6.1 GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE

6.1.1 INTRODUCTION

Research in the field of climate change focuses on three areas: the **avoidance of greenhouse gas emissions** and the capture of greenhouse gases and carbon (core question: How can emissions of climate-relevant greenhouse gases be avoided [Mitigation] and how can the gases be removed from the atmosphere [sequestration]?); research on the **impact of climate change** (core question: What consequences does climate change have on humans and the geo-ecosystem in the various regions of the world?); and the **development of adaptation strategies**, an area which is gaining in importance (core question: How can/must the various sectors of the economy in different regions of the world adapt to climate change?).

An increasing body of observations gives a collective picture of a warming world and other changes in the climate system. Changes in sea level, snow cover, ice extent, and precipitation are consistent with a warming climate near the Earth's surface (IPCC, 2001). The vast majority of researchers attribute the increasing incidence of weather anomalies and extreme weather events to ongoing climate change (IPCC, 2002).

There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities – the emission of **green-house gases** (GHGs) (IPCC, 2001). Greenhouse gases influence the energy flows within the atmosphere by absorbing infrared radiation. The most important anthropogenic greenhouse gas emissions are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

In Austria, greenhouse gas emissions increased by about 10% between 1990 and 2001. This means that already in 2001 emissions reached the level projected with current measures for 2010. Thus Austria is far from complying with the 13% reduction required under the Kyoto Protocol, meaning that Austria will have to reduce its emissions annually by 1.4 million tonnes of CO_2-equivalents to fulfil its obligations.

Especially due to their rapid development, the changes in the global climate system projected on the basis of climate models for the 21st century have created considerable adaptation pressure for all ecosystems as well as a number of human activities.

In the temperate latitudes (Central Europe), the prognosis is as follows: an increase in annual average temperatures, especially winter temperatures, a decrease in the snow cover at lower altitudes, the ongoing retreat of Alpine glaciers and shifts in precipitation patterns, including more convective precipitation (thunderstorms). The rapid shift of vegetation zones towards the poles and towards higher altitudes is too much of a challenge to the adaptation abilities of natural ecosystems and those influenced by humans and may lead to the migration or even extinction of species. In particular, the problems expected in Central Europe concern the fields of agriculture, forestry, water supply and distribution, energy supply and tourism. The general warming process may mean that pathogens currently confined to warmer regions will also occur in temperate zones (see Chapter 2.1.3.2), not to mention the consequences of the flood of the century in August 2002, which illustrate (see Chapter 6.2) more than ever the importance of measures to adapt to the current climate changes.

6.1.2 ENVIRONMENTAL POLICY TARGETS

The changes projected and already present in the global climate system and the resulting ecological and economic problems have increased willingness at the international level to implement concerted measures to reduce anthropogenic greenhouse gas emissions. In 1992 the **climate framework convention** (United Nations Framework Convention on Climate Change – UNFCCC) was adopted and has been ratified in the meantime by 188 states including Austria (as of 17 February 2003). The objective of the Convention is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (UNFCCC, 1992).

Under the **Kyoto Protocol,** which has been ratified by 120 states (as of 26 November 2003) but has not yet entered into force, industrialised countries agreed on quantitative emission reduction targets. The EU has undertaken to reduce GHG emissions by 8% in relation to 1990 levels by 2010. EU Member States decided to meet their commitments jointly and agreed upon different reduction targets for the individual EU Member States (the “EU bubble“). Within this EU bubble, Austria has taken on the obligation to reduce its GHG emissions by 13% in relation to 1990 levels by 2010 (see Table 6.1-1).

Member State	2008–2012 targets under the Kyoto Protocol and in the “EU bubble“
Austria	-13.0%
Belgium	-7.5%
Denmark	-21.0%
Finland	0.0%
France	0.0%
Germany	-21.0%
Greece	25.0%
Ireland	13.0%
Italy	-6.5%
Luxembourg	-28.0%
Netherlands	-6.0%
Portugal	27.0%
Spain	15.0%
Sweden	4.0%
United Kingdom	-12.5%
EU-15	**-8.0%**

Tab. 6.1-1: 2008–2012 reduction targets under the Kyoto Protocol and in the “EU bubble“ with regard to the base year (1990 for CO2, CH4, N2O, 1995 for fluorinated gases).

However, the reduction targets outlined in the Kyoto Protocol and the EU bubble are by no means sufficient to reach the goal of stabilizing the GHG concentration in the atmosphere, since this would require a reduction in global GHG emissions of at least 70%. The timing of the reduction is crucial to the level at which the GHG concentration in the atmosphere will be stabilised: the sooner the reduction is achieved, the lower the level of stabilisation will be (IPCC, 2001).

Together with other ministries and the Federal Provinces, the *Bundesministerium für Land- und Forstwirtschaft, Umwelt- und Wasserwirtschaft (BMLFUW)* [Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management] has developed the *Strategie Österreichs zur Erreichung des Kyoto-Ziels* [Austrian Climate Strategy to reach the Kyoto target] (BMLFUW, 2002). The core issue of this strategy is to define sector goals and create a package of measures to meet the Kyoto target.

6.1.3 SITUATION AND TRENDS

In recent years, Austrian has not come closer to the GHG reduction goal of 13% under the Kyoto Protocol. Figure 6.1-1 shows that as of 2001 greenhouse gas emissions had increased by 9.6% since the base year[45]. Thus Austria's deviation from the linear (hypothetical) Kyoto path amounted to 16.8 index points in 2001. With this deviation, Austria ranks fourth to last among EU Member States.

