2 Emissions and removals of greenhouse gases

2.1 Introduction

Swedish emissions of greenhouse gases governed by the Kyoto Protocol were almost exactly the same in 1999 as in 1990 (less than 0.1 per cent). Normal-year-corrected emissions were instead somewhat lower in 1999 than 1990. Normal-year correction alters emissions from heating and electricity generation, since these sub-sectors are affected by weather (temperature, wind etc) and water supply to hydro-power plants.

This chapter deals with emissions of anthropogenic (caused by man) greenhouse gases in Sweden during 1990 - 1999. Emissions are presented sector by sector in line with the classification used in the reports submitted under the Climate Convention. The sectors inquestion are energy (including transport), industrial processes, solvent use, agriculture, land use (carbon dioxide emissions and carbon dioxide sinks, ie, the change in the carbon dioxide stored in wood and wood biomass) and waste. Emission calculations have been made for carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The tables appendix also contains estimates of emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOCs), which are also included in the annual emission inventories made under the Climate Convention.

Section 2.3 presents emissions of greenhouse gases in Sweden broken down into different gases. Section 2.4 deals with emissions from each sector.

The methods used conform to the IPCC Revised Guidelines for National Greenhouse Gas Inventories 1996, to be used when reporting emissions under the Climate Convention. One consequence of this is that greenhouse gas emissions from international shipping and air traffic are not included in national emissions, but are instead presented separately. Carbon dioxide emissions from the burning of biomass fuels and decomposition of organic waste are not included in the national total under the guidelines either. However, emissions of other gases from these sectors are included. The combined effect of various greenhouse gases has been calculated using "GWP" (global warming potential) factors. These have been developed by the IPCC and are used as a means of comparing the relative significance of various gases in terms of their greenhouse effect, expressed as carbon dioxide equivalent emissions (see table). These factors are also used in the Kyoto Protocol.

The emissions and removals presented here are largely based on official Swedish statistics, including those on energy waste, agriculture and forestry. Data on emissions from industry has been obtained from reports on pollutant emissions in the annual environmental reports to the regulatory authorities and also

Table 2.1
Emissions (+) and removals (-) of greenhouse gases in 1990 and 1999 by sector, ktonnes carbon dioxide equivalent emissions

	Energy use (inc. transport)	Industrial processes	Solvents	Sectors Agriculture	Waste	Total, not including LUCF	LUCF
Estimated actual emissions							
1990	54,270	5,568	111	7,991	2,554	**70,495**	(-20,292)
1999	54,727	5,958	111	7,599	2,147	**70,543**	(-24,305)
Percentage change	+0.8	+7.00	0	-4.9	-15.9	**+0.07**	+19.8
Normal-year-corrected data							
1990	57,437					**73,662**	
1999	56,648					**72,464**	
Percentage change	-1.4					**-1.6**	

Source: Swedish Environmental Protection Agency

Table 2.2
Global warming potential (GWP) based on the second IPCC evaluation 1995.
Relative greenhouse effects are based on a 100-year time horizon.

Greenhouse gas	Chemical formula	1995 IPCC GWP
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Hydrofluorocarbons, HFCs		
HFC-23	CHF_3	11,700
HFC-32	CH_2F_2	650
HFC-41	CH_3F	150
HFC-43-10mee	$C_5H_2F_{10}$	1,300
HFC-125	C_2HF_5	2,800
HFC-134	$C_2H_2F_4$	1,000
HFC-134a	$C_2H_2F_4$	1,300
HFC-152a	$C_2H_4F_2$	140
HFC-143	$C_2H_3F_3$	300
HFC-143a	$C_2H_3F_3$	3,800
HFC-227ea	C_3HF_7	900
HFC-236fa	$C_3H_2F_6$	6,300
HFC-245ca	$C_3H_3F_5$	560
Perfluorocarbons, PFCs		
Perfluoromethane	CF_4	6,500
Perfluoroethane	C_2F_6	9,200
Perfluoropropane	C_3F_8	7,000
Perfluorobutane	C_4F_{10}	7,000
Perfluorocyclobutane	$c\text{-}C_4F_8$	8,700
Perfluoropentane	C_5F_{12}	7,500
Perfluorohexane	C_6F_{14}	7,400
Sulfur hexafluoride	SF_6	23,900

Source: UNFCCC/CP/1999/7. Guidelines on reporting and review of national communications.

calculations made on the basis of information on activities and emission factors, and, in some cases, expert assessments.

The complete emission tables are found in Appendix 1.

Table 2.3 provides an overview of the methods used. A detailed description of these methods is given in "Sweden's National Inventory Report 2001", available at the Swedish EPA website: www.environ.se.

The emission calculations have largely been performed in the same way as for Sweden's annual report of greenhouse gas emissions under the Climate Convention in April 2001.

Minor adjustments have been made however.

The methods used to estimate greenhouse gas emissions were revised in autumn 2000 and 2001. This was done to achieve closer conformity to the IPCC guidelines. Adjustments have been made for the years 1990 to 1999. This means that most estimated emissions do not tally with the data previously presented in the Second National Communication.

2.2 Historical background

Emissions of greenhouse gases have varied greatly over the last century as a result of changing conditions in various sectors of society. Carbon dioxide emissions from the burning of coal, oil and gas increased along with growing industrialisation and transport.

Emissions rose particularly quickly after the Second World War. Around 1900 emissions of carbon dioxide were about 10,000 ktonnes a year. They peaked at just over 90,000 ktonnes a year in the early 1970s. Reduced use of fossil fuels in the housing and service

Table 2.3
Summary of methods used

Sector	Method
Energy	National, energy statistics and emission factors
Industrial processes	National, environmental reports, estimates
Solvents and other product use	National, estimates
Agriculture	National, IPCC, agricultural statistics and emission factors
The forest sink	National, forest statistics
Waste	IPCC, waste statistics and emission factors

Source: Swedish Environmental Protection Agency

sector, industry and other sectors, combined with the development of hydropower and nuclear power, as well as increased use of biomass fuels, led to reduced emissions thereafter. Greenhouse gas emissions have fallen by about 35 per cent from their peak around 1970.

Historically, we know very little about emissions of methane and nitrous oxide. Agriculture was probably a major source of both these gases throughout the 20th century, although it is not clear how much emissions varied. It is likely that methane emissions from agriculture have declined somewhat since the 1930s, when the number of dairy cattle (which are a particular source of this gas) reached its peak. It is also highly likely that natural emissions of methane have decreased over the past 100 years as a result of more widespread drainage of forest land and peat bogs. The increased use of nitrogenous fertilisers over the last 50 years is thought to have increased emissions of nitrous oxide from agricultural land and manure management but specific figures are not available.

The greenhouse gases covered by the Kyoto Protocol also include sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarb-ons (PFCs), which are used or released from a limited number of applications. Little is known about historical emissions of SF_6 and fluorocarbons in Sweden. SF_6 used as an insulating gas in electrical appliances for several decades, and some emissions are likely to have occurred. Fluorocarbons are formed during the manufacture of aluminium, which has been conducted in Sweden for many years. Here too, emissions have occurred.

Commercial production of HFCs only began in the 1990s and emissions in Sweden prior to this ought to have been negligible. This group of chemicals are now frequently used to replace CFCs and HCFCs, which are ozone-depleting.

2.3 Overview of greenhouse gas emissions

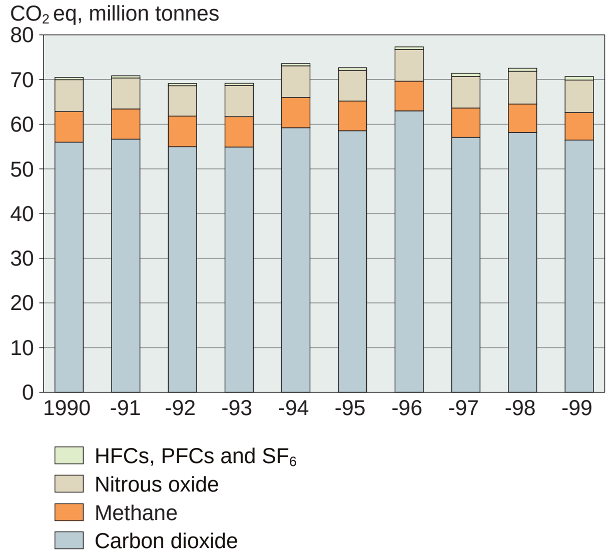
Total emissions of greenhouse gases during 1990 – 1999 rose by less than 0.1 per cent, expressed as carbon dioxide equivalent emissions (Figure 2.2). These emissions do not include emissions from international

Figure 2.1
Carbon dioxide emissions in Sweden 1880 – 1900

*Boden, T., Marland, G., (2000) Estimates of Global, Regional, and National Annual CO2 Emissions from Fossil-Fuel Burning, Hydraulic Cement Production, and Gas Flaring: 1950 – 1992. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, University of North Dakota, USA.

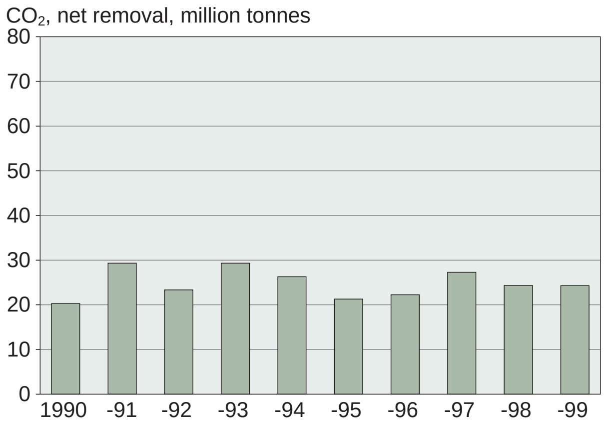
Source: Swedish Environmental Protection Agency

Figure 2.2
National emissions of greenhouse gases, not including emissions and removals from land use and forestry or emissions from international transport.



Source: Swedish Environmental Protection Agency

Figure 2.3
Net removal of carbon dioxide in the forest sector (sink in an increasing timber volume) and land use (losses due to cultivation of organic soils and use of lime)



Source: Swedish Environmental Protection Agency

shipping and air traffic, which the guidelines stipulate should be presented separately. Changes in the forest sink (net removal of carbon dioxide), the carbon sink in wood products, emissions resulting from the liming of agricultural land, and carbon dioxide emissions from organic soils are not included in total emissions either. The changes in these assemblages (except for the carbon sink in wood products) is shown in Figure 2.3.

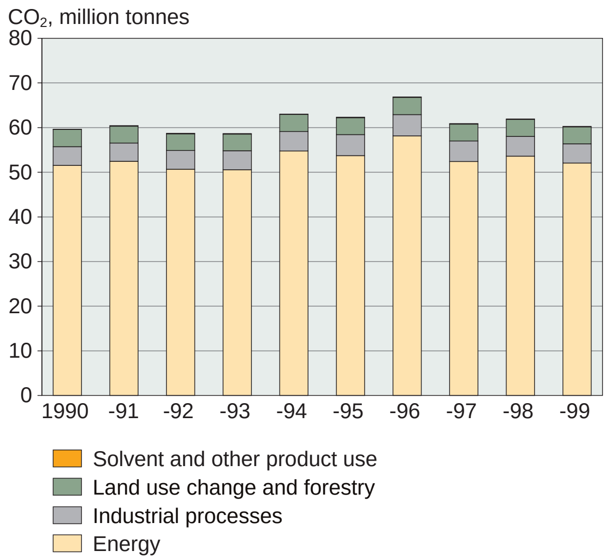
2.3.1 Carbon dioxide

Carbon dioxide accounts for the major part of greenhouse gas emissions in Sweden. Figure 2.4 shows carbon dioxide emissions per sector using the IPCC sectoral classification.

Carbon dioxide emissions have risen by just under 1 per cent since 1990. Carbon dioxide represented just over 80 per cent of all greenhouse gas emissions, expressed as carbon dioxide equivalent emissions, in 1999.

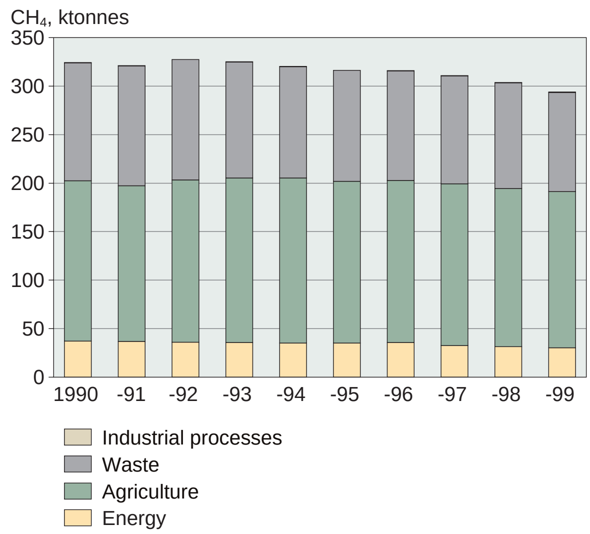
Carbon dioxide emissions come primarily from the energy sector, ie, the burning of fossil fuels for trans

Figure 2.4
Carbon dioxide emissions by sector



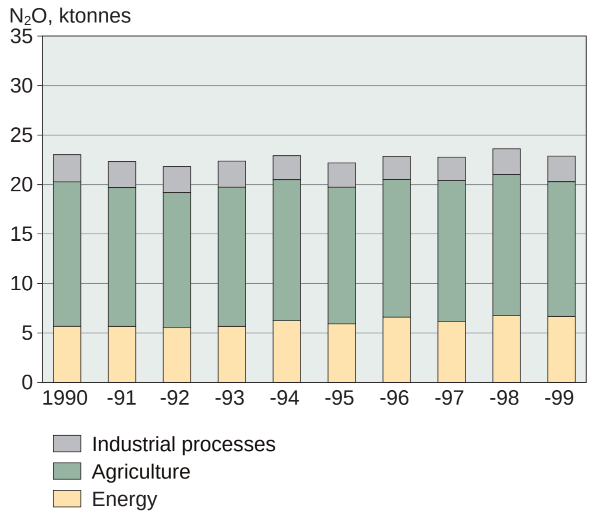
Source: Swedish Environmental Protection Agency

Figure 2.5
Methane emissions by sector



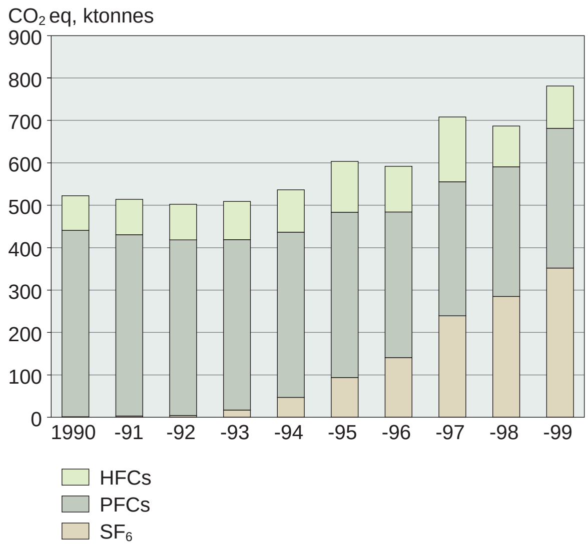
Source: Swedish Environmental Protection Agency

Figure 2.6
Nitrous oxide emissions by sector



Source: Swedish Environmental Protection Agency

Figure 2.7
Emissions of fluorinated gases governed by the Kyoto Protocol



Source: Swedish Environmental Protection Agency

port, residential and commercial/industrial heating etc. These sources account for 87 per cent of all carbon dioxide emissions. Industrial processes and agricultural land use also produce emissions of this gas (see also under the sections on the individual sectors).

2.3.2 Methane

Figure 2.5 shows methane emissions by sector. The main sources are enteric fermentation (agriculture) and landfill sites. These sources account for just under 90 per cent of total methane emissions. The energy sector also produces methane emissions. Emissions of this gas fell by about 9 per cent between 1990 and 1999.

2.3.3 Nitrous oxide

Emissions of nitrous oxide accounted for just under 10 per cent of Swedish greenhouse gas emissions, expressed as carbon dioxide equivalent emissions, in 1999. Figure 2.6 shows nitrous oxide emissions by sector. Agricultural management and use of artificial fertilisers and farmyard manure are the main sources. Nitrous oxide emissions remained constant in the 1990s, with a slight decline in agriculture and a slight increase in the energy sector.

2.3.4 Halocarbons and SF_6

Halocarbons have a number of applications and are emitted as a pollutant during aluminium production (see also section 2.4.2) They all have very great GWP and despite the very low emissions in absolute terms (ktonnes), their contribution to Swedish greenhouse gas emissions (expressed as carbon dioxide equivalent emissions) is not insignificant. These gases accounted for just over 1 per cent of all greenhouse gas emissions in Sweden in 1999. Figure 2.7 shows emissions of halocarbons and SF_6 in the 1990s.

2.4 Emissions of greenhouse gases from the various sectors

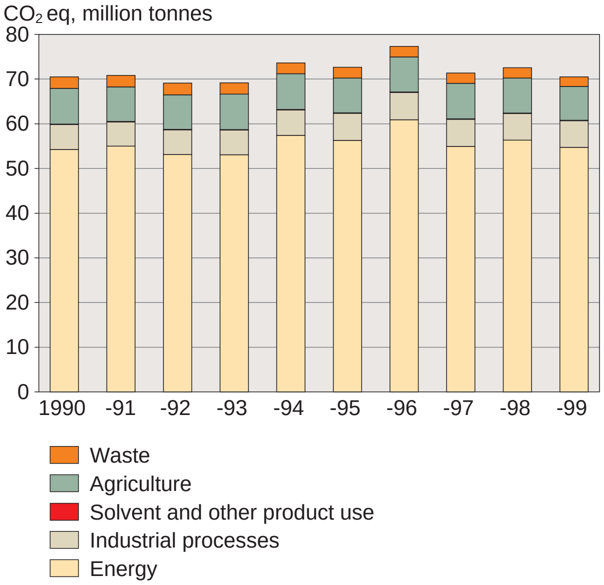
Greenhouse gas emissions by sector are presented below, together with a brief explanation of the changes in the 1990s. The table below shows emissions in the 1990s expressed as carbon dioxide equivalent emissions.

2.4.1 The energy sector, including transport

The energy sector (including transport) has long accounted for the major part of Swedish greenhouse gas emissions; carbon dioxide emissions predominate overwhelmingly in this sector. International shipping and air traffic are not included in total emissions; these are presented separately under the heading "International Bunkers" in the tables appendix.

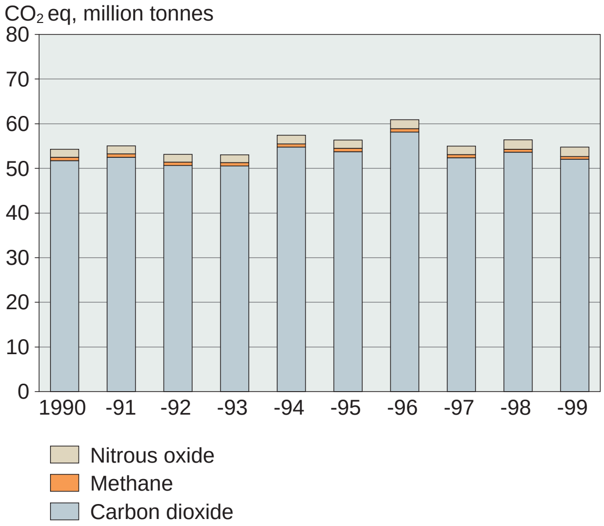
Domestic transport is responsible for approximately one third of Swedish carbon dioxide emissions. Figure 2.9 shows greenhouse gas emission trends in the energy sector in the 1990s. Emissions of nitrous oxide (see tables appendix) have increased from electricity and heat producers, "Other sectors" including the housing and services sectors, and from transport. The increase from electricity and heat generation is because

Figure 2.8
Greenhouse gas emissions by sector, not including land-use changes, forestry or international transport



Source: Swedish Environmental Protection Agency

Figure 2.9
Emissions from the energy sector, including transport



Source: Swedish Environmental Protection Agency

burning of biomass fuels produces somewhat higher emissions of nitrous oxide (see section 2.3.3). Figure 2.10 shows carbon dioxide emissions in the 1990s from the energy sector, broken down into sub-sectors.

Greenhouse gas emissions from electricity and heat production were lower in 1999 than in 1990. Emissions rose in the first half of the 1990s, but have since fallen. District heating expanded rapidly in the 1990s; production rose by 10 TWh (almost 20 per cent) between 1990 and 1999. The use of biomass fuels for district heating production almost trebled during the same period, mainly owing to the carbon dioxide tax on heat production using fossil fuels and the subsidy for development of biomass-fuel based combined power and heating plants. The use of oil in district heating production increased in the early 1990s, but has since decreased simultaneously with reduced use of coal-fired and electric boilers during the period. The use of coal for electricity generation remained unchanged until the mid-1990s but has subsequently fallen. The use of biomass fuels in electricity generation has increased owing to the subsidy for development of biomass fuel-fired combined power and heating plants, among other things. There is great variation from one year to another, depending on hydropower and nuclear power availability. Greenhouse gas emissions from refineries and from the manufacture of solid fuels etc increased in the 1990s.

Natural variations in temperature, wind and solar radiation affect energy use for heating.

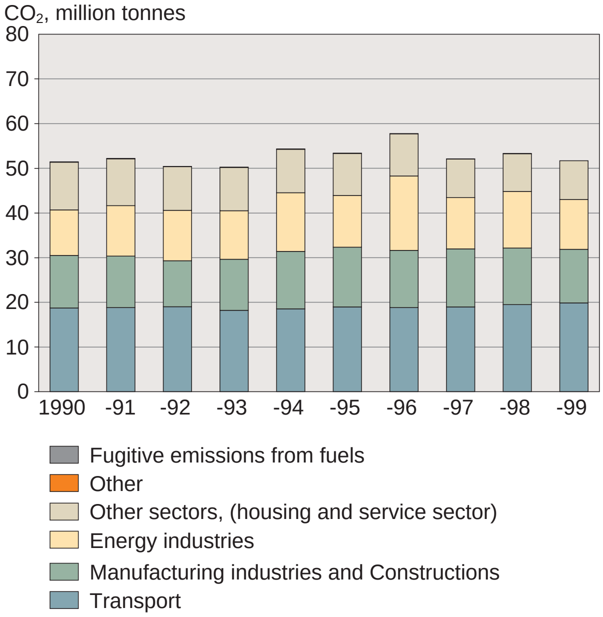
More fossil fuels are used when there is a sharp rise in the demand for energy (for heating). Precipitation also affects energy use because of its influence on hydropower supply. "Normal-year correction" has been carried out to allow analysis uninfluenced by climate effects. Account has been taken of annual variations in temperature, solar radiation and wind, as well as hydropower supply. Fluctuations in the economic cycle and shutdowns at nuclear power plants are not included in normal-year correction. The calculation model is described in Appendix 3. The model used for this communication is a revised version of that used for the previous communications. Figure 2.11 shows normal-year-corrected carbon dioxide emissions compared with actual emissions, using the new normal-year correction method.

As may be seen from Figure 2.11, fluctuations in carbon dioxide emissions from year to year were not as great after normal-year correction. The 1990s were generally warm and wet, except 1996, which was colder than normal, with little precipitation. All years except 1996 therefore have higher emissions after normal-year correction. The largest correction was made for 1990, which was a wet year with a very mild winter. The figures for 1996, which was a cold and dry year, with a high demand for energy for heating and a limited supply of hydropower, have instead been adjusted downwards. Emissions of carbon dioxide from electricity generation were twice as great in 1996 as in 1995 and 1997.

Emissions from the transport sector largely run parallel with the amount of road traffic.

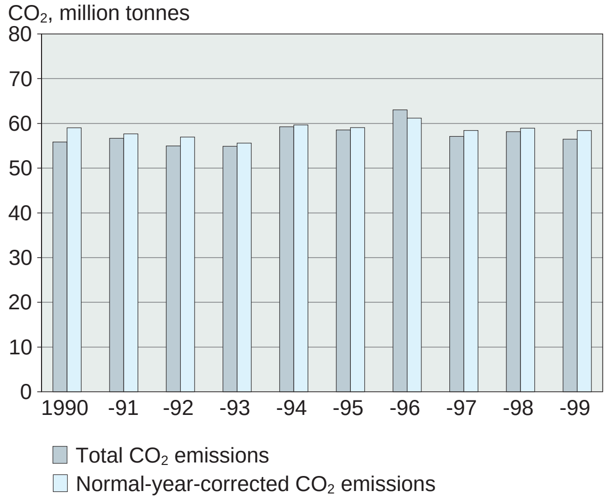
Emissions varied in the 1990s, being at their lowest in 1993 and 1994, when Sweden was in recession (see

Figure 2.10
Emissions of carbon dioxide from the energy sector, broken down into sub-sectors



Source: Swedish Environmental Protection Agency

Figure 2.11
Normal-year-corrected carbon dioxide emissions from the energy sector



Source: Swedish Environmental Protection Agency

Figure 2.12). Over the whole decade, carbon dioxide emissions from the transport sector rose by just under 6 per cent.

Road traffic accounted for the largest emissions increase in the 1990s. Emissions of carbon dioxide rose by just over 1,000 ktonnes (8 per cent) between 1990 and 1999. Heavy trucks with a total weight exceeding 16 tonnes were responsible for most of this increase. Average automobile fuel consumption fell by 11 per cent between year models 1995 and 1999. It fell most for petrol-driven cars. The proportion of buses on the road that are capable of running on alternative fuels (ie, not petrol or diesel) is rising and is currently approximately five per cent. Gas-driven buses account for most of this rise.[1] Both passenger traffic and goods traffic continued to increase in 2000, mainly thanks to a rise in GDP of almost 3.6 per cent.

Use of diesel fuels for rail traffic rose by 4 per cent in 2000 compared with 1999, but total emissions are nonetheless low. The parties' commitments under the Kyoto Protocol only include emissions of greenhouse gases from domestic air traffic. New aircraft and ships have both become more fuel-efficient in recent years, although their operational life is long and the increase in traffic considerable, which explains why total emissions from these sources are continuing to rise. The mean carbon dioxide emission figure per person fell from 170 g per person and kilometre in 1998 to 158 g per person and kilometre in 2000, a reduction of 7 per cent. The explanation for this positive trend is that more journeys are now made using larger, more modern and more fuel-efficient aircraft, and that each aircraft has been flying closer to capacity.[2]

However, methane emissions from transport fell sharply in the 1990s thanks to better exhaust treatment systems, including catalytic converters, among other things. This has also reduced emissions of NMVOCs and NO_X, for which figures are given in the tables appendix.

Emissions of nitrous oxide from the transport sector are increasing because of the growing proportion of vehicles fitted with catalytic converters. These vehicles emit more nitrous oxide than those without catalytic conversion.

All in all, growth in transport has led to an increase in total fuel consumption and hence emissions of greenhouse gases, particularly carbon dioxide.

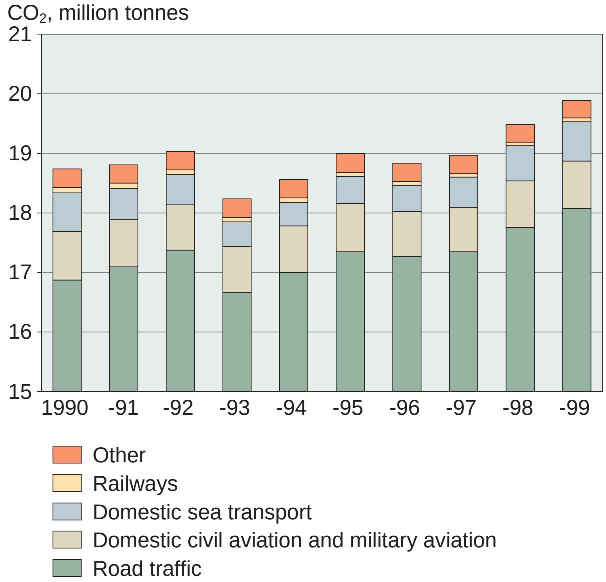
National statistics show a constant and significant fall in carbon dioxide emissions from other sub-sectors, including the heating of residential, industrial and commercial premises, in the 1990s. Emissions of carbon dioxide from other sub-sectors in 1999 were approximately 81 per cent of those in 1990. One reason for this reduction is the increased use of district heating in homes and commercial/industrial premises, which gives greater energy efficiency. Another is the increased use of biomass fuels.

Industrial energy consumption has remained fairly constant, with little variation from one year to another. Emissions from refineries are included under the sub-sector "Energy industries", however.

[1] Swedish transport authorities' joint environmental report 2000

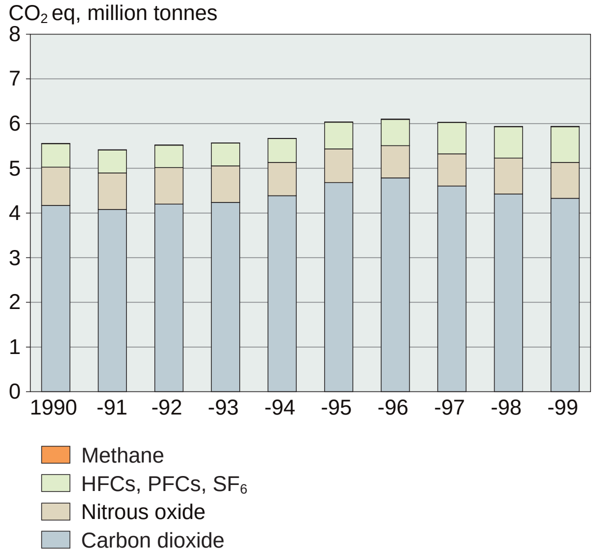
[2] ibid.

Figure 2.12
Carbon dioxide emissions from the transport sector



Source: Swedish Environmental Protection Agency

Figure 2.13
Emissions from industrial processes and from use of fluorinated gases

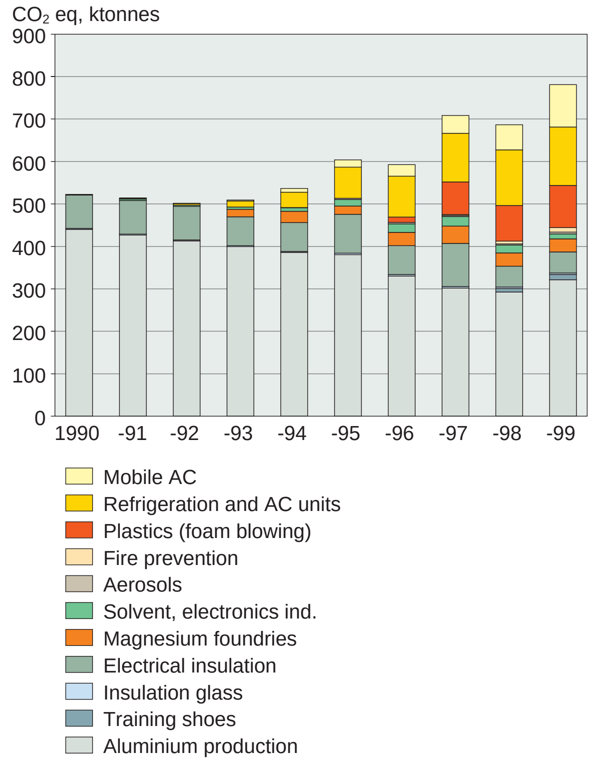


Source: Swedish Environmental Protection Agency

2.4.2 Industrial processes and use of HFCs, PFCs and SF_6

In accordance with the IPCC guidelines, industrial emissions are broken down into industrial combustion and industrial processes. Figure 2.13 shows emissions of greenhouse gases from industrial processes in the 1990s.

Figure 2.14
Emissions from various uses of fluorinated greenhouse gases



Source: Swedish Environmental Protection Agency

Production of iron, steel and other metals was the predominant source of carbon dioxide emissions in the industrial sector in the 1990s. Coke production at primary steelworks is regarded as industrial combustion, where the use of coke in blast furnaces is classified as an industrial process. The use of dolomite and limestone in the manufacture of pig iron also produces emissions of carbon dioxide. Other sources are the use of coal in reduction of copper, coke use in the manufacture of ferro-alloys and carbon electrodes used in aluminium smelting. Emissions from metal production varied in the 1990s. They rose steadily between 1990 and 1996, but have since fallen somewhat. The increase between 1990 and 1999 was approximately 12 per cent. Emission variations are linked to fluctuations in production volumes.

Limestone is used to make cement and quick lime. This process produces carbon dioxide emissions. Cement manufacture is a major source of carbon dioxide emissions. The variations in the 1990s are linked to production variations.

Dolomite and soda (sodium carbonate) are used in the manufacture of glass, glass wool and mineral wool. Lime is burnt in blast furnaces during the recovery of pulping chemicals in pulp manufacturing processes. This also gives rise to limited carbon dioxide emissions.

Nitric acid is used in the manufacture of nitrogenous fertilisers. Manufacture of this acid gives rise to nitrous oxide emissions. These varied somewhat between 1990 and 1999, but do not display any clear trend.

Many processes produce emissions of nitrogen oxides and sulphur dioxide. These are shown in the tables appendix.

Aluminium manufacture gives rise to emissions of PFCs (CF_4 and C_2F_6. Available information indicates that these emissions fell somewhat in the 1990s.[3]

Emissions of these substances from aluminium manufacture, together with the use of HFCs in refrigeration, freezer and air conditioning units, and heat pumps, constitute the main sources of emissions of halocarbons. HFC emissions rose from almost nothing in 1990 to the equivalent of about 350 ktonnes in 1999. This sharp increase occurred largely because

HFCs often replace ozone-depleting chlorofluorocarbons (CFCs and HCFCs), whose use is to be discontinued under the Montreal Protocol on protection of the ozone layer, EC legislation and Swedish legislation. The increase is also due to a growing number of air conditioning units in cars and buildings. HFCs have also replaced CFCs and HCFCs in other applications, such as blow-moulding of expanded polystyrene and as a propellant in aerosol sprays.

SF_6 is used mainly as an insulating gas in high voltage electrical equipment, and also as a controlled atmosphere gas at some magnesium foundries and in sound insulation glass. Figure 2.14 shows emissions of fluorinated greenhouse gases broken down into applications.

2.4.3 Solvent use

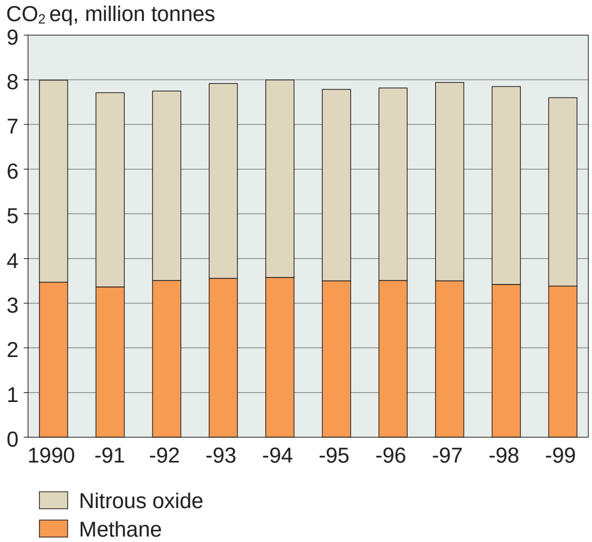
Solvent use causes emissions of VOCs. It is assumed that the carbon content of these emissions oxidises to carbon dioxide. These carbon dioxide emissions are included in the figures for total emissions. Since the uncertainty as to the size of the emissions and variations from year to year is considered significant, and since emissions are small compared with other greenhouse gas emissions, emissions are assumed to have remained unchanged between 1990 and 1999. However, solvent emissions are more important in relation to other environmental issues and international commitments, and it is therefore important to have reliable information about the size of these emissions. The method of arriving at data on emitted quantities of hydrocarbons from solvent use will therefore be reviewed.

2.4.4 Agriculture

Agriculture accounted for just over 10 per cent of total greenhouse gas emissions in 1999, expressed as carbon dioxide equivalent emissions. This figure does not include carbon dioxide emissions from tractors and other equipment used in agriculture. These emissions are presented under the energy sector. Nor are carbon dioxide emissions from land use included; these emissions are presented under the section on forestry and land use as recommended in the IPCC guidelines.

Over 80 per cent of methane emissions from agriculture derive from enteric fermentation and manure.

Figure 2.15
Greenhouse gas emissions from the agricultural sector



Source: Swedish Environmental Protection Agency

Emissions caused by other livestock are greatest from horses, sheep and reindeer. Variations in emissions between the years are mainly explained by fluctuations in animal numbers. Dairy cattle produce the greatest emissions, both in total and per animal; their numbers declined by 22 per cent in the 1990s. However, the number of beef cattle used solely for meat production almost doubled in the 1990s, whereas fattening pig production fluctuated during the period. Total annual methane emissions thus do not vary very much, although emissions rose between 1991 and 1994, probably as a result of the national food policy decision in the early 1990s, which favoured extensive grazing and hence meat production.

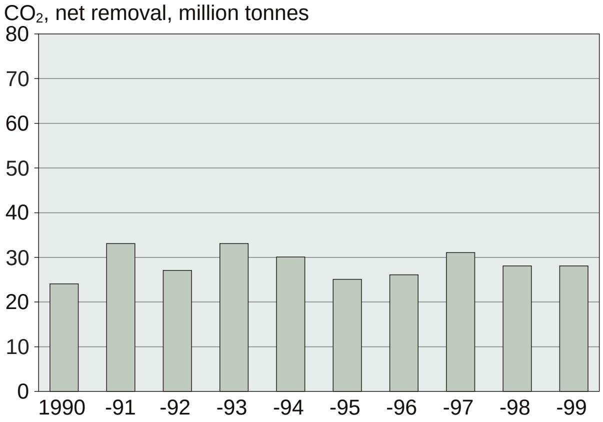
Following EU entry in 1995, the number of beef cattle in Sweden has remained fairly constant, or has fallen slightly, which has led to a slow fall in emissions.

Emissions of nitrous oxide mainly derive from manure management and use of manure and artificial fertilisers. Variations in the number of beef cattle and pigs therefore affect nitrous oxide emissions. Emissions of nitrous oxide fell in the 1990s, mainly because of a changeover to slurry management in dairy and pork production, although the change was small in absolute terms.

[3] This reduction is uncertain, however, since no monitoring is performed at the plant. But the plant manager considers that better control of the process has reduced emissions.

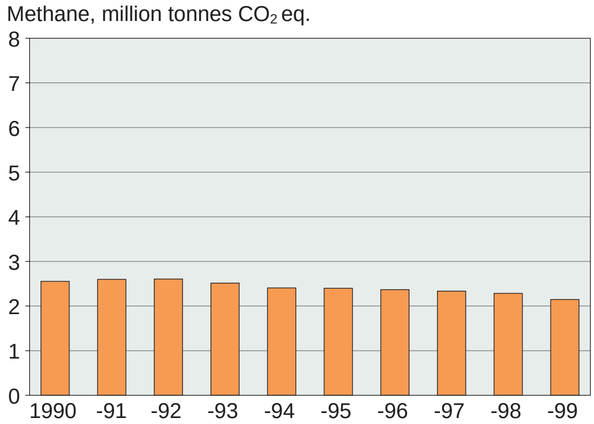
[4] Natural wastage may be in the form of assemblage losses caused by pests, forest fires, storm damage etc.

Figure 2.16
Net removal of carbon dioxide by forests. Variations between the years are mainly the result of fluctuations in felling. The variation in forest growth is evened out over five-year periods.



Source: Swedish Environmental Protection Agency

Figure 2.17
Emissions of methane from waste



Source: Swedish Environmental Protection Agency

2.4.5 Carbon dioxide sinks and losses in forestry and agriculture

Forest removals of carbon dioxide

As they grow, Sweden's forests absorb carbon dioxide, which is fixed in tree biomass.

Carbon dioxide is released when the biomass decomposes or is burnt. Throughout the 1990s, as indeed for much of the 20th century, annual Swedish forest growth exceeded annual felling, including natural wastage.[4] The increase in timber volume represents a "carbon dioxide sink".

The National Board of Forestry estimates the forest carbon dioxide sink on the basis of data obtained from the national forest survey and other forestry statistics and analysis.

Timber volume data has been used as the initial value for each five-year period. The variations from one year to another are mainly the result of fluctuations in felling. The mean values for five-year periods have been used for forest growth, which actually also varies markedly between the years, since there is considerably uncertainty when it comes to the figures for individual years. There was little increase in the store in branches and tree tops because forests became denser.

A considerable proportion of the forest biomass harvested is used for processed products such as paper or various qualities or timber. However, just over half is used for energy production within a year or so. As time goes by, an increasing proportion of wood and paper products are being recycled. However, some products gradually decompose when no longer used. The National Board of Forestry estimates that the increase in forest industry products in use in the 1990s represented less than 100 ktonnes carbon per year (<400 ktonnes carbon dioxide per year) in Sweden.

Figure 2.16 shows forest removal of carbon dioxide.

Figures on flows of carbon dioxide to and from forest soils are highly uncertain.

Preliminary data from the survey of forest biotopes suggests that the net removal of carbon dioxide in the mor layer of naturally well-drained forest soils was between 7,000 and 18,000 ktonnes carbon dioxide per year between 1985 and 1993. the size of the change in the sink in mineral soils has not yet been estimated, but a rough calculation based on data from the survey of forest biotopes indicates that the change is small. Carbon dioxide losses from drained forest soils are probably in the range 4,000 – 11,000 ktonnes carbon dioxide per year. These figures are not included in any further summaries because of the uncertainty of the estimates for forest soils.

Emissions from agricultural land use

Emissions of carbon dioxide from land use have not been presented in previous national communications. The same emissions from organic soils are reported for the entire time series. Variations in quantities emitted from year to year are thus related to the area of agricultural land limed. Emissions from agricultural land use are estimated at about 3,000 ktonnes carbon dioxide per year.

2.4.6 Waste

Landfill sites are the second-largest source of methane emissions. Gas, largely consisting of methane, is formed when landfilled organic waste decomposes under anaerobic conditions. Measures to reduce the quantity of organic waste going to landfill reduce the potential for methane formation. Measures have recently been decided. For example, landfilling burnable waste will be banned as from 2002, landfilling organic waste as from 2005. Measures of this kind will only have an impact over the long term, since methane gas formation declines slowly. Measures such as gas recovery will be necessary to minimise methane emissions from existing landfilled waste. A number of gas recovery/energy extraction units were built in the 1990s. Emissions are estimated to have fallen by about 15 per cent between 1990 and 1999.[5] Figure 2.17 shows emissions of methane expressed as carbon dioxide equivalent emissions in the 1990s.

Waste incineration plants also produce emissions of carbon dioxide, among other things. Carbon dioxide emissions from incineration of waste originating from fossil fuels is governed by the Kyoto Protocol. However, waste incineration in Sweden always involves production of district heating, and sometimes electricity. Emissions from these facilities are therefore included under the energy sector. Energy extraction from waste incineration in Sweden features a high level of conversion efficiency.

---

[5] For a detailed description of the calculation method used, see Metanemission från svenska deponier 1990, 1995 och 1998 ("Methane emissions from Swedish landfills 1990, 1995 and 1998"), Statistics Sweden Report PM MR/MI 2000:3.

3 Objectives, measures and instruments affecting emissions and removals of greenhouse gases

This chapter describes objectives, measures and instruments influencing emissions and removals of greenhouse gases. The principal purpose of some of these objectives, measures and instruments has been to reduce emissions of greenhouse gases. Others, introduced for other reasons, have had a secondary impact on greenhouse gas flows. Since the Climate Convention guidelines for the Third National Communication[1] focus on objectives, measures and instruments decided or used in the 1990s, this report does not contain any proposed new measures except for those considered to be in an advanced planning stage, eg, following a parliamentary decision in principle.

3.1 Swedish climate policy

Swedish climate policy is influenced by the fact that Sweden's scope for reducing its greenhouse emissions differs from that in many other countries. For example, the substantial emission reductions achieved since the early 1970s often make further reductions more expensive in Sweden than elsewhere.

Swedish committees and commissions of enquiry and our widespread use of the consultative process play an important part in preparing reforms and examining the consequences of various political courses of action. The consultative process ensures that government proposals gain broad support throughout society. Examples of public commissions playing an important role in formulating climate policy in the 1990s are

- The Energy Commission.[2] This was set up in 1994 to examine the ongoing energy policy programmes for adjustment and development of the energy system, and to analyse the need for change and additional measures.
- The Green Tax Commission[3] was created in 1994 and was made up of members of parliament, whose task was to analyse the impact of tax legislation on environmental behaviour from a socio-economic perspective, and to use that analysis as a basis for examining the scope for incorporating the environmental dimension in Swedish tax legislation.
- The Committee on Environmental Objectives[4] was appointed in 1998; it was made up of members of parliament.
- The Government Commission for Measures Against Climate Change[5] was established in 1998 as a parliamentary commission charged with the task of presenting a proposed Swedish strategy and action programme to control and reduce emissions of carbon dioxide and certain other greenhouse gases.
- The Commission of Enquiry to examine the feasibility of making use of the flexible mechanisms of the Kyoto Protocol in Sweden was set up in 1998 as an expert commission.

The first climate policy objective in Sweden was formulated in 1988[6], when parliament decided that the government should ascertain the impact of energy consumption on carbon dioxide concentrations in the atmosphere and develop a programme for the emissions nature was capable of withstanding. A subsidiary national objective was that "carbon dioxide emissions should not increase above their present level". Parliament amended the 1988 climate policy objective in 1991. The new objective was that emissions of all greenhouse gases should be limited in all sectors of society.[7] The 1991 objective involved an action-oriented coherent strategy for reducing impact on climate, based on administrative and economic instruments. It was also stated that national efforts in this area should enable Sweden, together with other west European countries, to assume a pro-active role in the international arena.

The present Swedish climate strategy is largely based on the climate policy decision of 1993[8] and the energy policy guidelines laid down in 1997.[9] The 1993 climate policy decision was adopted as a national strategy for complying with the Climate Convention by stabilising emissions of carbon dioxide from the burning of fossil fuels in 2000 at their level in 1990 and then reducing them. A cost-effective Swedish climate policy was also advocated. In this way, economic instruments such as energy and carbon dioxide taxes have come to play an important part in national climate policy.

---

[1] UNFCCC guidelines on reporting and review, UNFCCC/CP/1999/7, pp 83 – 86.
[2] Directive 1994:67
[3] Directive 1994:11
[4] Directive 1998:45
[5] Directive 1998:40
[6] Gov. Bill 1987/88:85 and 1987/88:90
[7] Gov. Bill 1990/91:90, p 18, and Gov. Bill 1990/91:88
[8] Gov. Bill 1992/93:179
[9] Gov. Bill 1996/97:84

Sweden has also initiated joint projects with the Baltic States, Poland and Russia to promote greater energy efficiency and increased use of renewable energy sources.

An additional emission target was set in 1995, when parliament decided that emissions of HFCs, PFCs and related gases, expressed as carbon dioxide equivalent emissions, should be limited by 2000 to a level representing no more than 2 per cent of Sweden's carbon dioxide emissions in 1990.[10]

The 1997 energy policy guidelines contain a strategy for reducing the impact of energy consumption and energy generation on climate. The main features are that efforts to combat the greenhouse effect must be made globally and reflect a long-term approach. It was also said that national emissions of carbon dioxide should be limited as far as possible, taking account of Swedish competitiveness, employment and welfare, and that Sweden should press internationally for emission reductions from heavy industry as well. Emissions should ultimately converge towards a common international target, expressed as emissions per inhabitant.[11] A programme was also initiated to develop an ecologically and economically sustainable energy system. The programme has two elements: a long-term component, involving continuing research and technological development, and a short-term component, designed to replace the shortfall of electricity following closure of the Barsebäck nuclear power plant.

Parliament laid down fifteen environmental objectives in 1999.12 These form the basis for future Swedish environmental policy. One objective, entitled "Reduced climate impact", confirms the climate policy objectives adopted earlier:

"Under the UN Framework Convention on Climate, the content of greenhouse gases in the atmosphere must be stabilised at a level at which human activities will not have a harmful effect on climate systems. This objective is to be achieved in a manner and at a rate such that biological diversity is preserved, food production is assured and other sustainable development objectives are not jeopardised. Together with other countries, Sweden is responsible for achieving these objectives."

The environmental quality objective, described in the Swedish Environmental Objectives Bill[13] and confirmed in a new bill in April 2001[14], is to concentrate on taking action to ensure that the concentration of carbon dioxide in the atmosphere stabilises at a level lower than 550 ppm, and that concentrations of other greenhouse gases in the atmosphere do not increase. It has further been established that achievement of this objective is heavily dependent on action taken in other countries and that responsibility for implementing the necessary measures rests with a number of Swedish agencies at the central, regional and local level. The government intends to present a bill in autumn 2001, which will clarify the strategy, measures and instruments to be used to achieve the objective.

Swedish climate policy is increasingly influenced by developments in the EU. The EU is committed under the Kyoto Protocol to reducing its total emissions by at least 8 per cent between 1990 and 2008 – 2012. The contribution to this reduction to be made by each member state must be established in order for the EU and the member states to ratify the Kyoto Protocol. The respective burdens were decided in the form of "Council Conclusions" at the meeting of EU environment ministers in June 1998. For Sweden's part, an emission level in 2008 – 2012 equivalent to 104 per cent of the level in 1990 was stipulated for the six greenhouse gases governed by the Kyoto Protocol. In addition to this obligation imposed as to Sweden's share of the EU Kyoto commitment, EU common climate policy also influences the form taken by Swedish measures. Important areas are creation of a system for tradable permits, to facilitate the use of renewable energy sources. In the light of this, parliament passed a bill in 200015 containing guidelines for a coherent system to promote renewable energy production, intended to come into force in January 2003. The system is to be based on trade in certificates, combined with an obligation when supplying or purchasing electricity to include a certain percentage of renewable energy meeting certain environmental standards.

3.1.1 Description of areas of policy in which there are objectives, measures and instruments capable of influencing emissions or removals of greenhouse gases

Energy policy

Energy policy covers issues relating to supply, distribution and use of energy, energy research, safety and readyness in case of emergencies in the energy field. Energy policy breaks down into two areas: energy market policy and policy for a sustainable energy sys-

[10] Gov. Bill 1993/94:111

[11] Gov. Bill 1996/97:84, p 74

[12] Gov. Bill 1997/98:145

[13] ibid.

[14] Gov. Bill 2000/01:130. Swedish environmental objectives – subsidiary objectives and strategies

[15] Gov. Bill 1999/2000:134 on the economic premises for electricity generation from renewable sources

tem. The latter area includes programmes for greater energy efficiency, investments in renewable energy and continued research and development in the energy field. Current energy policy dates from 1997.[16]

The aim of Swedish energy policy is to assure a supply of electricity and other forms of energy in the near and long term on terms that are competitive in relation to the world around us. Energy policy is intended to result in efficient use of energy and cost-effective Swedish energy supply, with little effect on health, environment and climate, and to facilitate a changeover to an ecologically sustainable society. The energy policy decision includes a specific strategy for reducing the impact on climate of the energy sector and for efforts in relation to bilateral and multilateral cooperation on joint implementation under the Climate Convention. Energy policy is also intended to create stable conditions for competitive trade and industry, to renew and develop Swedish industry and broader cooperation on energy, environment and climate in the Baltic region.[17] The parliamentary decision of 1997 laid down the guidelines for Swedish energy policy.

To all intents and purposes, the 1997 decision confirmed that in 1991, although an additional feature was the shutdown of the two nuclear reactors at Barsebäck. But 2010 is no longer given as the date by which all reactors are to have been shut down. Instead, the reactors are to be decommissioned at a rate ensuring that adverse effects do not occur in terms of the electricity price, availability of electricity to industry, the balance between output and demand, or the environment and climate. Parliament subsequently enacted a new law on nuclear phase-out.

Energy markets have been gradually deregulated, and trade in electricity in northern Europe occurs over national boundaries in an efficient market. There is now therefore less need to be self-sufficient in electricity. Deregulation also means that national policy cannot differ too much from policies in other countries if market distortions are to be avoided.

Transport policy

Transport policy covers maintenance of roads and railways, road traffic, rail transport, shipping, air traffic and sectoral research.[18] The parliamentary transport decision adopted in the spring of 1998 laid down the present principles and overall aims of transport policy in line with the government transport policy bill.[19] The objectives are framed as a single overall objective with five subsidiary objectives for various areas. The overall objective of transport policy is to assure a socio-economically effective and sustainable supply of transport for private individuals and trade and industry throughout the country. In addition, there are five long-term subsidiary objectives, as follows (in no particular order):

- An accessible transport system – The transport must be designed to meet the transport needs of private individuals and trade and industry.
- High quality transport – The design and function of the transport system must provide high quality transport for trade and industry.
- Safe traffic – the long-term objective of traffic safety is that no-one should be killed or seriously injured in traffic accidents. The design and function of the traffic system must be adapted to this end.
- A good environment – The design and function of the transport system must be adapted to meet the need for a good quality and healthy environment for everyone, while protecting the natural and the man-made environment from damage. Efficient management of land, water, energy and other natural resources must be promoted.
- Positive regional development – The transport system must promote positive regional development by (i) evening out differences in the potential for development in different parts of the country; and (ii) counteracting the drawbacks of long transport distances.

Interim objectives have been set, particularly under the subsidiary objectives for transport quality, traffic safety and environment. The interim objectives are to be achieved by a ceratin date and are specified, so it is possible to ascertain whether or not they have been achieved. The "good environment" objective is specified in relation to emissions of greenhouse gases (carbon dioxide) and air pollutants (nitrogen oxides, sulphur dioxide, VOCs), impact of air pollutants on health, noise, adjustment to achieve sustainability, the natural and man-made environment. The interim objective for emissions of greenhouse gases (carbon dioxide) require emissions of carbon dioxide to be stabilised at their 1990 level by 2010. The indications are that the stated interim objective for the impact of transport on climate will not be met unless further steps are taken before 2010.

Housing policy and social planning policy

The construction, use and management of buildings accounts for a substantial proportion of society's overall consumption of resources, eg, energy con-

[16] Gov. Bill 1997/97.84. A Sustainable Energy Supply

[17] ibid.

[18] Draft Finance Bill 2001, 2000/01:1

[19] Gov. Bill 1997/98:56. Transport policy for sustainable development

sumption. Housing, building and planning legislation has progressively incorporated requirements reflecting greater concern for the environment. The same applies to other legislation governing activities affecting the use of land, water and other natural resources.

Housing policy covers issues concerning state subsidies for the housing sector, housing supply, social aspects of housing, social planning and housing-related issues concerning ecology and the environment.[20] The aim of housing policy is that everyone should be able to live in good quality housing at a reasonable cost and in a stimulating and safe environment within an ecologically sustainable framework. The home environment should help to achieve equal, civilised living conditions and, in particular, offer a good environment in which children and young people can grow up.[21] Ecological sustainability should form the basis for planning and construction.

Ecologically sustainable development is an important objective of all social planning and all construction. The process of adjustment throughout society to achieve ecological sustainability requires that the construction process, buildings and constructions, the transport system and the rest of the infrastructure are made environmentally compatible and make better use of resources than is currently the case. One of the environmental quality objectives – "a good urban environment" – means that towns, cities, urban areas and other built-up areas should offer a good quality and healthy living environment and help to achieve a good regional and global environment. The objective also covers the indoor environment.[22] The government bill entitled "Swedish environmental objectives – subsidiary objectives and strategies"[23] proposes the following subsidiary objective under the "good urban environment" objective: By 2010 spatial planning and infrastructure construction must be founded on programmes and strategies for:

- ways of achieving a varied range of housing forms, workplaces, services and culture so as to reduce car use and increase the scope for environmentally compatible and resource-efficient transport;
- ways of achieving greater energy efficiency, making use of renewable energy resources and promoting development of production facilities for district heating, olar energy and wind power;
- reducing the burden placed on the environment by energy use in homes and commercial/industrial premises, so that it is lower in 2010 than it was in 1995. One way of achieving this is by making overall energy use more efficient so that it will ultimately decrease.

The economic climate varied in the 1990s, moving from a large number of new housing starts in the early 1990s to an unprecedentedly low level in the middle of that decade. The government now has four priority areas within the framework of the overall objective of housing policy:

- Housing supply, particularly removal of obstacles to, and stimulation of, housing construction in expansive regions.
- Development of public housing companies.
- Lower construction and housing costs.
- Increase ecological sustainability in society.

Achievement of the environmental quality objectives will require more joint action on the central government, regional and municipal level to make the national objectives more tangible and ensure that steps are taken to achieve them in regional and local planning.

Trade and industry policy

As well as trade and industry matters, this policy area covers some technical research and development and its infrastructure, competition issues and regional trade and industry policy.[24]

Knowledge-intensive production of goods and services makes up a growing proportion of total production. For Sweden's part, this means that there is no longer any point in having a separate industry policy.

The aim of trade and industry policy is to promote sustainable economic growth and higher employment provided by a growing number of successful companies.[25]

Private enterprise is central to Swedish growth and employment. The main emphasis in trade and industry policy is on general measures to provide the right business conditions and incentives. Investment in research and development is crucial to maintain a supply of know-how and competence in the sector.

Taxation policy

The aim of tax policy[26] is to ensure that the requisite revenues in the form of tax, customs and charges are collected fairly and cost-effectively, to achieve simplicity

[20] Draft Finance Bill 2001, 2000/01:1

[21] Gov. Bill 1997/98:119, report 1997/98:BoU, rskr, 1997/98:306

[22] Government communication 1999/2000:13 Sustainable Sweden – determining the effectiveness of measures to achieve ecologically sustainable development

[23] Gov. Bill 2000/01:130. Swedish environmental objectives – subsidiary objectives and strategies

[24] Draft Finance Bill 2001, 2000/01:1

[25] ibid.

[26] The policy area covers the operations of the tax administration (not including its role in relation to general elections), Swedish Customs and the Swedish Enforcement Service.

and prevent crime. The government intends to make a systematic review of the state budget so as to make it more oriented towards ecological sustainability. Environmental accounts, which are intended to create a broader understanding of the link between economics and environment, are central to these efforts.

Taxation of activities detrimental to the environment has long been seen as an effective tool for achieving sustainable development. Selective purchase taxes have long been used as an instrument of Swedish policy. Taxes on electricity and other forms of energy were introduced in the 1950s. These taxes were introduced to strengthen state finances, but were used during the oil crisis of the 1970s to encourage energy consumers to use electric energy instead of oil. Environmental policy objectives entered the scene in the 1980s. For example, petrol taxation was differentiated to favour the use of unleaded petrol over its leaded counterpart.[27] The environmental profile of energy taxation was further raised in conjunction with a major tax reform implemented in 1990/91. Carbon dioxide tax, sulphur tax and VAT on energy[28] were introduced at that time. The Swedish energy tax system is now a very important factor in limiting carbon dioxide emissions.

The total environmental tax burden is high in Sweden. Major changes were made to the system (eg, in the field of energy and transport taxation) following EU entry in 1995. The "kilometre tax" on diesel vehicles became a diesel oil tax in 1994. Diesel oil tax and petrol tax were replaced by energy tax in 1995.[29]

The EC Mineral Oils Directive[30] sets minimum levels of tax on motor fuels and heating oils. Proposals for broadening the scope of the Mineral Oils Directive were presented in 1997, but the member states have not been able to agree on the issue. A common system of energy taxation in the EU has been discussed, but has not resulted in a decision. Several other EU countries have introduced or announced that they will introduce a national carbon dioxide tax.

Environmental policy, including waste policy and local initiatives

This policy area covers measures and the result of measures in relation to the environ- mental quality objectives and the overall objectives of policy in this area. Much is also done to further environmental interests in other policy areas.[31]

The aim of environmental policy is to pass on to the next generation a society in which the major problems in Sweden have been solved. Parliament has laid down 15 environmental quality objectives defining the situation to be achieved over a generation.[32]

According to the government, Sweden must also set an example when it comes to making the adjustments necessary to achieve ecologically sustainable development. Efforts to achieve the environmental quality objectives are to be intensified and will permeate all government policy. A greater environmental emphasis in the taxation system attained by shifting the tax emphasis in favour of environmental interests may help to realise the aims of environmental policy.

Waste policy is an integral part of environmental policy. Waste policy covers collection, transport, recycling and disposal of existing waste, including inspection and control of these operations and remediation of landfill sites. This delimitation is supplemented in certain product areas by producer responsibility, which is also intended to bring about the development of more environmentally compatible products. The environmental quality objective entitled "a good urban environment" has a subsidiary objective on waste quantities. The quantity of waste going to landfill, not including mining waste, is to be reduced by 50 per cent between 1994 and 2005, the total quantity of waste generated to remain the same. The government considers that the other steps already taken will suffice to ensure that this objective is attained.[33]

Since the Environmental Code[34] came into force in 1999, there has been a statutory definition of waste in Sweden. Waste is any object, material or substance that is included in a waste category or that the holder disposes of, intends to dispose of, or is under an obligation to dispose of.[35]

Sweden employs a waste management "hierarchy".[36] Waste management is based on the aim that generation of waste is to be avoided as far as possible and that end-of-life products should, in the first place, be reused. Failing that, they should be recycled for the materials they contain. The third tier of the hierarchy is recycling for energy extraction; the fourth is landfill. This essentially conforms to the EU waste hierarchy.[37]

One of the most powerful instruments of sustainable waste management is the incorporation of principles

---

[27] Government report 2000:73. Evaluation of the energy tax model proposed by the Swedish Green Tax Commission.

[28] National Energy Administration Report ER 13:2001

[29] Miljöskatter och miljöskadliga subventioner ("Environmental taxes and environmentally harmful subsidies"), Environmental Accounts Report 2000:3. Statistics Sweden

[30] Council Directive 92/81/EEC of 19 October 1992 on harmonising the structures for sales taxes on mineral oils.

[31] Draft Finance Bill 2001, 2000/01:1

[32] ibid.

[33] Gov. Bill 2000/01:130. Swedish environmental objectives – subsidiary objectives and strategies

[34] Swedish Code of Statutes 1998:808. Environmental Code. National preparatory works; Gov. Bill 1997/98:45, report 1997/98:JoU20, rskr. 1997/98:278

[35] Government communication 1998/99:63

[36] ibid.

[37] EC Waste Directive (75/442/EEC, Art. 3)

on sound management and ecocycles as some of the general "rules of consideration" in the Environmental Code. These rules impose a responsibility for conserving products and energy, and stipulate that the potential for reuse and recycling must always be taken into account. More stringent requirements governing landfill and the introduction of a landfill tax increase the cost of sending waste to landfill and thus encourage reuse and recycling. The EC Waste Incineration Plant Directive imposes additional requirements on these plants with regard to preventive environmental protection measures and control.[38]

One subsidiary objective of waste policy is that methane emissions from landfill should be reduced by 30 per cent by 2000.[39]

The government is striving to achieve an environmentally oriented product policy that will create scope for an efficient single market while assuring a high degree of protection for human health and the environment. The EU is in the process of drafting a common Integrated Product Policy. This is intended to give consumers the opportunity and encouragement to act in an environmentally friendly way. Consumer issues will have to be taken into account when systems for sorting waste at source are designed, and when improving information supplied to consumers about the results of their efforts to sort waste.[40]

One central feature of local Agenda 21 projects at municipal level has been information and the use of good examples to achieve a society in which concern for the environment, conservation of natural resources, an ecocycles approach and development of a sustainable society are guiding principles. Some local Agenda 21 projects have involved distributing information to local inhabitants and businesses about waste minimisation, recycling, sorting at source and waste treatment. Agenda 21 at municipal level may ultimately reduce the quantities of waste going to landfill.

Agricultural policy

Agricultural policy is part of food policy, which also includes fisheries policy. The EU Common Agricultural Policy (CAP) falls within this area.[41] The aim of Swedish food policy is to achieve ecologically, economically and socially sustainable food production. Policy should promote a broad and varied range of safe foodstuffs at reasonable prices, sustainable agricultural and food production and contribute to global food safety. Adjustments in line with principles of the market economy are an important means of achieving this objective.[42]

Since the Second World War, Swedish agricultural policy has largely been governed by three main objectives: the production objective, the income objective, and the efficiency objective. For a long time, the main thrust of the production objective was to achieve a high degree of self-sufficiency in food supply and was justified for reasons of national security. The income objective was that farmers should be assured a certain level of income; the efficiency objective was to bring about rationalisation of the agricultural sector by means of government subsidies. A general environmental objective was added to these three objectives in the mid-1980s.

The food policy decision of 1990 marked the beginning of the abolition of Swedish farming subsidies. The income objective was abolished as a specific aim. Import restrictions and customs were retained, but the internal regulation system began to be dismantled in 1991. An adjustment programme was intended to give farmers temporary support over a period of five years. Funds were allocated to pay compensation to farmers for landscape conservation. However, there was not time for these measures to be fully implemented, since Sweden applied for EU membership and began to harmonise its agricultural policy prior to joining.

Sweden joined the EU in 1995 and is therefore subject to the CAP. The aims of the CAP are:

- to increase agricultural productivity
- to give farmers a reasonable standard of living
- to stabilise the markets
- to safeguard food supply
- to supply food to consumers at reasonable prices

Forest policy

The forest policy decision of 1993 established that Swedish forests are a national asset, to be managed so as to provide a sustainable high yield and conserve biodiversity.[43] These aims remain.[44]

The forest policy established in 1993 is based on the decisions made at the UN Conference on Environment and Development in Rio de Janeiro in 1992, since manifested in "Agenda 21" and "the Forest Principles". One fundamental principle is that forests and forested land should be managed in a

---

[38] Waste Incineration Directive 2000/76/EC

[39] Gov. Bill 1992/93:179 on "Measures to prevent impact on climate". Achievement of this objective has not been evaluated.

[40] Government communication 1999/2000:114

[41] The account does not include measures under Council Directive EC/1257/1999 of 17 May 1999 on support from the European Development and Guarantee Fund for Agriculture for development of rural areas, and on amendments to, and repeal of, certain regulations.

[42] Draft Finance Bill 2001, 2000/01:1

[43] Swedish Code of Statutes 1993:533 Act Amending the Silvicultural Act (Swedish Code of Statutes 1979:429). Gov. Bill 1992/93:226, report 1992/93:JoU15, rskr. 1992/93:252

[44] Gov. Bill 1997/98:158 Evaluating achievement of forest policy

sustainable way to meet the social, economic, ecological, cultural and spiritual needs of present and future generations.

The production objective for forestry laid down by parliament is that forests and forested land is to be used efficiently and responsibly so as to provide sustainable high yield. Forest production is to be organised so as to allow free choice of the way forest products are used.

The environmental objective of forestry is to conserve the natural productive capacity of forested land. The biological diversity and genetic variation of forests are to be safeguarded. Forests are to be used in such a way that their natural flora and fauna are able to survive under natural conditions and in viable populations. Endangered species and ecotypes are to be protected. Cultural heritage in forested areas, and the aesthetic and social value of forests are to be protected.[45]

3.2 Measures and instruments limiting emissions or increasing removals of greenhouse gases

3.2.1 Measures and instruments relating to energy supply and energy use

This section describes measures and instruments in the policy areas of taxation, energy, transport and housing (including social planning) that significantly influence energy consumption and emissions of greenhouse gases. These four sections together describe the policy impacting on emissions in what Chapter 2 calls "the energy sector". Measures and instruments in other policy areas (eg, forest policy), described later in this chapter, also have some bearing on energy use, although the link is a weaker one.

Responsibility for implementing measures to reduce greenhouse gas emissions rests with a number of agencies and ministries. Moreover, nowadays it is the task of the sectoral authorities to pursue environmental issues. The energy sector cuts across the housing, transport and industrial sectors and climate issues must therefore be regarded as "supra-sectoral", involving the need of a great degree of coordination.

Impact of emission-reducing measures and instruments relating to energy supply and energy use (the energy sector)

The measures implemented by Sweden in the energy sector often have other purposes, such as to assure energy supply. However, these programmes have also played an important part in limiting carbon dioxide emissions from the energy sector. As a result of the policy it has pursued, Sweden's carbon dioxide emissions in the late 1990s were more or less the same as they were in 1990.46 Emissions of greenhouse gases[47] from the energy sector only increased from 54,269 to 54,727 ktonnes carbon dioxide equivalent emissions between 1990 and 1999 (ie, by just under 1 per cent).

Energy and carbon dioxide taxes are the most effective instruments for reducing and limiting carbon dioxide emissions. These taxes are expected to have reduced carbon dioxide emissions by at least 10,000 ktonnes by 2010.[48] They have also yielded other environmental benefits, eg, because sulphur emissions to air have decreased as a result of increased use of biomass fuels. A more detailed analysis of the combined effects of the most important instruments is presented in Chapter 4.

In a number of instances, the aim of the measures taken has been to reduce electricity consumption or to increase electricity production from renewable sources. The type of electricity production replaced by action taken under the energy policy programme may be discussed, since the Swedish electricity market is integrated with those in Norway, Finland and Denmark, and direct transfers are possible to Germany, Denmark and Poland. This chapter presents estimates of the size of emission reductions resulting from various measures. Unless otherwise stated, the calculations made in respect of measures that have reduced electricity consumption or increased production of renewable electric energy relate to two different cases. In the first case, it is assumed that electric energy would otherwise have been generated at new gas combination power plants (in Sweden or abroad). In the second case, it is assumed that production would instead have taken place at existing coalfired condensing power plants (outside Sweden). The estimated emission reductions may therefore also relate to countries other than Sweden.

The energy policy programme contains measures to reduce the use of electricity for heating. Grants are available for property conversions and connection to district heating or individual heating. The grants system has recently been revised, since evaluations of measures in the field of energy policy quickly showed that the

[45] Gov. Bill 1997/87 158 Evaluating achievement of forest policy
[46] UNFCCC, Article 4.2 a and b
[47] Revised date, November 2001. See www.environ.se
[48] The calculation has been made using the MARKAL model. This model optimises the cost of the energy system and has limited capacity for estimating the effect of changes in energy taxes on income.

Table 3.1
Measures of performance for government grants available under the 1997 energy policy programme, measured as kg carbon dioxide per krona of grant

Investment programme Efficiency measured as kg carbon dioxide per krona of grant (kg/SEK)	
Conversion form electric heating to individual heating	0.2
Conversion from electric heating to district heating	0.4
Reduced power requirement	0.1
Investment grants for small-scale hydropower	0.8
Investment grants for wind power	0.7
Investment grants for biomass-fuel based combined power and heating	1.1

Note: The figures have been calculated on the assumption that renewable energy forms and reduced use of electric heating replace electricity generated at natural gas combination power plants.

Source: National Energy Administration

measures would not have achieved the stated objective in their original form.

The energy policy programme also involves action in the field of information and education, eg, in the form of funding for municipal energy advisory services and information campaigns at regional energy offices, trade associations and the like. Technology procurement is also used as a means of accelerating developments and the launch of new technology on the market, eg, to encourage greater use of more energy-efficient and environmentally friendly products.

The programme of investment grants for biomass fuel-based combined power and heating plants and wind power plants has aided a rapid increase in the output available from these sources. One drawback of support of this kind is that grants paid for a limited period for plants with a long operating life may cause the market to become saturated with plants from that period, thus inhibiting further investment in even better technologies. The system is therefore currently under review. The total effect of decisions taken to date on funding for measures to reduce electricity consumption and increase electricity generated from renewable energy sources is estimated to have reduced the electricity requirement by approximately 0.4 TWh and increased electricity generated from renewable sources by about 1.5 TWh. Converted into reduced carbon dioxide emissions, this gives a reduction of 800 – 1,600 ktonnes per year.

The table below shows the efficiency of the invest-

Table 3.2
Some energy and environmental taxes in the 1990s, SEK millions

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Petrol tax[1]	17,169	14,538	14,344	17,554	22,030	1,711	0	0	0	0
Energy tax	15,165	10,489	9,546	7,875	10,239	27,456	30,371	34,212	36,900	37,573
Carbon dioxide tax	-	8,157	9,194	10,641	6,943	11,078	15,053	12,599	12,796	12,811
Sulphur tax		-299	190	190	217	146	212	134	115	104
Special tax on electric power from nuclear power plants	130	139	117	116	137	133	974	1,478	1,537	1,553
Hydropower tax[2]	1,018	896	1,030	1,026	817	908	1,423	194	0	0
Special acidification tax	57	73	63	58	63	69	64	58	58	65
Environmental tax on domestic air traffic	27	156	168	190	271	177	128	0	0	0
Tax on pesticides and artificial fertilisers	184	158	153	171	205	277	343	413	371	378
Tax on energy and environment	**33,750**	**34,905**	**34,805**	**37,821**	**40,922**	**41,955**	**48,566**	**49,088**	**51,777**	**52,484**
Total environmental taxes in Sweden				47,718	48,461	50,640	57,277	56,485	59,638	-
Percentage of Swedish GDP				3.2	3.0	3.0	3.3	3.1	3.2	-
Percentage of GDP in the EU				2.8	2.8	2.8	2.9	2.9	-	-

[1] Petrol tax has been included in energy and environmental taxes since 1996
[2] The hydropower tax was converted into a raised real property tax on 1 January 1997
Note: VAT on energy is not included in the table, nor are a number of environmental taxes unrelated to energy use.

Source: National Tax Board and Special Tax Office in Ludvika. Total environmental taxes and percentages are taken from Statistics Sweden: Miljöskatter och miljöskadliga subventioner, Miljöräkenskaper ("Environmental taxes and environmentally harmful subsidies, Environmental accounts") Report 2000:3.

ment programmes for whose implementation the National Energy Administration has been responsible.

It is difficult to make quantitative estimates of the efficiency of funding to improve energy efficiency. It is possible to use sales statistics to gain an impression of the impact of technology procurement and labelling on the market for particularly energy-efficient products. If all types of project for more efficient energy use are added together, the reduction is estimated to be 0.4 TWh oil and 0.4 TWh electric energy. Converted into reduced carbon dioxide emissions, this represents a reduction of 100 – 200 ktonnes per year. However, not all this reduction can be attributed to government action for greater energy efficiency; some of it is the result of spontaneous technological developments.

Taxation policy

Energy and carbon dioxide taxes are the most important instruments in Sweden for limiting carbon dioxide emissions. It is estimated that the combined effect of energy and carbon dioxide taxation, as well as efforts to encourage the use of renewable energy sources, is a reduction in carbon dioxide emissions of about 5,000 ktonnes in 2000, rising to about 10,000 ktonnes by 2010.

Energy consumption is taxed to create an incentive for reducing energy use. The taxes also generate revenues. The state's revenues from taxes on energy, carbon dioxide emissions and VAT on energy totalled approximately SEK 60 million in 1999.

When Sweden joined the EU, certain changes were made in the field of energy taxation to finance the membership fee. Other increases in energy taxes have been used to finance a broad range of investments in education, for example. Table 3.2 shows revenues from various environmentally related taxes between 1990 and 1999. In addition to the taxes shown, many users of fossil fuels also bear the burden of an environmental charge on nitrogen oxides.[49]

Energy, carbon dioxide and sulphur tax on fuels[50]

Tax on energy was introduced in 1957 and has since then undergone a number of changes in terms of purpose, rates and those obliged to pay it. Following the tax reform in 1991, environmental protection has become one of the express aims of energy tax. Energy and carbon dioxide taxes are now the most significant instruments in Sweden for limiting carbon dioxide emissions.

Energy tax

State revenues from energy tax totalled approximately SEK 37.5 billion in 1999. Fuels subject to energy tax are petrol, fuel oil, diesel oil, paraffin, LP-gas, coal, petroleum coke and raw tall oil. In addition to fossil fuels, tax is also levied on other fuels used to drive vehicles (including biomass fuels). Under a scheme known as "pilot project tax relief", the government has lowered the tax on certain alternative motor fuels, mainly ethanol and RME. This relief also applies to natural gas used as a motor fuel. Biomass fuels and peat used for heating are not covered by the energy tax. Diesel and fuel oils used in commercial shipping and aviation fuel are exempt from energy tax. Fuels other than petrol used to run trains and other modes of rail transport are also exempt from energy tax. Energy tax is levied on electric energy delivered to end users. Double taxation is avoided by exempting fuels used to generate electricity from energy tax. The taxpayer is normally the supplier. No energy tax is levied on fuels used in manufacturing processes in industry, agriculture, forestry or aquaculture. However, this exemption does not apply to petrol (regardless of the purpose for which it is used) or other fuels used to operate motorised vehicles. With some minor exceptions, energy tax is not levied on fuels used or produce electricity. Biomass fuels and peat used to produce electricity are also exempt from tax. Electricity consumed by electricity producers themselves is also tax-free. Energy tax is not charged on electric energy produced by wind power plants.[51] Electricity produced by a reserve generator or generated and consumed aboard ships or other modes of transport is not taxable either. Energy tax on fuels is levied at a fixed rate per unit of weight or volume. Tax rates do not differ in proportion to the energy value. The highest rate is levied on oil products; the lowest on LP-gas. This difference originates from the 1970s and the desire at that time to favour other products at the expense of oil. The energy tax rate on certain fuels varies depending on whether the fuel is used to operate motorised vehicles or for heating. Fuels used to operate vehicles are taxed at a higher rate of energy tax.

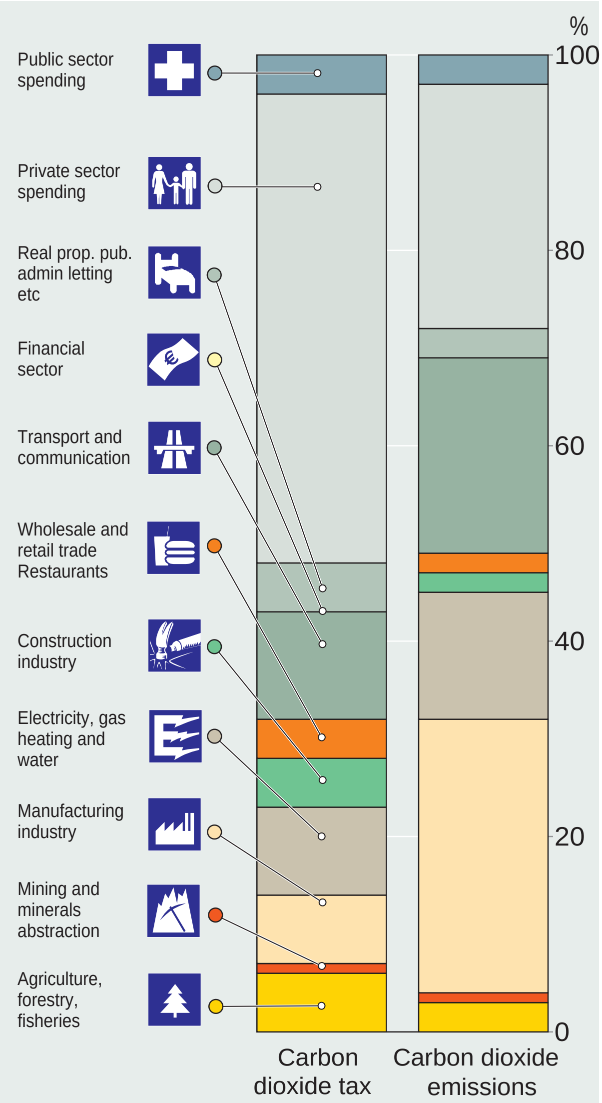
However, the tax on petrol is not related to the purpose for which it is used. LP-gas and natural gas

[49] Swedish Code of Statutes 1990:613; Gov. Bill 1989/90:141, 1989/90:JoU24, rskr 1989/90:349. For a detailed description of these instruments, see the National Energy Administration NC3 Report ER 13:2001.

[50] A new Energy Tax Act entered into force when Sweden joined the EU. The act replaced earlier acts on a general energy tax (Swedish Code of Statutes 1994:1776; Gov. Bill 1994/95:54, report 1994/95:SkU4, rskr. 1994/95:152), carbon dioxide tax (Swedish Code of Statutes 1990:582; Gov. Bill 1989/90:111, 1989/90:SkU31, rskr. 1989/90:357) and sulphur tax (Swedish Code of Statutes 1990:587, Sulphur Tax Act. Gov. Bill 1989/90:111, 1989/90:SkU31, Rskr. 1989/90:357). The new act retained the existing terms "carbon dioxide tax" and "sulphur tax", whereas "general energy tax" was replaced by the term "energy tax".

[51] The Finance Bill for 2002 proposes that the link between the "environ-mental bonus" for wind power plants and energy tax on electricity be removed. It is proposed that the environmental bonus should be fixed at SEK 0.181 per kWh, ie, it will not follow the proposed rise in the tax on electricity.

Figure 3.1 Breakdown of carbon dioxide taxes and emissions into sectors, 1995.



Source: Statistics Sweden: Miljöskatter och miljöskadliga subventioner, Miljöräkenskaper ("Environmental taxes and environmentally harmful subsidies, Environmental accounts") Report 2000:3.

used as motor fuels are exempt from energy tax. In addition, the tax rate on petrol and on oil products used in motorised vehicles is differentiated from other environmental classes.

The energy tax rate on electricity consumption is differentiated, depending on who consumes the electricity and where in Sweden it is consumed. According to the energy policy decision of 1997, the shortfall of electricity consumption arising from the shutdown of the first Barsebäck reactor was mainly to be counterbalanced by reduced electricity consumption at district heating plants. Electric boilers are normally used alongside fuel- fired boilers in district heating systems. The electric boilers are switched off when heating requirements can be met more cheaply using other fuels. Electricity used in electric boilers was tax-exempt between 1984 and 1991, provided that the boilers were not used when fossil fuels were in use in the Swedish electricity production system. Exemption was abolished in 1991. Taxation is one of the reasons that use of electric energy to operate electric boilers in the district heating system declined throughout the 1990s. The "electric boiler tax" on electric boilers with a power output exceeding 2 MW in winter was raised by SEK 0.023/kWh in 1998. This rise means that electric energy used to operate electric boilers in the district heating system is taxed in the same way as electricity for household use. The expected effect, viz., that the tax rise would reduce electricity consumption by 3 – 4 TWh, was partly based on erroneous grounds; the reduction in 2000 was only 0.3 – 0.5 TWh electric energy.[52]

Carbon dioxide tax

Carbon dioxide tax has been levied on fossil fuels since 1991.[53] Together with the energy tax and VAT on energy, the carbon dioxide tax is the most significant Swedish instrument in terms of climate policy.

Unlike energy tax and VAT on energy, the main reason for introducing carbon dioxide tax was to limit carbon dioxide emissions.

In addition to the fossil fuels mentioned earlier, the tax is also payable on mineral oils used for heating and on all motor fuels (including biomass fuels). Here too, the government is able to grant "pilot project tax relief". Biomass fuels and peat used for heating are not subject to carbon dioxide tax. Diesel and fuel oils used in commercial shipping and aviation fuel are exempt from energy tax. Fuels other than petrol used to run trains and other modes of rail transport are also exempt from the tax. Carbon dioxide tax is not levied on fuels used to produce electric energy. Biomass fuels and peat are exempt whether used for electricity or heat production.

Carbon dioxide emissions are directly related to the consumption of fossil fuels. Even though carbon dioxide tax is a tax on raw materials or end products, it functions very much as a tax on emissions. The tax is computed on the basis of the carbon content of fuels. Coal, for example, has the highest rate of carbon dioxide tax per unit of energy.

Since its inception, the carbon dioxide tax rate has been raised from SEK 0.25/kg carbon dioxide in 1991 to SEK 0.37/kg carbon dioxide in 1996, and subsequently to SEK 0.53/kg carbon dioxide as of 2001. The tax rate is not related to whether or not the fuel is used as a motor fuel or for heating purposes.

For competition reasons, only 35 per cent carbon dioxide tax is levied on fuels used in industrial manufacturing processes or in agriculture, forestry or aquaculture.[54] The reduced tax rate does not apply to petrol (regardless of the purpose for which it is used) or other fuels used to operate motorised vehicles. Figure 3.1 shows the proportion of carbon dioxide emissions from various sectors in relation to the amount of carbon dioxide tax each sectors pays to the state each year.

In addition to the general tax reduction, companies consuming large amounts of energy may be granted a further reduction of the carbon dioxide tax. If the carbon dioxide tax paid by a company in the manufacturing, agricultural, forestry or aquaculture sectors exceeds 0.8 per cent of its gross sales, the tax will be reduced so that only 24 per cent of the additional tax remains. Carbon dioxide tax on coal and natural gas has been reduced (the "1.2 per cent rule") until 2003. This reduction only applies to the cement, lime, rock and glass industries. The total tax payable by companies in these industries may not exceed 1.2 per cent of their gross sales.[55]

Right from the outset it has been possible to receive a refund of carbon dioxide tax if carbon dioxide emissions from use of the fuel have been reduced. An application may be made to the tax authorities for a refund of carbon dioxide tax in proportion to the amount by which emissions have been reduced.[56] Some companies engaged in hothouse cultivation have made use of this opportunity.

VAT on energy

VAT has been payable on the purchase of energy since 1990. The tax is computed on energy prices including selective purchase taxes. VAT on energy means that commercial operations such as industrial companies can deduct the VAT they pay on energy in the same way as they can for other products purchased for their business. However, activities not regarded as commercial (mainly households) are not entitled to make any such deduction and must bear the full cost of the tax. The VAT rate on energy is the standard VAT rate, ie, 25 per cent.[57] State revenues from VAT on energy totalled some SEK 13 billion in 1999.[58]

Green taxes

More and more countries with a heavy tax burden are pursuing green taxation as a way of reducing environment impacts and also of preventing a growing tax burden on trade and industry. A sizeable shift towards green taxation occurred in Sweden in the early 1990s, when VAT was imposed on energy etc simultaneously with a reduction of tax on earned income. This shift in the tax burden was one of the main reasons for the rapid increase in the use of biomass fuels at district heating plants in the 1990s.

Sweden place further emphasis on green taxation in 2001, raising tax on energy and lowering that on labour. The aim is to heighten the environmental aspect of energy taxation. The shift towards green taxation involved a total of SEK 3.3 billion. Energy taxes were raised, the personal allowance in the income tax system was raised by SEK 1,200 and the employers' social security charges were lowered by 0.1 percentage point.[59] Green tax changes in 2001 involved a rise of about 40 per cent in the carbon dioxide tax. This rise was partly (25 per cent) offset by an 8 per cent reduction in energy tax. This rendered the tax changes fiscally neutral to some extent. The carbon dioxide tax is now more closely related to the adverse effects of emissions of carbon dioxide than is the energy tax. The shift in the burden from the energy tax to the carbon dioxide tax thereby enhances the environmental impact of these taxes on the choice between various fuels. In addition to the fiscally neutral component, the carbon dioxide tax was also raised by the equivalent of 15 per cent. Raised taxes on carbon dioxide make electric energy cheaper than other forms of energy, so the tax on electricity was raised by SEK 0.018/kWh.[60]

The rises in the tax on carbon dioxide and electricity only affect consumers. Taxes on the transport sector were left largely unchanged. Aside from the rise in the prices index, taxation on petrol has not risen, although there has been a slight rise in the tax on diesel. It was decided to reduce the VAT rate on passenger transport and other commercial transport from 12 to 6 per cent to mitigate any disadvantages arising from increased fuel costs for public transport.

Production taxes on electricity

A number of taxes on electricity production were imposed in the 1990s. These are nuclear power tax[61], hydropower tax, and a charge/tax on storage of radio-

[52] KM background report to the Ministry of Industry and Trade. Evaluation of the 1997 energy policy programme. Assignment number 77183.

[53] Carbon dioxide tax is levied on petrol, heating oil, diesel oil, paraffin, LP-gas, natural gas, coal and petroleum coke. Peat burning for energy purposes is not currently covered by the carbon dioxide tax, although peat is treated as a fossil fuel in international reports.

[54] Manufacturing industry, commercial greenhouse cultivation and, since 1 July 2000, agriculture, forestry and aquaculture.

[55] Government report 2000:73. Evaluation of the energy tax model proposed by the Swedish Green Tax Commission

[56] ibid.

[57] ibid.

[58] Miljöskatter och miljöskadliga subventioner ("Environmental taxes and environmentally harmful subsidies"), Environmental Accounts Report 2000:3. Statistics Sweden

[59] National Energy Administration Report ER 13:2001

[60] National Energy Administration Report ER 13:2001

[61] Swedish Code of Statutes 2000:466 Tax on Thermal Output of Nuclear Reactors Act; Gov. Bill 1999/2000:105, report 1999/2000:SkU22, rskr. 1999/2000:246

active waste and dismantling of nuclear power plants.[62] The nuclear power tax was introduced in 1984 and is payable on all electric energy generated at nuclear power plants. The tax was SEK 0.027/kWh in 1999. The tax on nuclear power was altered in 2000, becoming a fixed output tax of SEK 5,514/MW and month, instead of a variable production tax. The purpose of this change was to reduce the risk of distortions in the electricity production system, resulting in less efficient use of resources. There also used to be a production tax on electricity generated at hydropower plants, but this was replaced in 1997 by a higher rate of property tax on the taxable value of land used for hydropower plants. The raised property tax was abolished in 1999.

Some problems with the current system of energy taxation

The Swedish energy tax system gives rise to a number of secondary effects. One effect is that there are differences between the taxation of electric energy and fuels in the industrial and energy sectors. The provisions governing taxation of these sectors have been amended several times over the last few years. This has created substantial doubts about the future in these sectors. This applies both to the special regulations governing combined power and heat production, and the changes in tax rates. Some of the changes in the tax system have created radically new conditions governing the choice of fuels and technology at new plants for combined power and heat production. As a result, some of the tax changes have not fully achieved their purpose. In particular, there has been little incentive to develop and operate combined power and heat facilities.[63]

Differentiation of energy taxation may provide an incentive to transfer fuels between sectors in a less than efficient manner. However, there is good reason for tax differentiation of energy products, since Swedish companies in the energy-intensive sector operate in an international market in which many of their competitors pay no energy taxes at all.

The imposition of energy tax and the resulting cost difference between fossil fuels (which are taxed) and biomass fuels (which are not) has provided much of the impetus for the growth in the biomass fuel market. But taxation may cause some adverse effects. If production of heat and electric energy occur at the same time (at a combined power and heat plant), the tax legislation may create a situation whereby fossil fuels and biomass fuels are mixed. For tax reasons, the biomass fuel component will be ascribed to heat production and the fossil fuel component to electricity production (which is tax-free). Admixture of coal increases the content of inert material in ash. This may result in a net input of heavy metals to the environment if the ash is returned to the forest, which is normally desired to maintain the nutrient balance in forest soils.[64]

Reform of the electricity market

The Swedish electricity market was reformed in 1996. Amendments were made to Finnish legislation on electricity at the same time, whereas Norway had opened up its market to competition as long ago as 1991. Thus, Finland, Norway and Sweden have had a common electricity market since 1996. Denmark joined the Nordic electricity market in 2000. The electricity market was reformed for economic reasons. The aim was to improve efficiency and give consumers greater choice.

Prior to the reform of the Nordic electricity markets, power was transferred between the countries by the major producers under a joint arrangement called Nordel. Nowadays, smaller market players, including end-users can participate in cross-border trade in electricity. The common marketplace (Nordpool) has led to more efficient pricing. Border tariffs have been removed between Norway, Sweden and Finland, which has also improved the efficiency of trade. The overall amount of electric energy traded between the Nordic countries has increased.

Electricity prices have varied greatly since the Nordic electricity markets were integrated.

An early evaluation of the common Nordic electricity market, when prices displayed a clear downward trend, suggests that the objectives of the reform of the Swedish market have been achieved. Emissions of carbon dioxide in Sweden have probably not been much affected. The low electricity prices between 1997 and 2000 may have temporarily reduced the profitability of greater energy efficiency and made it less financially advantageous to invest in renewable energy and combined power and heat.

The reform improves the scope for active consumer influence. Eco-labelling of electricity production (eg, Bra Miljöval El – "an environmentally friendly electricity choice") may have a favourable impact on carbon dioxide emissions from electricity generation. However, consumers have not been very active in the market. Up to 2000, approximately 11 per cent of Swedish households had tried to influence their electricity supplier, either by changing supplier or by renegotiating supply agreements.[65] Thus, it is not possible to make an unequivocal assessment of the effects of the electricity market reform on greenhouse gas emissions.

Taxes on transport

One general purpose of taxes is to finance public spending. Another is that they should be related to environmental issues. These two aims influence the form of taxes and charges in the transport sector. The government bill entitled Transport för en hållbar utveckling ("Transport for sustainable development")[66] proposed that "The taxes and charges that are levied on traffic and are justified for reasons of transport policy are to be based on a well-defined responsibility for costs arising that also takes account of the external impacts caused by traffic."

Among other things, there has been a desire to adjust the taxation of petrol and diesel so that it reflects the average marginal cost incurred as a result of each car on the roads. However, a study has shown that this marginal cost is generally higher than the current taxes on motor fuels, particularly in urban areas, where heavy traffic, noise and air pollution cause major external impacts.[67]

Aside from energy and carbon dioxide tax, taxes on transport are considered to play a marginal role in limiting greenhouse gas emissions. It is true that the tax on vehicle ownership, known as "motor vehicle tax", is differentiated to take account of vehicle weight.

Moreover, cars qualifying under environmental class 1 and newly registered in 2000 and 2001 confer entitlement to reduced motor vehicle tax. However, environmental classification is not specifically related to greenhouse gas emissions. Revenues in the form of motor vehicle tax increased from approximately SEK 4.1 billion in 1993 to about SEK 6.1 billion in 1998, at current prices.

"Pilot project tax relief" on biomass motor fuels

In some cases, the government has lowered the motor vehicle fuel tax rate on alternative biomass motor fuels under the "pilot project tax relief" scheme. Between 1997 and 1999 tax relief was granted on 84,950 cubic metres of RME and 129,005 cubic metres of ethanol. Lowering the energy tax rate is an important way of encouraging the introduction of alternative fuels.

The volume qualifying for relief is much greater than the quantity sold. One reason for this is that a large ethanol production facility is currently in the start-up phase. It is estimated that the quantity of biomass fuels sold in 2000 replaced 21,000 cubic metres of petrol and 8,000 cubic metres of diesel oil. The gross emission reduction is then about 55 ktonnes carbon dioxide. The actual reduction will be lower because a certain quantity of fossil energy is lost in the manufacture of biomass motor fuels.[68]

Environmental differentiation of shipping and air traffic charges

Shipping charges have been differentiated since 1998. Noise-related air traffic charges have been supplemented by a charge relating to emissions of hydrocarbons and nitrogen oxides.

These charges may be seen as a step towards realising the "polluter pays" principle (PPP).

Landfill tax

Waste going to landfill has been taxed since 2000.[69] The reduction in quantities of landfilled organic waste will in turn reduce methane formation. The purpose of the tax is to discourage landfilling of waste in favour of more environmentally beneficial disposal methods. Ultimately, the aim is also that waste going to landfill will involve costs such that producers and consumers choose other products and processes that do not generate waste that must be landfilled. The aim of taxation, in combination with other measures in the waste sector, is to halve the quantity of waste

[62] Swedish Code of Statutes 1981:671

[63] Government report 2000:73. Evaluation of the energy tax model proposed by the Swedish Green Tax Commission

[64] ibid.

[65] Kunden är lös! ("Customer on the loose") – consumer behaviour in the deregulated electricity and telecommunications markets. Swedish National Audit Office.

[66] Gov. Bill 1997/1998:56

[67] Swedish Institute for Transport and Communication Analysis Report 2000:10

[68] National Energy Administration Report ER 13:2001

[69] Swedish Code of Statutes 1999:673; Tax on Waste Act (1999:673). Gov. Bill 1998/99:84, report 1998/99:SkU20, rskr. 1998/99:258

[70] Draft Finance Bill 2001, 2000/01:1

Table 3.3
Volumes of tax-exempt RME and ethanol sold/used as a motor fuel between 1995 and 2000.

	995	1996	1997	1998	1999	2000
RME (m^3)	500	7,500	8,000	7,500	7,000	8,000
Ethanol (m^3)	6,000	8,000	12,000	14,000	16,000	21,000

Source: National Energy Administration

going to landfill over a ten-year period.[70] Tax is payable on waste entering a waste disposal facility at which hazardous waste or other waste exceeding more than 50 tonnes a year is landfilled or kept for longer than three years. The tax is SEK 250 per tonne of waste. Estimated annual revenues from the landfill tax are SEK 1.3 billion.[71]

Measures and instruments in the field of energy policy
This section describes measures and instruments in the energy field taken in Sweden as part of the 1997 energy policy programme. The programme includes projects within the scope of the Climate Convention pilot programme for Activities Implemented Jointly (AIJ), which is described separately. Estimates of the impact on carbon dioxide emissions of measures taken under the programme are generally based on the assumption that the electric energy saved or replaced would have been produced at a natural gas combination plant or a coal-fired carbon condensing plant.

In conjunction with the energy policy decision of 1997, the government considered that the role of public authorities in the energy sector should be clarified and reinforced. The new energy policy agreement also entailed new and broader requirements as to the way changes in the energy system are to be implemented. A new central energy agency was therefore established in 1998. The National Energy Administration is responsible for implementing most of the changes in the energy system and coordinating the process of changeover. Another central task for the administration is to monitor developments in the energy markets and energy system and analyse their significance in relation to the environment, technical developments and economic growth. The administration is also responsible for measures taken by the government to promote research and development in the energy field.

Another organisational change was made when the new government took office in 1998. A new Ministry of Industry and Trade was set up and was given overall responsibility for industrial, energy, transport and labour market issues. The ministry is thus responsible for a number of policy areas. The idea of gathering these policy areas under a single "umbrella" is to integrate them and thereby improve the prospects for enhancing welfare, creating jobs and ensuring a good, lasting and sustainable rate of growth throughout the country.

The 1997 energy policy decision also elaborated a strategy for Swedish climate policy in the energy sector. It was expressly stated that Sweden should adopt a pro-active approach to the use of effective measures and instruments in the energy field, and that Sweden should press for the introduction of a minimum level of energy taxation in the EU. The strategy includes measures to promote bilateral and multilateral cooperation for activities implemented jointly under the Climate Convention. SEK 350 million was allocated for this purpose over a seven-year period, starting in 1997. Some of these funds will be spent on a programme for developing energy systems in eastern Europe, the Baltic States and elsewhere. The strategy also involves efforts to develop new technology for ethanol production from raw materials from forestry. SEK 210 million has been earmarked for this over a seven-year period, starting in 1998. The aim of these research and development projects is to lower the cost of producing ethanol based on raw materials containing cellulose.

Apart from reducing greenhouse gas emissions, the aim of measures and instruments under the energy policy programme has been to

- improve energy efficiency;
- reduce the use of electric energy for heating purposes;
- promote the use of energy from renewable sources;
- increase international cooperation; and
- itake measures in other countries reduce carbon dioxide emissions.

The programme contains a near-term and long-term component. The near-term component involves measures to reduce electricity consumption and subsidising investment in electricity production facilities. These measures are essential to compensate for the 8 TWh shortfall of electricity following shutdown of the Barsebäck 1 nuclear reactor.[72] The first reactor was shut down in 2000. According to the energy policy decision, the second reactor can only be decommissioned provided that the electricity production shortfall can be compensated for by new energy supply and reduced energy consumption. The long-term component involves measures such as research and development. This component is described later on in this section and in Chapter 7.

The near-term energy system adjustment programme
Approximately SEK 3.5 billion has been allocated for implementation of the near-term programme component. This comprises:

- funding to reduce the use of electricity for heating purposes (SEK 1.65 billion);
- funding to increase the supply of electric energy from renewable sources (SEK 1 billion);
- funding to improve energy efficiency (SEK 450 million);
- measures to develop the supply of electricity and heating in the south of Sweden (SEK 400 million).

Table 3.4
Current subsidies for electricity generated from renewable sources.

Electric energy from	Current subsidy SEK/kWh
Wind	
Investment grant, max 15%	0.04 – 0.05
Environmental bonus 0.181	
Small-scale electricity generation, max. 1,500 kW	
Temporary subsidy	0.09
Small-scale hydropower	
Investment grant, max 15%	0.03 – 0.04
Small-scale electricity generation, max 1,500 kW	
Temporary subsidy	0.09
Biomass fuels	
Investment grant, max 25%	0.05 – 0.07

Note: The above figures have been calculated on the basis of the full depreciation period for the plants.

Source: National Energy Administration

Current subsidies expressed as SEK/kWh for investment grants and operating subsidies are shown in Table 3.4 below. As may be seen from the table, wind power receives the highest government subsidies, currently at a rate of just over SEK 0.30/kWh.

Funding to reduce the use of electricity for heating purposes
Some 40 per cent of Swedish houses are heated using electric energy, which is a high proportion seen in an international perspective.

The energy policy programme includes measures designed to reduce the use of electricity in homes and commercial/industrial premises. These take the form of grants for property conversions and connection to district heating, grants for extending the district heating network, grants for conversion to individual heating systems and grants for investment in solar heating. A total of SEK 1.3 billion has been allocated for the period 1998 – 2002.

However, an evaluation of these forms of funding quickly showed that the energy use reduction objective would not be achieved. In its spring 1999 finance bill the government therefore proposed that the grants be discontinued at the end of April that year. Among other things, the cost of converting heat distribution systems had not fallen as expected. The government subsequently examined the form grants should take in the future and reinstated grants (in a revised form) for conversion to district heating systems and to individual heating systems as of 1 June 2001. The aim of these revised measures is to increase the chances of achieving the parliamentary objective of a 1.5 TWh reduction in energy consumption.

The reinstated conversion grants improve the prospects of achieving the target. The main change is that partial conversions, whereby the household remains partly dependent on electric heating after conversion, now qualify for a grant. Grants have also been lowered so that funds will suffice for more projects.

Grants for conversion to district heating
The aim is to reduce the use of electricity for heating homes and commercial/industrial premises by connecting them to a district heating network. Grants totalling approximately SEK 230 million had been authorised by 30 June 2001. It is estimated that electricity consumption will fall by 0.25 TWh, and that the power output requirement will fall by 140 MW as a result of grants received to date. The grants given for conversion to district heating are expected to reduce carbon dioxide emissions by around 220 ktonnes a year, assuming that the electricity replaced would have come from coal-fired condensing power plants.

Grants for conversion from electric heating to other individual heating systems (not including district heating)
The aim is to reduce the use of electricity for heating homes and commercial/industrial premises by converting them to another individual heating system. Grants totalling approximately SEK 100 million had been authorised by 30 June 2001.

It is estimated that electricity consumption will fall by 0.12 TWh, and that the power output requirement will fall by 50 MW as a result of grants received to date. The grants are expected to yield an annual reduction in carbon dioxide emissions of around 80 ktonnes, assuming that the electricity replaced would have come from coal-fired condensing power plants.

Until 30 April 1999, grants were also available for output-reducing measures, such as the installation of automatic power output regulators and supplementary heating units. Grants totalling around SEK 150 million were paid out. These measures are estimated to have reduced annual electricity consumption by 0.028 TWh and power output requirements by 16 MW. These grants are reduce annual carbon dioxide emissions by around 28 ktonnes, assuming that the electricity replaced would have come from coal-fired condensing power plants.

[71] ibid.
[72] Swedish Code of Statutes 1997:1320. Nuclear Power Phase-Out Act 1996/97:176, report 1997/98:NU5, rskr. 1997/98:132

Solar heating grants
SEK 10 million (2000) and SEK 20 million (2001) has been earmarked for a new solar heating grant as part of the measures being taken to reduce electricity consumption. The grant is paid to facilities for permanent accommodation and premises not used for commercial or industrial purposes. The size of the grant depends on the estimated annual production of the solar panels. SEK 2.50/kWh/year is paid, subject to a maximum of SEK 7,500 for houses, SEK 5,000 for apartments in apartment buildings, and SEK 5,000 for "housing-related facilities". The grant for solar heating units in apartment buildings or housing-related facilities may not exceed 25 per cent of the investment cost. The grant is also limited to a maximum of SEK 250,000 per property. Grants totalling SEK 10.8 million have so far been authorised, which is expected to yield energy savings of 7.5 GWh per year and to reduce carbon dioxide emissions by about 2 ktonnes a year.

Other measures
Grants for extending the district heating network were introduced in January 2000 as part of the measures to reduce electricity consumption. Grants totalling SEK 15 million were authorised for this purpose in 2000. Steps are also being taken to identify ways of reducing the cost of converting houses with direct electric heating.

Grants to increase the supply of electric energy from renewable sources
Investment grants are available as an incentive for developing electricity production based on renewable energy sources.[73] The 1997 energy policy programme states the aim of grants for investment in new electricity production from renewable sources to be to add an extra 1.5 TWh of capacity each year over a five-year period. Funds have also been allocated for procurement of new electricity generation technology. A total of SEK 1 billion has been allocated for the period 1997 – 2002 for the creation of new sources of electricity supply.

To some extent, the present system of grants represents a continuation of the 1991 energy policy programme. Investment grants to increase the use of electricity from renewable sources complemented the environmental impact of energy taxation, since no carbon dioxide tax is levied on electricity production. A special operating subsidy for small-scale electricity generation was introduced in 2000. A special "environmental bonus" for wind power production was introduced as long ago as 1995.

Investment grants for biomass fuel-fired combined power and heating plants
A grant of SEK 3,000 per kW of installed electricity generation capacity is available for investment in combined power and heating plants run on biomass fuels. The maximum grant is 25 per cent of the investment cost, however. The aim of these grants is to increase the supply of electric energy produced from biomass fuels by at least 0.75 TWh per year over a five-year period. Ten plants, with a combined capacity of 164 MW, have received grants totalling SEK 445 million. These plants are expected to produce 0.88 TWh of energy a year, which will reduce carbon dioxide emissions by 490 – 820 ktonnes per year. The broad range is because the reduction depends on whether it is assumed that the electric energy derives from natural gas combination plants or coal-fired condensing plants. The grants for new or planned combined power and heating plants are the most cost-effective forms of funding available under the near-term component of the adjustment programme.

The relatively low electricity prices of recent years have not been an obstacle to decisions; all those receiving grants are in fact implementing their projects.

Investment grants for wind power plants and operating subsidies for wind power production
Wind power plants with an electric power output of at least 200 kW qualify for an investment grant not exceeding 15 per cent of the investment cost. The aim of these grants is to increase the supply of electric energy produced using wind power by at least 0.5 TWh per year over a five-year period. The grant represents about SEK 0.06/kWh over the depreciation period of the investment.

The operating subsidy for ongoing wind power production is currently SEK 0.27/kWh. The operating subsidy consists of two elements: the "environmental bonus", equivalent to the energy tax on electric energy, which in 2001 is SEK 0.181/kWh, and a special subsidy for electricity generated at small-scale production facilities.[74] The special subsidy is available until the end of 2001 and is SEK 0.09/kWh.

The investment grant in combination with the operating subsidy makes investment in wind power plants profitable. Plants with a power output of less than 1,500 kW qualify for the operating subsidy, which may mean that fewer larger units are built. Applications have been received for plants having a potential output of 1,750 kW, which are set not to exceed 1,500 kW, so as to qualify for the operating subsidy.

The appropriation totals SEK 380 million over a five-year period. By the end of 2000, 269 wind power plants had received investment grants totalling SEK

235 million. 167 of these are operational; the remainder are expected to become so by the autumn of 2001.

Electricity production from wind power plants receiving investment grants before the end of 2000 is estimated at 0.444 TWh. The combined electric power output from plants in receipt of grants is 188 MW. The reduction in carbon dioxide emissions is expected to be 170 – 414 ktonnes per year.

Investment grants and operating subsidies for small-scale hydropower plants

Small-scale hydropower plants with a minimum power output of 100 kW and a maximum output of 1,500 kW qualify for an investment grant not exceeding 15 per cent of the development cost. The aim of these grants is to increase the supply of electric energy produced using small-scale hydropower by at least 0.25 TWh per year over a five-year period. The nine hydropower plants so far in receipt of grants are expected to increase electricity production capacity by 12.9 GWh per year. Based on the information given in the applications, the total additional electricity generated by new small-scale hydropower plants may be estimated at 24.8 GWh per year. Again based on successful applications, the reduction in carbon dioxide emissions will be in the range 4 – 12 ktonnes a year. It is not expected that the target of increasing the supply of electric energy from small-scale hydropower plants by 0.25 TWh per year will be achieved. The reason that more small- scale plants of this kind are not being built is that their construction is often difficult to reconcile with other environmental considerations, such as conservation of biological diversity. Like wind power, these small-scale hydropower plants qualify for a temporary operating subsidy of SEK 0.09/kW.

Grants to achieve greater energy efficiency

The 1997 energy policy programme allocated SEK 100 million over a five-year period for procurement of more energy-efficient technology. The aim is to provide an incentive for development and to ensure that more energy-efficient technology comes onto the market by initiating and running projects for procurement of technology.

Funding for procurement of energy-efficient technology was introduced in 1988[75] in the form of a grant not exceeding 50 per cent of the development costs or a loan with a term not exceeding five years. The idea was to reduce the purchaser's financial and technical risks and thereby to provide an incentive for procuring products and systems that can replace electricity and are energy-efficient. The 1991 energy policy programme extended this form of support to include all kinds of improvement in energy efficiency. The 1997 energy policy decision revised and redefined the support to cover procurement of more energy-efficient technology. The new ordinance[76] entered into force on 1 July 1999. The grant covers 50 per cent of the additional cost of the actual procurement of technology and 30 per cent of additional investment costs. On the basis of figures on sales of new products, these grants are estimated to have reduced electricity consumption
by about 0.4 TWh and oil use by 0.4 TWh. These efficiency improvements are expected to reduce carbon dioxide emissions by 200 – 400 ktonnes per year.

Measures to develop the supply of electricity and heating in the south of Sweden

Specific action has been taken in southern Sweden to develop electricity supply and thereby compensate for the production shortfall resulting from the shutdown of the nuclear power plant at Barsebäck. A separate authority under the Ministry of Industry and Trade has been established for this purpose – the Committee for Energy Supply in Southern Sweden (DESS). Its task is to increase the supply of electricity and heating in the south of Sweden in the near term by:

- making a study of the energy situation in the area;
- funding projects;
- instigating action.

DESS funds research, training, information, projects and studies, as well as planning and investment. The authority has been allocated a total of SEK 400 million for 1998 and 1999. These activities are still in progress.

The projects receiving investment grants are expected to add about 0.8 TWh per year to the energy balance in south Sweden. Approximately one quarter of the funds allocated has been used for information, training and advisory services. Carbon dioxide emissions are expected to be reduced by 70 ktonnes a year as a result of the measures taken.[77]

The long-term adjustment programme for energy systems

Climate change is a long-term environmental problem. Measures are now being taken to limit emissions of

[73] Ordinance on Government Grants for Certain Investments in the Energy Field (1998:22)

[74] Ordinance on Grants for Small-Scale Electricity Production (2000:614)

[75] Ordinance on Government Grants for Procurement of Technology (1998:806)

[76] Ordinance on Government Grants for Procurement of Energy-Efficient Technology and New Energy Technology (1999:344)

[77] National Energy Administration Report ER 13:2001

greenhouse gases, but further technological development will be required to find a long-term solution to the problems. Research, development and demonstration form the basis of the Swedish strategy for creating sustainable development of the energy system and a limited influence on climate change. An overall aim of Swedish energy research and funding for development of energy technology is to lower the cost of using renewable forms of energy so as to render them economically viable alternatives to nuclear power and fossil fuels. The aim is to dramatically increase the proportion of electric energy and heat production based on renewable energy sources over the next ten to fifteen years. To do this will require development of new technology that is profitable and commercially available.

The government Sustainable Energy Supply Bill[78] proposed an allocation totalling SEK 5.3 billion over a seven-year period, starting in 1998, for research and development of energy technology. The table below shows the funds allocated to the different areas.

Funds are available to several authorities, although the National Energy Administration has overall responsibility for coordination. The research programmes receive all their funding via government appropriations, whereas funding of the development programmes is supplied jointly with trade and industry. Research areas given particular priority are:

- biomass fuel-based combined power and heat;
- biomass fuel supply and related ash disposal issues;
- new processes for ethanol production based on raw materials containing cellulose;
- alternative fuels;
- new technology for large-scale use of wind power and marine wind power;
- solar cells;
- improving energy efficiency in buildings (described in a later section), the industrial sector and the transport sector (described in a later section).

Research on renewable energy sources for electricity production

Sweden is investing in research and development as regards the use of water, wind and sun as sources of energy. Swedish investment in wind power has recently led to a technical breakthrough in the form of the "Windformer", which is expected to have a major impact. The new technology makes it possible to do without a number of components normally found in conventional wind power systems. The Windformer™ makes it possible to build marine wind power stations with a power output of 6 to 300 MW. According to the manufacturer, the production cost of Windformer™ is less than SEK 0.4/kWh, which is competitive in comparison with conventional gas or oil-fired power plants. A pilot facility with a power output of 3 – 3.5 MW will shortly begin operating at Näsudden off the island of Gotland.

Electricity generated using solar cells may also eventually become competitive. Swedish research into solar power is currently being conducted in the form of two major programmes. SolEl 00-02 is examining the potential for using solar cells in the existing electricity system at a reasonably cost, and is also determining the degree of development necessary to enable solar cells to play a part in Swedish electricity production. Research at the Ångström Solar Center in Uppsala includes projects on thin-film solar cells, nanocrystalline solar cells and "smart windows".

Research on biomass fuel-based electricity and heat production

Biomass fuels have been used in Sweden for a long time, but their use has increased dramatically over the last 20 years or so. There is considerable technically and ecologically available potential in the use of forest fuels at a reasonable cost. This potential has hitherto been unexploited. Realistically, the biomass fuel potential over the next twenty years may be around 130 – 150 TWh[80], which would represent an increase

Table 3.5
Allocated and estimated funds for research and development under the long-term adjustment programme for energy, 1998 – 2004,

Allocation/item	1998	1999	2000	Est. 2001	Est. 2002	Est. 2003	1998 – 2004	Total 2004
SEK millions								
Energy research total[79]	320	335	402	431	461	426	2,801	426
Energy technology grants and introduction of new energy technology	250	360	360	360	360	360	2,480	430
Total	**570**	**695**	**762**	**791**	**821**	**786**	**5,281**	**856**

Source: National Energy Administration

of about 50 per cent from current levels. Over the longer term, intensive forest cultivation may yield additional fuel.

The aim of ongoing research is to determine the actual potential of biomass fuels and to improve the entire biomass fuel chain in various ways: from production, ecology, handling, transport and possible processing, to energy conversion and optimum use. Research is also being conducted on the ecological, economic and technical potential for forest fuel production, including ash recycling, energy forest and energy crops. The scope for intensive forest cultivation is also being examined.

The state funds a number of research and development programmes with a view to developing technologies for producing electricity and heat from biomass fuels with increasing conversion efficiency, less environmental impact and at a competitive cost.

Particular efforts are being made to reduce emissions of hazardous substances from small-scale combustion.

Materials and systems are being developed to avoid corrosion in the superheater during the steam turbine process and to achieve higher steam data and conversion efficiencies.

Development of processes using gas turbines are critical for natural gas-based production.

Basic research is being conducted in Sweden into a process for hydrogen production via artificial photosynthesis. The aim is to create a system by which hydrogen is produced from water and sunlight. This Swedish research is at the forefront of international research in this field.

Research into improving energy efficiency in industry
Swedish efforts in this area involve all the country's resources: innovation companies, universities and colleges, research institutions and others all have an important contribution to make to the development of technology to improve energy efficiency. The National Energy Administration is funding a research programme on process integration. The programme is developing methods for designing and modifying industrial processes to reduce their investment and operating costs. Unit processes in industry include strategically important and energy-intensive process stages in various manufacturing processes, such as blast furnace processes in the steel industry and the cooking of kraft pulp in the pulp and paper industry.

The funding of pilot research projects conducted by industrial research institutions is important for technological development in heavy industry. The state contributes to research and development by working together with the Swedish Forestry Technical Research Institute (STFI) and the Foundation for Metallurgical Research (MEFOS). A new process for manufacturing chloralkali is one example of development in the chemical industry. Another is the development of black liquor vaporisation in kraft pulp manufacture. Other areas in receipt of government funding include a technology for more energy efficient furnaces using high-temperature combustion, which is being tested at the Royal Institute of Technology in Stockholm, and a joint project being conducted by the National Energy Administration and the Association of Swedish Foundries, whose purpose is to improve knowledge of energy-efficient forging methods.

Other measures

Long-term agreements on greater energy efficiency
In addition to legislation, taxes and subsidies, new instruments need to be developed to achieve a balance between environmental concerns and industry's need to remain competitive. In furtherance of this aim, the Ministry of Industry and Trade started a pilot project on long-term agreements in autumn 1998. The idea was to examine the scope for making use of long-term agreements between industry and the state to increase energy efficiency in Sweden. Long-term agreements of this kind are used in several of the countries among Sweden's competitors as a complement to conventional instruments, particularly taxes. The pilot project has shown that long-term agreements between industry and the state may have an important part to play in certain circumstances.

On 31 August 2000 the government decided to appoint a negotiator, charged with the task of producing a basis for, and drafts of, long-term agreements for efficient energy use in the energy-intensive industries and for reduced emissions of greenhouse gases. It is intended that these long-term agreements should encourage industry to take cost-effective steps resulting in lower energy use and reduced greenhouse gas emissions. It is expected to be possible to implement a system of this kind by way of long-term agreements under which the state and the other contractual party make commitments in order to achieve the stated aims.

The negotiator was due to report to the government by 31 October 2001. For obvious reasons, there has been quantification of the emission reductions that can be achieved.

To date, few agreements or accords involving measures designed to reduce greenhouse gas emissions

[78] Gov. Bill 1996/1997:84

[79] Approximately 80 per cent of the appropriation is administered by the National Energy Administration. The remainder is administered by VINNOVA, FORMAS and the Science Council.

[80] National Energy Administration background report for Förslag till Svensk Klimatstrategi ("Proposed Swedish Climate Strategy"), Swedish Government Official Report SOU 2000:23

have been drafted. However, it may be noted that the state and the Swedish automobile industry have agreed that carbon dioxide emissions from new cars are to be reduced by 25 per cent by 2008. This has subsequently been overshadowed to some extent by the EU agreement on an emission level for new cars of 0.140 kg carbon dioxide/km.

Information and communication projects on economically and ecologically sustainable energy systems
The energy policy decision of 1997 included an allocation of SEK 350 million for information, advisory services and eco-labelling between 1997 and 2002. The National Energy Administration carries on information and communication projects designed for specific target groups. These help to bring alive the vision of an economically and ecologically sustainable energy system. Other project aims are to encourage a long-term approach. Operations, which received funding of about SEK 200 million during 1997 – 2000, break down as follows:

- general energy information;
- target information about more efficient energy use and renewable energy sources;
- contributions to information projects;
- contributions to municipal energy advisory services;
- information on municipal energy planning;
- the interrelationship between energy, economics and the environment;
- information relating to joint EU activities and the OPET information office.

The nature of these activities is described in greater detail in Chapter 8 – Education, training and public information. The aim of information activities is to increase knowledge.

This knowledge will in turn lead to action that will contribute to more efficient energy use and greater use of renewable energy sources. Follow-up efforts concentrate on ascertaining the extent to which knowledge has improved among target groups, and the extent to which this has led to action. However, follow-up activities of this kind are expensive and measurement of effects has been largely confined to major activities such as campaigns.

Campaigns aimed at the general public about the energy consumed by white goods, low-energy light bulbs and the advantages of waterborne heating systems have had a great impact. Energy savings as a result of these campaigns, estimated on the basis of sales statistics etc, have been in the order of 0.15 TWh/year. Information about newly procured technology is thought to have been a major factor contributing to the introduction of the 17 technologies procured during 1998 – 2000. However, it is not possible to identify separately the effects of information dissemination and the effect of the technology development projects. New heat pump technology has gained particularly wide acceptance; these have replaced both oil-fired and electric heating systems. A very rough estimate of the effects of new heat pumps is 0.4 TWh reduced oil use and 0.13 TWh reduced use of electric heating. These appraisals are based on sales statistics. Other calculation methods might give different results.

It is fairly difficult to assess the efficacy of the contribution to municipal energy advisory services, and to quantify the effects in terms of reduced electricity use or reduced carbon dioxide emissions is virtually impossible. Several evaluations have been made, however.

They indicate that advisory services both increases public awareness of energy consumption and influences people's behaviour, investments and planning for greater energy efficiency, particularly among householders.

Municipal energy planning
In the late 1970s the Municipal Energy Planning Act[81] imposed a duty on Swedish municipalities when planning to promote energy conservation and take steps to ensure a sufficient and reliable supply of energy. Municipal planning must include an examination of the scope for joint action with another municipality or important stakeholder in the energy field (eg, a manufacturing or power company) to resolve issues of importance in relation to energy conservation or supply. The plan must also include an analysis of the impact the activities described in the plan have on the environment, health and conservation of land, water and other resources. No evaluation has been made of the effect of this act on greenhouse gas emissions. The existence of municipal climate objectives, described in the section on local initiatives, may be the indirect result of the production of municipal energy plans.

Measures and instruments in the field of housing policy, including social planning
The importance of adapting municipal spatial planning to achieve better integration of environmental aspects has recently attracted increasing attention. Parliament has adopted a specific environmental objective entitled "a good urban environment", and has stated that energy, water and other natural resources must be used in an efficient and sustainable manner whereby resources are conserved and renewable energy sources used.
It has not been possible to quantify the impact of measures and instruments in the field of spatial planning on greenhouse gas emissions. However, their long-term positive effects are considered to be potentially significant.

General municipal planning
Municipalities bear primary responsibility for spatial planning. Spatial planning includes siting and designing traffic facilities and the preparation of general and detailed plans under the Planning, Building and Housing Act.[82] Spatial planning is one of the most long-term forms of planning in use. This makes it of particular interest from a climate and energy point of view, particularly in the housing, service and transport sectors. There are gains to be made in terms of energy saving and reduced emissions from the burning of fossil fuels by planning so as to save energy. Building design and location in relation to infrastructure, among other things, is of central importance in relation to future climate policy.

The Planning, Building and Housing Act
The Planning, Building and Housing Act[83] give municipalities certain powers to decide where various activities can and cannot be located. If there are sufficient grounds, municipalities can limit or prohibit trade in foodstuffs within a detailed planning area.

Regional planning only takes place in exceptional cases in Sweden and is not legally binding. The role of county administrative boards in promoting inter-municipal cooperation gives them certain powers of intervention if there is a difference of opinion between the municipalities concerned with regard to the permissibility or location of a certain activity.

The importance of the Planning, Building and Housing Act in limiting greenhouse emissions has not been quantified, however.

The Environmental Code in relation to the environmental impacts of infrastructure projects
Following the entry into force of the Environmental Code[84] in 1999, the permissibility of certain kinds of major traffic infrastructure must now be considered by the government.

The code imposes a greater obligation to properly examine the environmental impacts of infrastructure projects at an early stage. This creates more scope for achieving more environmentally compatible overall solutions.[85] Some major investments in railway infrastructure are described in the section on measures and instruments in the field of transport policy.

Measures and instruments relating to the construction of housing and commercial/industrial premises
It has not been possible to quantify the impact on greenhouse gas emissions of the measures and instruments described below in relation to the construction of housing and commercial/industrial premises. They are considered to have some positive effects.

Investment grants for ecological building etc
The government has allocated SEK 635 million for investment grants for ecological building[86], which is intended to promote the ecological sustainability of housing construction during 2001 – 2004. The grants will then be evaluated. Grants are available for all forms of ecological building, and enhanced efficiency in the use of energy and natural resources is therefore one criterion. The maximum grant is SEK 2,000 per square metre of heated usable floor area up to a limit of 35 square metres per dwelling. Local Investment Programmes (LIP), are also very much a matter of making environmental improvements in residential properties. Most of the building modifications take the form of energy conversion and improvement of energy efficiency. These are described in the section on environmental policy, however.

Building regulations
Building regulations have been made gradually tightened in relation to the energy needs of new buildings. The energy efficiency requirements laid down in the building legislation for buildings with direct electric heating were extended to include all buildings (no longer only houses). Direct electric heating is only permitted if the building in question uses 40 per cent less energy for heating than buildings heated by other means.[87] Since 1991 electricity used to run pumps, fans and the like must be included when calculating energy consumption.[88] Electric energy efficiency, heat recovery and boiler conversion efficiency must also be taken into account.[89, 90]

---

81 Swedish Code of Statutes 1077:439. Municipal Energy Planning Act. Gov. Bill 1976/77:129, CU 1976/77:39, rskr. 1976/77:338

82 Swedish Code of Statutes 1987:10 Housing, Building and Planning Act. Gov. Bill 1985/86:1, BoU 1986/87:1, rskr. 1986/87:27

83 Swedish Code of Statutes 1987:10. Preparatory works: Gov. Bill 1985/86:1, BoU 1986/87:1, rskr. 1986/87:27

84 Swedish Code of Statutes 1998:808. Environmental Code. National preparatory works; Gov. Bill 1997/98:45, report 1997/98:JoU20, rskr. 1997/98:278

85 Government communication 1999/2000:13 Sustainable Sweden – evaluating the effectiveness of measures to achieve ecologically sustainable development

86 Swedish Code of Statutes 2000:1389. Ordinance on Government Grants to Promote Ecologically Sustainable Housing Construction, cf Gov. Bill 1997/98:119, 2000/01:26, report 1997/98:BoU10, 2000/01:BoU2, rskr. 1997/98:306, 2000/01:91

87 Statutes of the National Board of Housing, Building and Planning 1988:18. De första Nybyggnadsreglerna ("The First Construction Regulations"), entered into force on 1 January 1989

88 Statutes of the National Board of Housing, Building and Planning 1990:28

89 Statutes of the National Board of Housing, Building and Planning 1993:57

90 Statutes of the National Board of Housing, Building and Planning 1993:58 with amendments up to and including 1998:38

The National Board of Housing, Building and Planning has also decided to introduce tougher standards for thermal insulation in new buildings. The result will be to raise the required thermal transmittance (or "U-value") by 10 – 15 per cent. These changes will be implemented as calculation methods in line with European standards are finalised and translated into Swedish standards.

Measures and instruments aimed at building repair and maintenance

Over the last ten years, various grants have been paid out that have influenced building construction as such, and also their energy requirements. As a result, they have indirectly influenced carbon dioxide emissions. These are grants for conversion of electrically heated buildings, various other energy-related grants and solar heating grants.[91] The Interest Subsidies Ordinance also includes grants for energy-saving measures in connection with building alterations.[92]

It has not been possible to quantify the impact on greenhouse gas emissions of the measures and instruments described below in the area of building repair and maintenance.

Overall, they are considered to have had some positive effects on emissions of greenhouse gases.

Energy declarations for white goods

The Swedish Consumer Agency has introduced energy declarations for white goods. These have raised public awareness of energy efficiency and have to some extent hastened replacement of old fridges and freezers by more energy-efficient units containing refrigerants contributing less to the greenhouse effect.

The "Swan" criteria for oil burners

A common eco-labelling system for oil burners in the Nordic region was introduced in autumn 2000. The Swan labelling criteria for oil and combination burners largely accord with those for the German "Blauer Engel" scheme and the general principles of the ISO 14024 international eco-labelling system. The aim of labelling is to minimise emissions from oil burners and to improve energy efficiency. It is particularly expected that the electricity consumed by circulation pumps will decrease substantially as a result of the eco-labelling rules.[93]

Energy declarations for apartment buildings

A draft energy declaration has been evaluated as part of a government-instigated National Board of Housing, Building and Planning project on declarations for housing and schools.

The board proposes the introduction of a voluntary system of energy certificates.

Individual metering of, and charging for, heating and hot water

A typical feature of the housing sector is that many actors take place in the decision-making process. These include building contractors, installation firms, building maintenance and repair firms and tenants. One obstacle to greater energy efficiency is the split responsibility for implementation, where the property owner decides on the equipment, but the tenant pays for the energy. The National Board of Housing, Building and Planning has made changes in its regulations governing water and heating meters[94] in order to reduce the cost and simplify installation of individual meters.

Research on improving energy efficiency in the building sector

The government supports research and development aimed at improving energy efficiency in the building sector, mainly in the form of further development of tried and tested construction and installation technologies, and also development of new materials, components, methods and systems. The small number of housing starts means that measures to improve energy efficiency and conservation in building construction is only having a slight impact. Energy improvements in conjunction with alterations and maintenance are therefore important. The sector offers great potential. By using currently available new technology total energy consumption in new houses of a given size and type may be as little as 8,000 – 12,000 kWh a year, compared with 15,000 – 25,000 kWh a year in older houses.

Long-term funding of research and development on energy consumption in buildings is channelled via FORMAS (the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, formerly the Council for Building Research) and the National Energy Administration. Projects include building construction and installation technology solutions, research into solar heating, district heating, heat pump technologies and small-scale biomass fuel use. Sweden has very considerable know-how in the field of solar heating thanks to long-standing investment in this field. In the field of thermal solar heating, funding is given for research, development and demonstration via an integrated programme involving participants from the scientific community, manufacturing industry and potential customers.

Sweden is at the forefront of international research on heat pump technology and is also a leader when it comes to replacing refrigerants influencing climate with other, mainly natural, refrigerants such as ammonia, propane and carbon dioxide. The National Energy

Administration and some 30 companies are funding an applied research and development programme at two universities. The aim is to develop low-cost efficient systems having little environmental impact.

Since 1998 the National Energy Administration and the Swedish District Heating Association have also been jointly funding a research and development programme in the field of hot water technology, ie, distribution, district heating distribution centres, as well as control and monitoring. The aim is to develop energy-efficient and environmentally compatible district heating systems.

Lighting and ventilation, which accounted for approximately 70 per cent of electricity used for non-heating purposes in the early 1990s, have become more efficient thanks to better light sources and improved operational control and dimensioning. Research into the use of white LED (light-emitting diodes) for lighting purposes is being conducted in two parallel research projects; technological developments and the potential market are among the aspects being examined.

In addition to the above technological projects and investments, the National Energy Administration, FORMAS (formerly the Council for Building Research) and the Electricity Research Council are funding a research programme designed to reduce electricity consumption in buildings and small/medium-sized industrial facilities (ELAN). The object of the programme is to accelerate development in the field of electricity use/electricity applications. A "Smart House" project is also receiving funding.

Measures and instruments in the field of transport policy

The measures and instruments considered to have the greatest impact in the field of transport policy are economic instruments that can be used to influence technological development, transport demand and choice of mode of transport. As mentioned earlier, correct socio-economic pricing of transport is also a fundamental principle of Swedish transport policy. However, the use of economic instruments in the transport sector in the form of taxes and charges has already been dealt with in section 3.2.1.

Increased investment in railway infrastructure[95]

The government has allocated funding to a number of projects to improve the potential for an efficient railway network of goods and passenger traffic.[96]

The Mälarbanan and Svealandsbanan line combine to form a ring round Lake Mälaren.

When investment in upgrading has been completed, the total journey time between Stockholm and Örebro will be less than two hours.

The planned Botniabanan line between Kramfors (Nyland) and Luleå will be 190 km long and join the present main line to form a twin-track stretch along this route. This will improve efficiency, enabling goods traffic to go north on the main line and both passenger traffic and express goods trains to go south on the Botniabanan line. Construction of the first phase between Örnsköldsvik and Husum was begun in summer 1999. The five railway reports on other parts of the Botniabanan line have been submitted to the government for its assessment of permissibility under the Environmental Code. Assuming the government grants permission for the Botniabanan line under the code, it will be ready for service in 2006.

The rail network immediately south of Stockholm Central Station is the busiest in Sweden and is a bottleneck impeding through-traffic. The current rail track system, with only two tracks over Årstaviken, is operating virtually at full capacity. Construction of a new railway bridge over Årstaviken has started and alternative measures in central Stockholm to increase rail capacity and the scope for public transport are being examined.

A rail link has been built between Stockholm centre and Arlanda Airport as a consequence of the conditions set forth in the permit granted by the government for expansion of the airport and the addition of a third runway.

The "Gothenburg Agreement" involves the allocation of SEK 4.2 billion for an investment programme for environmental and traffic improvements in the Gothenburg region.

Some SEK 1.9 billion will be spent on public transport improvements in the form of new tram routes and trams, and on environmental and traffic safety improvements to the local road network. Central government funding covers 75 per cent of the Gothenburg Agreement investment programme; the region and municipalities are paying for the rest.

[91] Swedish Code of Statutes 2000:287 Ordinance on Government Grants for Investment in Solar Heating, cf Gov. Bill 1999/2000:1 publication area 21, report 1999/2000:NU3, rskr. 1999/2000:115

[92] Ordinance Amending the Regulations Governing Interest Subsidies for Energy Saving Loans, cf. Gov. Bill 1980/81:63, CU 1980/81:12, rskr. 1980/81:106

[93] Stiftelsen Miljömerking i Norge (Norwegian Eco-labelling Foundation), 2000, Miljomerking av Oljebrennere og oljebrenner/kjel kombinasjon ("Eco-labelling of oil burners and oil/coal combination burners")

[94] Statutes of the National Board of Housing, Building and Planning 1994:26

[95] Government communication 2000/01:38 Sustainable Sweden – determining the effectiveness of measures to achieve ecologically sustainable development

[97] Swedish Institute for Transport and Communication Analysis SAMPLAN, 1999.

Research and development projects relating to the transport system

Current Swedish know-how on combustion engine technology is considerable, and the Swedish vehicle manufacturing industry is at the forefront of research and development in this field. A key area of new technology is to combine combustion engine technology with electricity technology for use in flexible fuel vehicles.

Vehicles and fuels are in progress as part of the 1997 energy policy programme and are also receiving funding from other programmes. The then Transport and Communications Commission (KFB) concluded a seven-year demonstration programme for electric and flexible fuel vehicles in 2000. A similar programme for biomass fuel vehicles ran between 1991 and 1996. KFB merged with the newly-formed body VINNOVA (the Swedish Agency for Innovation Systems) on 1 January 2001.

Research and development into ethanol production in Sweden is being conducted by ten or so institutions. Biogas is already being used as a fuel (mainly for goods and passenger transport) in central and southern Sweden.[97] The National Energy Administration has initiated a programme with a view to establishing a pilot plant for vaporisation of raw materials from forestry and biomass motor fuel production.

It has not been possible to quantify the impact of the research projects described above on greenhouse gas emissions. The work being done in this field should be seen as part of the long-term efforts to reduce greenhouse gas emissions.

Quality assurance of transport services

In 2000 the National Road Administration continued to develop the market for safe and environmentally compatible transport. This has been done by funding actors in the market in their efforts to assure transport quality, by way of its own projects or via procurement.

Joint activities have also been commenced with trade and industry, principally companies and trade associations in the retail, food, engineering, steel, mining, forestry and transport sectors. Systems for quality assurance of transport services have so far been introduced by 19 county councils, 108 municipalities, 57 companies and 70 other organisations. In 2000 8 county councils, 49 municipalities and 15 other organisations procured transport services having stipulated specific environmental and safety requirements in the invitation to tender.

Fulfilment of these requirements will impact on carbon dioxide emissions, emissions harmful to health, speed, drink-driving, seat belt use and use of safe vehicles. Environmental standards governing National Road Administration vehicles have been laid down in all its contracting documentation. Efforts are also being made to assure implementation of administration travel policy.

"Sparsam körning" and Ecodriving

The National Road Administration is running a project called Sparsam körning ("Green Driving"), which intended to make people more aware of how their approach to driving impacts on the environment. Important elements of the project are Ecodriving and Heavy Ecodriving (for truck drivers), which are practical and theoretical training courses on which people learn to drive in an environmentally compatible way. The courses have been developed in cooperation with the National Association of Swedish Driving Schools and the National Energy Administration. Heavy Ecodriving has also involved the participation of the Occupational Health and Safety Board of the Swedish Transport Unions (TYA).

There are at present some 300 Ecodriving instructors and 70 or so Heavy Ecodriving instructors throughout the country. Just over 3,000 people have completed the Ecodriving course and about 400 the Heavy Ecodriving course. A further 1,500 or so people have undergone short practical training courses.[98]

The "Sparsam körning" project, in combination with quality assurance of transport services, is expected to reduce carbon dioxide emissions by almost 100 ktonnes a year by 2005. The cost of the projects is estimated at SEK 30 million per year.

Joint programme for development of more environmentally compatible vehicles

An agreement was concluded between the Swedish state and Swedish vehicle manufacturers in 2000. The agreement concerns a joint programme for developing more environmentally compatible vehicles. The government declaration of 1998 included an invitation to the industry to participate in this programme, which is designed both to reduce environmental harm caused by road traffic, and to enhance the prospects of the Swedish vehicle manufacturing industry remaining competitive over the long term. Up to SEK 1.8 billion is being invested jointly between 2000 and 2005, of which the government's share is a maximum of SEK 500 million. The programme covers areas such as advanced combustion technology, flexible fuel vehicles and fuel cell technology, weight reduction and general development of know-how. Universities and colleges, research institutions and vehicle industry suppliers are also involved.

Procurement of ethanol-petrol flexible fuel cars
The Swedish FFV (Flexible Fuel Vehicle) Buyer Consortium has been created at the instigation of NUTEK (the National Board for Industrial and Technical Development) to promote the manufacture of vehicles capable of running on fuel containing ethanol. The consortium comprises municipalities, companies, private individuals and two government agencies. The purpose is to demonstrate to vehicle and fuel manufacturers that there is a demand for cars capable of running on non-fossil fuels. The consortium invited tenders from sixty car manufacturers, of which one met the procurement requirements. The consortium had received 3,000 enquiries about purchasing flexible fuel vehicles99 by August 2001. The number of vehicles to be procured means that the cost per FFV is SEK 5,000 less than the equivalent petrol-driven model. There were about 40 petrol stations in Sweden selling E85 fuel (85 per cent ethanol and 15 per cent petrol) in August 2001.100

3.2.2 Measures and instruments in the field of trade and industry

This section first describes trade and industry policy and then steps taken by trade and industry to reduce greenhouse gas emissions. The reason these are presented together is that it is difficult to distinguish between them, since policy in this area is pursued in close consultation with trade and industry itself. It has not been possible to quantify the impact of the measures described on greenhouse gas emissions.

Regional trade and industry policy

Growing awareness of the important role played by local and regional conditions in the growth of trade and industry led to a government regional trade and industry policy initiative in 1998, the main tool of implementation being "regional growth agreements".

These agreements were developed throughout the country in 1998 and 1999. Teams of representatives in each county analysed the conditions for trade and industry and its development needs and agreed on proposed specific measures and the way they were to be funded. Many of these measures are closely related to investment in "environmentally driven" growth.

Competitive edge created by future regulation

International agreements on the environment impose obligations on many countries simultaneously. This gives companies able to offer technology, services and system solutions causing less environmental impact a competitive edge. One area very much at the forefront is the climate issue. It gives Swedish enterprise new opportunities to export technology and services capable of reducing greenhouse gas emissions. Studies have shown that there is great potential for increasing Swedish exports of climate-efficient technology.[101] For example, efficient process control offers scope for reducing consumption of energy in the form of fossil fuels and electricity. Replacing pneumatic tools with electric ones is another way of reducing energy consumption. Sweden has come a very long way in terms of information technology (IT) and there should therefore be great potential for using and refining IT-related products and services so as to find more ways of reducing emissions and energy consumption.

Climate measures taken by trade and industry

Total industrial energy consumption only rose by about 6 per cent in the 1990s, whereas the value of production rose by almost 30 per cent. Efficiency improvements were achieved even more rapidly prior to that decade, while industrial energy consumption rose by almost 60 per cent. However, measured by unit of production, electricity consumption remained almost constant between 1970 and 1988.[102]

Examples of measures taken to improve energy efficiency in industry are:

- Integration of pulp and paper industry and municipality. Supply of heat in the form of steam and secondary heating from a number of factories.
- Technical improvements in the pulp and paper industry, eg, presses to make paper drier even before it reaches the drying section of the paper machine, thus reducing energy consumption.
- Lower carbon dioxide emissions from cement manufacture by introducing a drier process.
- At the Rönnskär smelter, which is Sweden's only large smelting works for non-ferrous metals, energy consumption was reduced by 25 per cent between 1985 and 1996, while production virtually doubled.[103]
- One energy-saving measure being pursued by Swedish industry is more efficient recycling of

[97] See also the section on fuel-based energy generation.
[98] Swedish transport authorities' joint environmental report 2000
[99] FFV Buyer Consortium website: http://www.etanolbil.com, 16 August 2001.
[100] Swedish transport authorities' joint environmental report 2000
[101] MTD (Environmental Technology Commission) Report 2000:1 IT-based solutions with potential for reducing greenhouse gas emissions – an overview, MTD 2000:17 A survey of manufacturing techniques having environmental benefits, and MTD 2000:2 Swedish products that reduce carbon dioxide emissions. http://miljoteknik.nutek.se/rapporter/rapport_1999_5.pdf
[102] Klimatboken. Industrins grundsyn på klimatfrågan ("The Climate Book – Industry's basic view of the climate issue"). Federation of Swedish Industries 1999
[103] ibid.

materials. If steel use can be reduced by one ktonne, this will reduce carbon dioxide emissions during the raw material manufacturing stage by about 2.5 ktonnes. The emission reduction achieved by using 1 ktonne less copper is 6 ktonnes of carbon dioxide.

Swedish trade and industry is actively engaged in the international standardisation process.

Sweden has a fairly large number of environmentally certified companies: 1,484 have received ISO 14000 certification104 and 211 have gained EMAS approval.

3.2.3 Measures and instruments in the field of agricultural policy

Agricultural policy exercises a strong influence over the market for agricultural products.

There are 50 or so sets of regulations that can be classified either as trade barriers (customs), intra-community market regulation with intervention measures and export subsidies, general support, various forms of environmental and regional development support, as well as quota systems governing agriculture, the food industry and the retail trade.

Even though most instruments exist on the supply side of the agricultural market, it is on the demand side that there is the greatest potential for reducing the sector's impact on climate. Nowadays there is a pronounced tendency for consumption of animal products to rise in line with a rise in disposable income. Livestock farming generally produces larger emissions of greenhouse gases than arable farming.

This area of policy has no instruments designed specifically to reduce greenhouse gas emissions from the sector. Nor is any policy pursued in order to increase carbon dioxide sinks in agricultural soils.

The CAP is central to the extent, emphasis and profitability of agriculture, and naturally also influences its impact on climate.

In addition to market price subsidies, the CAP also uses different forms of specific, targeted environmental support, which are largely adapted to national conditions. In Sweden, these have been designed to maintain an open cultivated landscape, conserve biodiversity and reduce nutrient leaching. These instruments may also indirectly influence emissions of greenhouse gases, although no systematic evaluation of this has yet been performed.

Carbon dioxide emissions from agriculture derive from direct and indirect use of electric energy, fossil fuels and motor fuels used in agricultural operations, as well as from cultivation of the soil itself. General instruments to reduce fossil fuel use are primarily presented under the section on energy, transport and environmental policy. It is possible to reduce emissions to some extent by modifying farming methods. For instance, reduced mechanical soil cultivation also reduces diesel consumption, although the result may be a rise in quantities of pesticides used.[105] A changeover to organic cultivation or reduced use of artificial fertilisers for conventional cultivation indirectly reduces energy consumption, as well as emissions of nitrous oxide, in the fertiliser industry. However, no study has been made of the other effects of organic production on emissions and removals of greenhouse gases.

Cultivation of organic soils generates significant carbon dioxide emissions as organic matter in the soil decomposes. No instruments have been brought in to reduce these emissions, and there is no reliable information about the extent to which cultivation changed in the 1990s. A changeover from cultivation of root vegetables and grains to seeded grassland and permanent grazing on soils of this kind could potentially reduce emissions substantially. Annual crops are probably grown on about 40 per cent of the area covered by organic soils.[106]

Cultivation of energy forest in Sweden has remained steady at about 15,000 hectares in recent years, which, in the long term, may produce a yield corresponding to about 0.5 TWh fuel per year. If it is assumed that this fuel will replace fossil fuels, this will reduce carbon dioxide emissions by about 150 ktonnes a year. About 0.1 TWh of energy forest fuel was used at district heating plants in the latter half of the 1990s. Other biomass fuels based on agricultural products amounted to about 0.4 TWh per year. This was mainly straw used on the farm itself and, to a lesser extent, for district heating. Small quantities of biogas, energy grass and RME are also produced. