be limited. The costs of these measures in Western Europe would be about 21 billion EUR(1995) per year.

The study also analysed two additional scenarios of use of the Kyoto mechanisms were (more details on the assumptions are given in the chapter on air pollution). One scenario ('optimal banking') assumes that it is beneficial for the Russian Federation and Ukraine to 'bank' a large share of their available 'hot air' and supply only 25 % of its potential on the market. In such a scenario, the use of all flexible instruments (emission trading, JI and CDM) would result in a 3 % emission reduction compared with the baseline in WE, a 4 % reduction in Central Europe and a 6 % reduction in the NIS. This implies that about 80 % of the reductions in WE would be met by the use of flexible mechanisms. Using flexible mechanisms would therefore significantly reduce implementation costs in WE. Costs for domestic policies and measures in WE would decrease to 2 billion EUR/year. However, at the same time about 7 billion EUR/year would be spent on permits (both emission trading and joint implementation), giving a total of 9 billion EUR/year.

In the second scenario the maximum potential for spin-off benefits, in terms of reduced emissions of air pollutants, was explored by excluding trading in 'hot air'. In this scenario 60 % of the total emission reduction of CO_2 does not take place in WE but in Central Europe and the NIS. The total expenditures for WE in this scenario are about 10 billion EUR.

Table 3.2 Total annual costs for implementation of the Kyoto protocol in Western Europe[3] (billion euro/year)

Scenario	Domestic policies and measures	Kyoto mechanisms	Total
Domestic action	21	0	21
Kyoto mechanisms Optimal banking	2	7	9
Kyoto mechanisms with no hot air	4	6	10

Source: Van Vuuren et.al, 2002

3.6.5.2. Benefits

[3] Costs in Central and Eastern Europe and NIS are zero in all scenarios.

☺ Climate change policies can have significant positive effects ("co-benefits") by also reducing emissions of air pollutants and thus costs to abate air pollution.

Policies and measures to abate greenhouse gases result in lower emissions and lower concentrations in the atmosphere, which is expected to slow down climate change. However, there is a considerable time delay between the reduction of emissions and the stabilization of the concentrations. Many impacts of the greenhouse gases emitted during the past 150 years will only become visible during the second part of this century or even beyond. Assessment of the benefits (or of the avoided costs of damages) of abatement policies is therefore difficult. Furthermore, today's costs of reducing greenhouse gases are difficult to compare with the future costs of adaptation to climate change. Because of uncertainties in the quantification of climate-change impacts and difficulties in expressing these in monetary terms it is not possible to compare benefits (now and in future) directly with mitigation costs.

Climate-change policies can have significant positive effects on other environmental issues, in particular acidification, tropospheric ozone, and urban air quality (primary particulate matter) in terms of reduced emissions of air pollutants (SO_2, NO_X, particulate matter) and reduced costs (see also the chapter on air pollution). Climate change policies in the European Union may lower the cost of reaching acidification and ozone targets by 6 billion EUR per year.

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