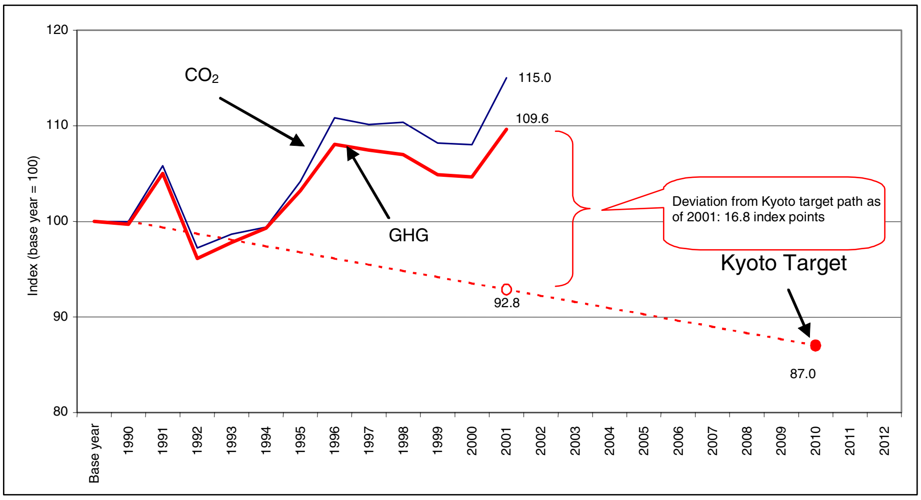

Fig. 6.1-1: Austrian greenhouse gas emissions (GHG) in CO_2 equivalents compared to the Kyoto target.

Source: UMWELTBUNDESAMT (2003a)

Note: Figure 6.1-1 shows the deviation of greenhouse gas emissions from the Kyoto path in the year 2001. This path provides for a linear reduction between the base year 1990 and the target year 2010. This method of evaluating progress is also used by the European Commission (EC, 2003) and the European Environment Agency (EEA, 2003).

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[45] When this report went to press, the data available were for 1990-2001. By the time this report is published, data for 1990-2002 are already available and are published in separate reports by the Umweltbundesamt. The most important results of the new period are included in the Annex 'Results of the Austrian Air Emissions Inventory 2002'.

The main reason for the increase in Austrian GHG emissions is the growing use of fossil fuels and the resulting increase in CO_2 emissions. The highest growth rates can be observed in the transport sector, where greenhouse gas emissions have increased by almost half (+ 49%) since 1990.

What is remarkable in the trend curve is the emission peaks of 1991 and 1996. These peaks were caused by very cold winters, which led to an increase in the use of fuels for heating and electricity, especially in the small combustion and energy supply sectors.

In 2001 there was also an increase in greenhouse gas emissions of 4.8%. This can be explained on the one hand by the increased use of fuels caused by the relatively cold year of 2001 compared to the previous year (the number of heating degree days (HDD)[46] was 14% above that of the previous year, see Fig. 6.1-2), and on the other hand by the increased firing of power and district heating plants with CO_2 intensive brown coal (lignite) and hard coal.

6.1.3.1 Overall economic driving forces

Basically, greenhouse gas emission trends depend on a number of factors. As about two thirds of GHG emissions are caused by energy production, the most important parameters are the trends of energy consumption and the energy mix. The following factors can influence greenhouse gas emissions considerably (UMWELTBUNDESAMT, 2003a):

- population growth
- economic growth
- outdoor temperature and the resulting heating requirements (heating degree days)
- improvement of energy efficiency
- the proportion of renewable energy sources such as electricity generation in hydroelectric power stations (which influences the need for supplementary power production in thermal power plants)
- the mix of fossil fuels, for example in caloric power plants (natural gas combustion produces about 40% less CO_2 per energy unit than coal combustion)
- the structure and price effects of energy market liberalisation, which influence the use of various fuels in electricity production and the import of electricity
- world market prices for energy
- structural changes in the economy and in the behaviour of consumers.

Figure 6.1-2 illustrates the changes in important driving forces and in greenhouse gas emissions in Austria as an index (relative to 1990):

[46] Heating degree days are calculated using the sum of temperature differences between a specific constant room temperature (20^{o}C) and the daily average air temperature if this temperature equals or falls below a supposed heating limit temperature of 12^{o}C.

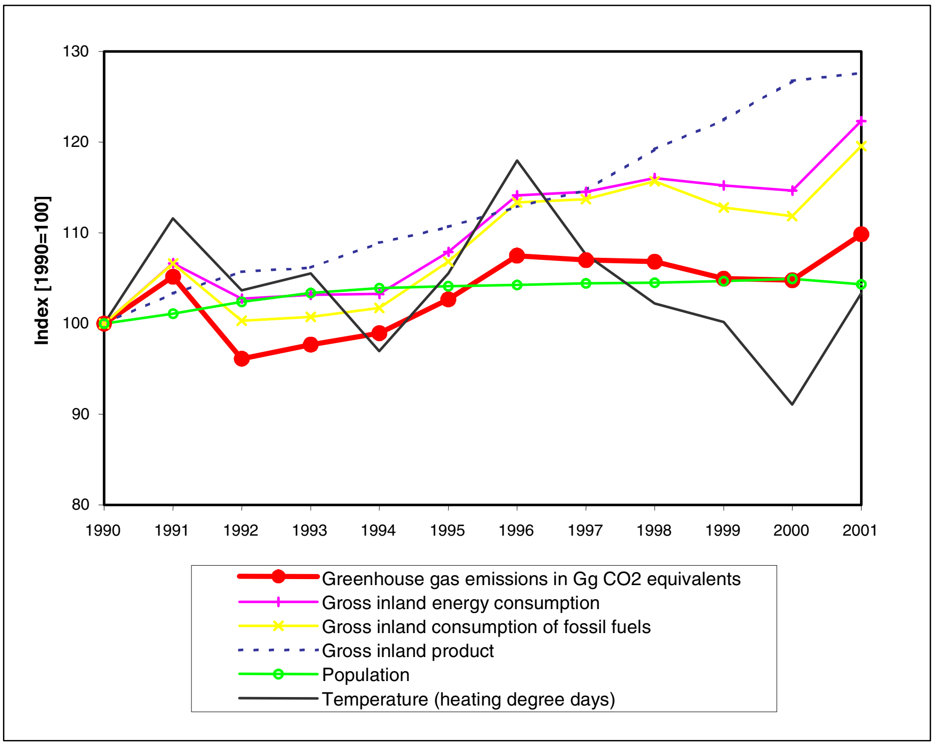

Fig. 6.1-2: Greenhouse gas emissions and driving forces 1990 to 2001.

Source: UMWELTBUNDESAMT (2003b)

Greenhouse gas emissions have increased by about 10% since 1990, while the Austrian population has only grown by 4%. However, a certain decoupling of the greenhouse gas trend from growth in Austria's gross inland product (+28%) and energy consumption (+22%) can be observed. This means that greenhouse gas intensity decreased by 17% (related to gross inland product) and by 8% (related to energy consumption). Important reasons for this decoupling were efficiency improvements in industrial processes, reductions in the use of solid fuels (especially coal) and structural changes in the economy.

6.1.3.2 Sectoral emissions trends

Figure 6.1-3 shows the trends in the main source sectors between 1990 and 2001 as well as their shares in Austrian greenhouse gas emissions for 2001. In 2001 industry accounted for 27% of total greenhouse gas emissions, transport for 23%, small combustion for 18%, energy supply for 17% and agriculture for 9%. The “Other“ category produced 6% of climate gases in 2001, the main source being methane emissions from waste disposal sites.

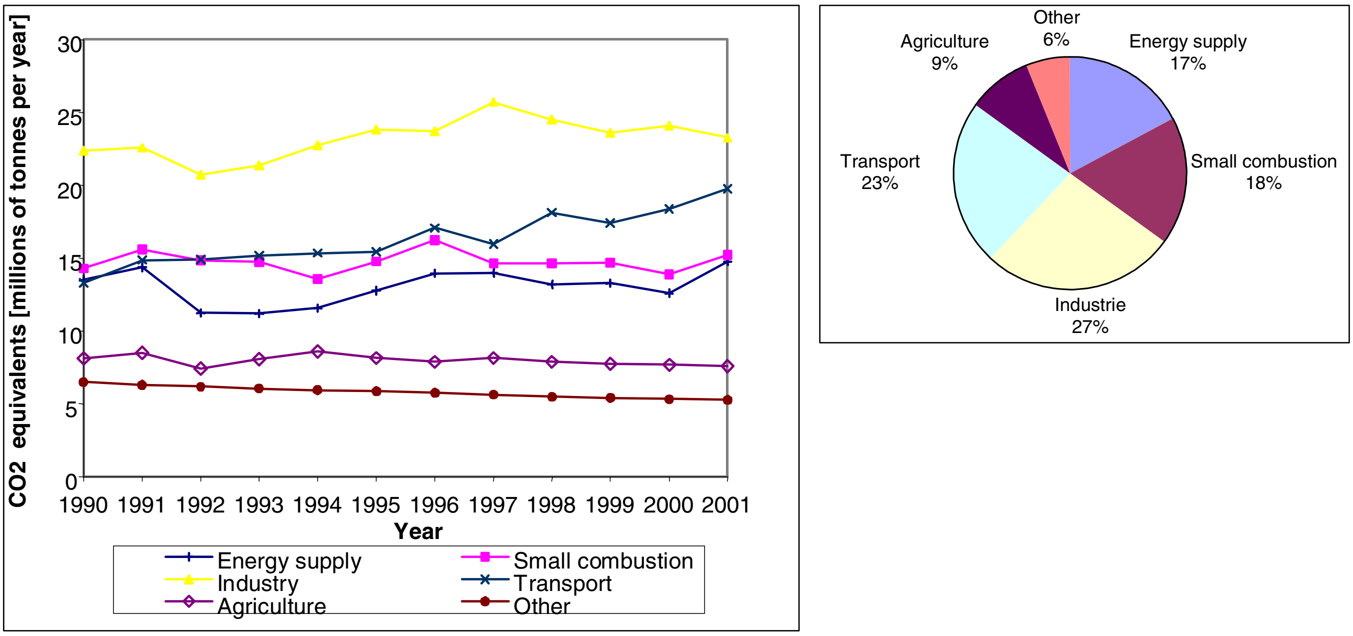

Fig. 6.1-3: Greenhouse gas emissions by sector (1990-2001) and main emitters' shares of GHG emissions (2001).

Source: UMWELTBUNDESAMT (2003b)

The greenhouse gas emissions of the transport sector increased the most between 1990 and 2001[47] (by 49% to 19.8 million tonnes), followed by the energy supply sector with an increase of 9.5%. The latter increased mainly from 2000 to 2001. The greenhouse gas emissions of the energy supply sector amounted to 14.8 million tonnes of CO_2 equivalents in 2001. The greenhouse gas emissions of small combustion increased by 6% between 1990 and 2001. The peak in 1996 indicates the increased heating requirements due to the cold winter. In 2001, these emissions amounted to 15.2 million tonnes. With emissions of 23.3 million tonnes in 2001, the industry sector showed an increase of 4% compared to 1990. The peak in 1997 mainly points to the positive economic situation in the iron and steel industry and the increased use of fuels for this purpose. Greenhouse gas emissions in agriculture increased by 7% to 7.6 million tonnes between 1990 and 2001, and those of the “Other“ category declined by 19% to 5.3 million tonnes of CO_2 equivalents.

Figure 6.1-4 illustrates the absolute changes in the greenhouse gas emissions of the six sectors between 1990 and 2001.

[47] Note that total emissions of the transport sector in this chapter and in the chapter ‘Air’ do not correspond with total emissions in the chapter ‘Transport’. The latter include emissions from mobile sources which are included in this chapter and in the chapter ‘Air’ in the sectors small combustion and industry - according to the international reporting requirements. For an overview of emitters please refer to Chapter 4.2.3. In addition, the chapter ‘Transport’ refers to a time series of 1980-2002.

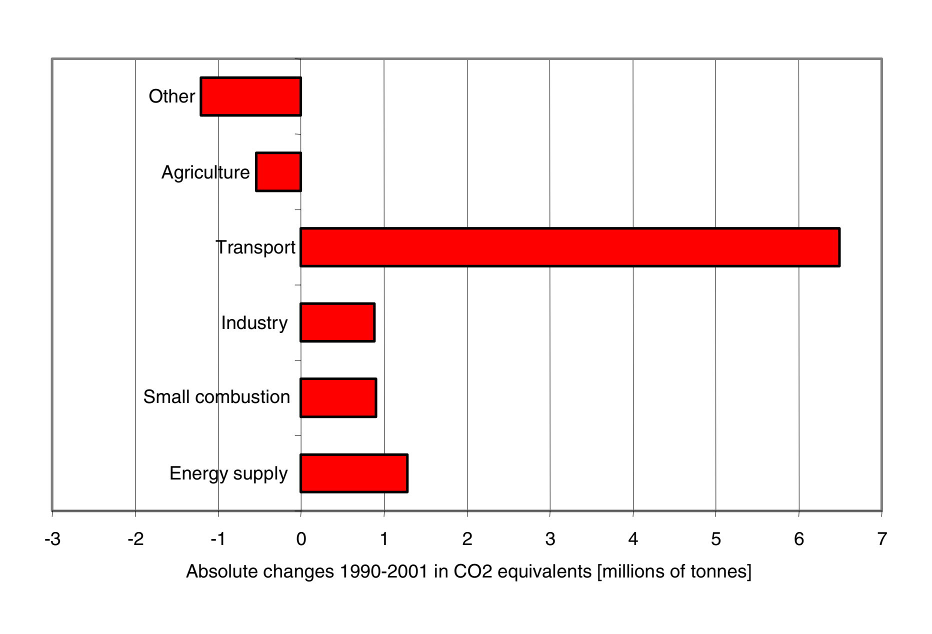

Fig. 6.1-4: Greenhouse gas emission changes in the six main source sectors between 1990 and 2001 (absolute figures in millions of tonnes of CO_2 equivalents).

Source: UMWELTBUNDESAMT (2003b)

Causes of emission trends

The greenhouse gas emissions of the **energy supply** sector consist of 99% CO_2 and 1% methane; they grew by 9.5% between 1990 and 2001. Especially from 2000 to 2001, a large increase of 17% could be observed. This increase can be explained by the increased use of fuels and increased firing of power plants with coal in 2001 (see Chapter 3.4). The share of energy supply in overall greenhouse gas emissions has remained stable at 17% since 1990.

While the greenhouse gas emissions of **small combustion** increased by about 6% between 1990 and 2001, their share in overall greenhouse gas emissions remained almost stable at 18%. 96% of these greenhouse gas emissions consist of CO_2, and an increase of 7.5% since 1990 can be observed. The generation of heat and warm water contributed a major share – 88% (2001) – to CO_2 emissions. The remaining 12% were produced by the use of off-road machinery (such as tractors) in agriculture and forestry.

By 2001, the **industry** sector had reduced its share in overall greenhouse gas emissions by two percentage points to 27% compared to 1990. Nevertheless, this sector's greenhouse gas emissions increased by 4% between 1990 and 2001 (see Chapter 3.10.3.1). The industry sector's greenhouse gases consist of 89% CO_2, 7% fluorinated gases[48] (F gases) and 4% N_2O (2001). While the CO_2 emissions of this sector increased by 4% compared to 1990, the emissions of fluorinated gases grew by as much as 17%. Only in N_2O emissions can a decrease of 11% be observed.

[48] Fluorinated gases comprise the groups of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) as well as sulphur hexafluoride (SF_6). These gases are used mainly in the following industries/products: refrigeration and air conditioning (HFCs), foam blowing (HFCs), noise insulating windows (SF_6), magnesium production (SF_6), micro-electronics (SF_6, PFCs), switching systems in electrical power generation (SF_6).

This reduction can be put down to the efforts of the chemicals industry to cut back N_2O emissions in nitric acid production by installing catalytic converters.

The greenhouse gas emissions of the **transport**[47] **sector** are subject to the highest growth rates. While the transport sector's share of overall greenhouse gas emissions was 17% in 1990, it grew to 23% in 2001. The total increase in greenhouse gas emissions from the transport sector was 49%; with the emissions of heavy goods vehicles increasing considerably more than those of passenger cars (see Chapter 3.6.3.5). 96% of the transport sector's greenhouse gas emissions consist of CO_2 released during the combustion of fuels (2001). The rest consists mainly of N_2O.

The rapid increase in transport emissions is also partly due to "tank tourism" due to low fuel prices, especially in the case of diesel. At this point, diesel fuel is cheaper in Austria than in most of its neighbouring countries (as of 5 December 2003); only in the Czech Republic is it slightly less expensive (BMWA, 2003).

The greenhouse gas emissions of the **agriculture** sector are composed of 53% CH_4 and 47% N_2O emissions (in GHG equivalents) in 2001. Varying numbers of livestock and the (resulting) varying amounts of organic manure, types of liquid manure storage and animal husbandry methods as well as the intensity of fertilizer use are the most significant factors influencing emissions in agriculture (see Chapter 3.1.3). At 9%, the share of agricultural emissions in 2001 was one percentage point lower than in 1990.

The greenhouse gas emission of the "**Other**" category consists of 87% methane, 8% CO_2 and 5% N_2O. 88% of these greenhouse gases originate from **waste treatment** (not including waste incineration for the purpose of energy production, which is included in the energy supply sector). Emissions in this area consisted almost exclusively of methane (99%). About 83% of these emissions are released by waste disposal sites, about 17% escape during waste water and sludge treatment as well as composting (see Chapter 3.11.3). The increasing gas recovery rate in waste disposal sites represents the most important reduction measure in this field. The remaining greenhouse gas emissions in the "Other" category are CO_2 and N_2O emissions from the solvents sector, and to a smaller extent from waste incineration (not for the purpose of energy production).

International emissions trends

Throughout the entire EU, greenhouse gas emissions were 2.3% lower in 2001 than in 1990. The most significant reason for this decrease in emissions was the reduction of emissions in Germany (due to improvements in efficiency and economic restructuring after reunification) and in United Kingdom (due to the conversion from coal to gas in electricity generation).

In the Accession countries, the emissions were 36% lower in 2001 than in the base year because of the decline and the restructuring of the economy and efficiency improvements. Worldwide, however, CO_2 emissions from the combustion of fossil fuels grew by 13% in the 1990s.

6.1.3.3 Temperature and precipitation trends in Austria

Temperatures have been recorded in Austria since 1767[49]. These records show that in Austria (and worldwide) the 1990s were the warmest time in recorded history. On a ten-year average, they show an increase in temperature of about 1.5° C compared to the end of the 19th century, but with considerable fluctuations from one year to the next. Seasonal differences are the most striking – the temperature increase in Austria (and in the whole Alpine region) has been considerably more pronounced in winter than in summer. At the regional level, the average temperature in the winter half-year in the 1990s was about 1.5 to 2.0° C higher than the average temperature in the 18th and 19th centuries, while the average summer temperature was only about 1.0° C higher than the average summer temperature in the 19th century. At the end of the 18th century, even higher summer temperatures than today were registered. On average, temperatures in 20th-century Austria were about 0.35° C higher than the average temperatures in the 19th century, with summer temperatures remaining fairly stable and winter temperatures increasing by 0.7° C. In high mountain regions, the warming was more drastic than in lower regions (AUER et al., 2001). Along with the temperature increases, a dramatic retreat of Alpine glaciers has been observed since about 1870.

In Vienna, the average temperature in 2000 deviated by +1.4° C, in 2001 by +0.3° C, and in 2002 by +1.1° C from the mean value in the climate period from 1961 to 1990. Throughout Austria, the deviations varied between +0.8° C and +1.6° C in 2002. The summer of 2003 was generally the warmest since the beginning of regular meteorological measurements. In Vienna, 1994 was the warmest year of the 20th century, with a temperature deviation of +1.6° C compared to the mean value of the climate period from 1961 to 1990; the second warmest year was 1992. The winter of 1997/1998 was the warmest of the entire 20th century in Vienna.

The Start Project Climate Protection (StartClim) produced a number of new findings, for example concerning temperature developments in Vienna in the 20th century: the number of "tropical days" (days with temperature peaks above 30° C) doubled from about 4.5 in the first half of the century to more than 9 in the second half of the century.

Scenarios calculated in the StartClim project another drastic increase in tropical days for Vienna in the period from 2025 to 2050, from the current 9 days to about 25 days in future. The number of frost days (days with a temperature minimum below 0° C), however, will not decrease to the same extent as the tropical days increase; according to the scenario, this figure will only drop to 90 from its current level of about 95. This development would thus lead to increasingly divergent temperature extremes, which would be in line with the general trend of more weather extremes.

Additional findings of StartClim 2003 are summarized in the final report, which is available online and free of charge at http://www.austroclim.at/startclim.

The annual amount of precipitation in Austria has not shown a uniform trend over the last 100 years. While it has decreased slightly in Vienna and Klagenfurt, for example, it increased slightly in Kremsmünster and remained fairly stable in Inns-

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[49] Longest measurement series at Kremsmünster (1767) and Vienna (1775).

bruck.[50] Throughout Austria, however, 2002 saw far more precipitation than the average, with northern regions experiencing more than one-and-a-half times the usual annual average amount of precipitation.

According to climate models, a warmer climate can be expected in Austria as a consequence of the anthropogenic greenhouse effect, with precipitation decreasing in the summer and increasing in the winter, and snowfall declining in general (see ÖAW, 1992). A decrease in the duration of snow cover and a lack thereof in lower regions are expected, as is the rapid retreat of glaciers. This would alter the water levels of rivers, especially in Alpine areas, which would affect the production of electricity (among other things).

A higher CO_2 level in the atmosphere would facilitate the photosynthetic activities of plants in general, but an increase in temperature and the altered precipitation patterns are expected to have dire consequences in particular for alpine and forest ecosystems which are not able to adapt to the altered conditions (see Chapters 5.4.3.2 and 5.4.4). The Austrian Academy of Sciences estimates that the extra-alpine and sub-alpine regions of Austria will become an unsuitable environment for spruce trees in the future. In general, vegetation zones will shift towards higher altitudes and towards the north within such a short period of time that ecosystems will not be able to adapt sufficiently. Problems can also occur in agriculture in the north-eastern regions of Austria, which are already rather dry. Serious consequences are expected for winter tourism due to the decrease in the duration of snow cover.

More recent surveys from Switzerland show that extreme incidents of precipitation will increase in the Swiss Alps and especially in the foothills of the Alps and Swiss Midlands. Reliable predictions concerning extreme precipitation (such as the rains causing the flood of the century in Austria in 2002 - see Chapter 6.2) are extremely hard to make since extreme events are rare by nature and thus difficult to analyse statistically. Therefore Swiss researchers only looked at higher levels of rainfall (below damage-causing levels) with a repetition interval of about one month.

Findings: Between 1901 and 1994, about two thirds of the Swiss monitoring sites for precipitation recorded a higher frequency of intensive daytime rainfall in the summer half-year. For the winter half-year, as many as 90% of the monitoring sites show this trend (OCCC, 2003).

6.1.4 SUMMARY ASSESSMENT AND OUTLOOK

6.1.4.1 Austrian emissions projections

The third national climate report of 2001 presented the latest greenhouse gas projections for 2010 (BMLFUW, 2001). The projections are based on expert judgement and take two scenarios into account: 'with current measures' and 'with additional measures'[51].

[50] http://www.zamg.ac.at

[51] In the climate reports for the UNFCCC Secretariat, projections for two scenarios have to be made: (1) the scenario 'with current measures' takes into account all measures implemented or adopted at

Figure 6.1-5 shows that greenhouse gas emissions in the scenario 'with current measures' will be significantly (about 8%) higher in 2010 than in 1990, while emissions drop to about 10% below the 1990 level in the scenario 'with additional measures'. The diagram also shows that already in 2001 emissions were slightly above the level projected for 2010[52].

Therefore, the projections in the third climate report assume that Austria will not reach its Kyoto target even if currently planned additional measures are implemented. The climate strategy of the Austrian Federal Government and the Federal Provinces thus provides for the use of flexible project-related mechanisms of the Kyoto Protocol abroad, namely the Joint Implementation (JI) and Clean Development Mechanism (CDM). In these projects, emission reductions due to investments in another industrialized country (JI) or in a developing country (CDM) are credited to the investor country's emissions account.

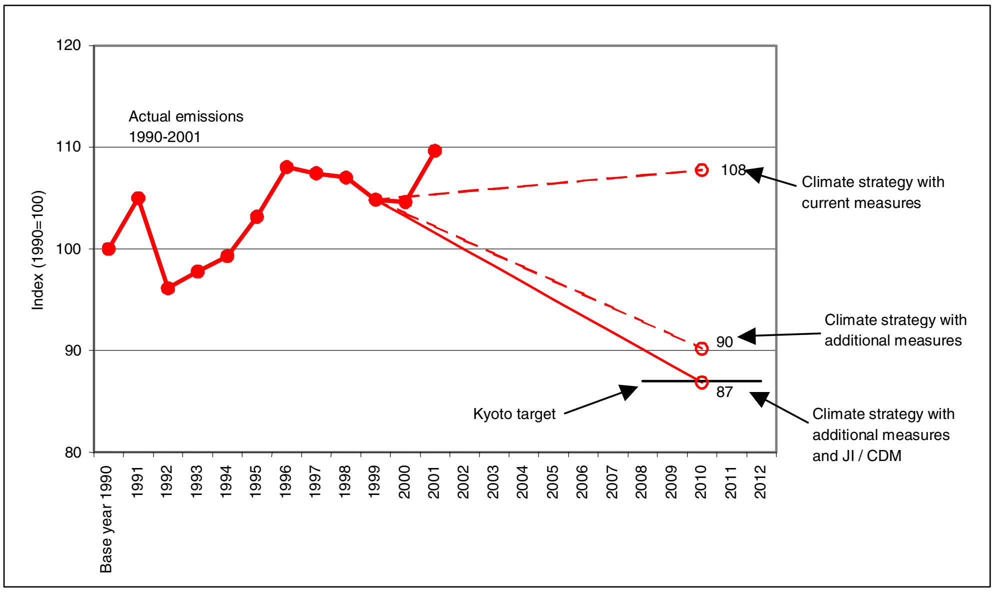

Fig. 6.1-5: Emission projections until 2010 (overall greenhouse gas emissions without land-use change and forestry).

Source: UMWELTBUNDESAMT (2003a)

Note: This diagram is based on the absolute figures from the projections in the third climate report (BMLFUW, 2001) and the actual emissions time series calculated in 2002. The absolute figures from the projections were calculated on the basis of the time series established in 2000, thus the percentage changes in the projections differ in relation to the base year from the percentage changes in the third climate report. Since the projections are taken from the third national climate report, they begin in 1999.

6.1.4.2 EU emissions projections

The latest EU progress report shows that the EU will not reach its Kyoto target with the existing measures (EC, 2003 and EEA 2003). According to the Member States' most recent estimates, the existing policies and measures which have been imple-

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the time of preparing the projections; (2) the scenario 'with additional measures' comprises existing measures as well as all measures planned for the future.

[52] The dramatic increase in 2001 does not necessarily conflict with the predictions because – as illustrated in Fig. 6.1-5 – some annual emission levels can fluctuate considerably.

mented at the national and European levels will only reduce EU-wide emissions by 0.5% by 2010. This reduction would be 7.5 percentage points less than the reduction agreed upon in the Kyoto Protocol (see Fig. 6.1-6). Only two Member States, Sweden and the UK, project that they will reach their target with the current measures.

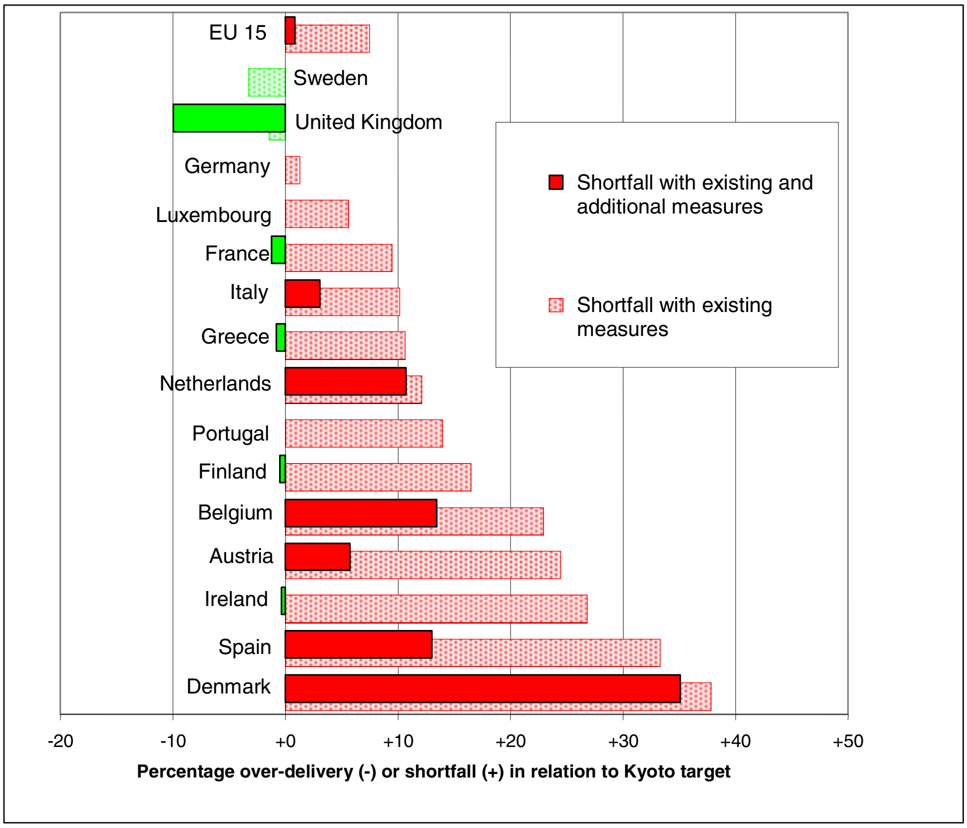

Fig. 6.1-6: Over-delivery or shortfall between emission projections (with existing measures or with existing measures plus additional measures) and the Kyoto target.

Source: EEA (2003)

Note: The EU Member States establish two projections: (1) a projection with currently existing measures, and (2) a projection with additional measures (see footnote 51). The diagram shows the deviations for each Member State (shortfall or over-delivery) between the Kyoto target and the two projections.

All other Member States project that they will not reach their targets with existing measures; the gap between the Kyoto target and the prognoses ranges from 1.3 (Germany) to 37.8 percentage points (Denmark).

The EU and most Member States are already planning additional measures to limit emissions. Important fields of policy are renewable energy sources, combined heat and power, improvement of energy efficiency, energy efficiency standards for buildings, agreements with car manufacturers on the reduction of specific CO_2 emissions, and the landfill directive. EEA (2003) provides an overview of the existing and additionally planned measures; furthermore, those measures are also outlined in the EU Member States' national climate reports.

If the additionally planned measures are implemented completely and have the expected effects, the EU will come very close to its Kyoto target. The projected emissions are 7.2% below the level of 1990 and thus 0.8 percentage points above the reduction target. Even with additional measures, six Member States (including Austria) will fall short (in some cases far short) of their Kyoto targets; Germany, Luxembourg and Portugal had not reported any additional measures at the time this report was drafted.

The scenario described for the EU assumes that the reductions achieved by the Member States exceeding their obligations (such as the UK) will be used to compensate for those States which do not reach their reduction targets. However, there is no legal basis for that at the moment.

In addition to the implementation of emission reduction measures on a national level, the Member States can also make use of Kyoto mechanisms to reach their emissions targets, namely emissions trading, Joint Implementation and the Clean Development Mechanism. Another option is to take CO_2 sequestration by forests, soil and agriculture into account. However, currently only little information is available on the extent to which EU Member States are planning to make use of this option in order to support the fulfilment of their targets.

6.1.4.3 Global emissions projections

The Intergovernmental Panel on Climate Change[53] (IPCC) assumes four different scenarios concerning the future development of emissions (IPCC, 2001). These scenarios differ with regard to global socio-economic and technological developments as well as the associated consumption and production patterns. However, no specific measures to reduce greenhouse gas emissions have been assumed.

The results of these scenarios can be summarized as follows:

- In all scenarios, global CO_2 emissions will keep rising until at least 2030. Thus a stabilization of the CO_2 concentration below 550 ppm cannot be expected.
- Global strategies coupled with a reduction of income differences between industrialized and developing countries as well as rapeconomic reform towards a service and information society will offer the best preconditions for limiting anthropogenic greenhouse effects.

6.1.4.4 Global climate change scenarios

Based on the work of the Intergovernmental Panel on Climate Change (IPCC, 2001) concerning the future changes in key climatological factors expected in the 21st century, and under the assumption that no specific measures to reduce greenhouse gas emissions are taken, the following statements can be made:

- the increase in the air temperatures and the rise in the sea level will continue throughout the 21st century (and beyond); an increase in the global average temperature of 1.4 to 5.8°C and a rise in the sea level of 10 to 90 cm are expected

[53] The IPCC (Intergovernmental Panel on Climate Change) was founded in 1988 by the United Nations Environment Program (UNEP) and the World Meteorology Organization (WMO). The IPCC does not carry out research itself but creates periodic scientific Assessment Reports regarding research on climate change and its effects.

- the CO_2 concentration (currently 370 ppm) will range between 550 and 800 ppm at the end of the 21^{st} century (due to the use of fossil fuels)
- measures to bind carbon in the terrestrial biosphere can only reduce the increase in concentration by 40 to 70 ppm at best
- most models suggest that a weakening of thermohaline circulation[54] can be expected in the North Atlantic and the Gulf Stream
- most alpine glaciers will have melted away in 100 to 200 years
- The Greenland ice sheet has a high probability of melting down (assuming the long-term warming of this region by more than 3°C). The melting would be coupled with an annual rise in the sea level by another 0.7 cm or by a total of 7 m in the long term.
- In addition, profound changes in local weather conditions are to be expected; these changes cannot be modelled with sufficient accuracy at the moment. The best indicator for this is annual financial damage caused by extreme weather events. At present, this damage amounts to USD 70 000 million, with a strong upward trend (doubling every ten years).

6.1.5 RECOMMENDATIONS

6.1.5.1 Austria

In June 2002 the Austrian Federal Government adopted the Climate Strategy in its Council of Ministers (BMLFUW, 2002). The core of this Climate Strategy is a package of measures which projects a reduction of the emissions of the six Kyoto gases by about 14 million tonnes of CO_2 equivalents. The reductions provided for in the Climate Strategy are such that Austria will not meet its Kyoto target through national measures alone. In addition to the common policies and measures of the EU, the flexible mechanisms under the Kyoto Protocol[55] will be used to meet the target[56].

The package of measures comprises regulatory measures, public aid and investments, economic measures (fiscal measures, national emissions trading), pilot projects and information campaigns. The additional funds required to finance the Climate Strategy amount to EUR 90 million per year.

The overall process of implementing the Climate Strategy will be controlled by the Kyoto Coordination Committee, which consists of high-ranking federal and provincial representatives. Nine working groups will develop measures and implementation strategies and prepare and evaluate implementation in the following fields: (1) space heating, (2) electricity and heat production, (3) waste management, (4) transport, (5) industry, (6) agriculture and forestry, (7) fluorinated greenhouse

[54] Sea currents are also caused by density differences in sea water. Since those differences are caused by variations in temperature and the salt concentration, such currents are also called thermohaline.

[55] The flexible mechanisms are: international emission trading, the joint implementation of measures among industrialized countries (Joint Implementation) and the use of environment-friendly technologies in developing countries (Clean Development Mechanism).

[56] A pilot phase of international emissions trading will start in the EU in 2005 (see Chapter 3.10.3.6).

gases, (8) financial coordination, and (9) economic instruments. The first comprehensive implementation report is to be produced in 2004 (BMLFUW, 2002).

As Austria will have to reduce emissions by at least 1.4 million tonnes of CO_2 equivalents annually in order to meet its obligations, the Federal Environment Agency is of the opinion that further packages of measures should be developed in addition to the implementation of the Climate Strategy. These packages should be implemented if emissions cannot be reduced by 1.4 million tonnes of CO_2 equivalents per year.

6.1.5.2 European Union

In June 2000 the EU Commission initiated the European Climate Change Programme (ECCP) to identify the most environment-friendly and cost-effective additional measures which will allow the EU to achieve its target and complement the efforts of the Member States. The ECCP's second progress report presents an overview of the most recent findings of the ECCP and the implementation status of measures defined at the start of the program (ECCP, 2003). The program forms the basis for the Commission's preparation of further measures in the most promising fields and guarantees that the most cost-effective measures are given preference.

The political concepts and measures under the ECCP (2003) have an emissions reduction potential totalling 578-696 million tonnes of CO_2 equivalents. This is about twice the EU-15's emissions reduction target of - 8%, which has to be reached in the first commitment period of the Kyoto Protocol. This means that the EU can reach its target with the appropriate measures.

The legal provisions that have already gone into effect or been proposed by the Commission have a reduction potential of 276-316 million tonnes of CO_2 equivalents. These include measures such as:

- Directive on the promotion of electricity produced from renewable energy resources (2001/77/EC)
- Directive on the Energy Performance of Buildings (2002/91/EC)
- Directive on the Landfill of Waste (1999/31/EC)
- Directive establishing a scheme for greenhouse gas emission allowance trading (2003/87/EC)
- Proposal to increase use of biofuels in transport (COM/2001/547)
- Proposal to promote the cogeneration of heat and power (COM/2002/415).

The preparations for a number of other key measures have already made sound progress. The following measures could increase the above-mentioned reduction potential by 25%:

- Energy services to increase the efficiency of final energy demand
- Creation of a framework for eco-design of energy-consuming products and definition of minimum energy efficiency requirements for such products
- Development of a proposal for a Regulation governing fluorinated greenhouse gases
- Public Awareness Campaign/Campaign for Take Off on energy efficiency
- Increased energy efficiency in public procurement.

Commission Services evaluate additional measures such as integrating climate-related targets in the structural funds, further steps to support the use of renewable energy sources for heating purposes, integrating energy efficiency in the Environment Management System (EMAS), and measures to reduce greenhouse gas emissions of air conditioning systems in motor vehicles.

6.1.5.3 Global need for action

At the global level, the Intergovernmental Panel on Climate Change compiles research findings in the field of emissions reduction potential (IPCC, 2001). The IPCC mainly considers the following means of reducing greenhouse gas emissions:

- Increasing efficiency in energy use
- Introduction of energy sources with low carbon content (such as natural gas instead of coal)
- Conservation or expansion of terrestrial carbon stocks (such as forests, soil)
- Emission reductions in non-energy sources and non-CO_2 greenhouse gases (such as CH_4 and N_2O from agriculture).

According to the IPCC, the international instruments which are mostly discussed are international emissions trading, Joint Implementation, Clean Development Mechanisms (CDM), a harmonized emissions/carbon/energy tax, international technical standards and voluntary agreements. The IPCC points out that usually a combination of instruments is used; and the selection criteria include: Efficacy in reaching environmental targets, cost efficiency, distribution effects, administrative and political feasibility, enforceability, and compatibility with other political goals. According to the IPCC, no general recommendations concerning preference for various instruments can be given. Furthermore, there is also the possibility of using all these instruments not only on a national but also on an international level.

Concerning costs, the IPCC points out that often the costs of certain measures are offset by advantages such as reduced energy costs and reduced emissions of conventional air pollutants. Thus these measures are referred to as “no-regret measures“ or measures whose implementation is advisable in any case. Usually these positive side-effects are not taken into account when costs are stated.

According to the IPCC, however, the costs of reaching the Kyoto target are low compared to the uncertainties concerning the projected economic development. In the next ten years they will influence economic growth by 0.01 to 0.1% annually, thus delaying economic growth only by one to two months.

Nevertheless it can be expected that some sectors of the economy (such as coal and energy-intensive products) will suffer losses, while others (such as renewable energy sources) will see gains. According to the IPCC's analysis, the oil sector will not be among the losers in the next few years. Instruments to cushion the negative effects are also available (such as restructuring or diversification).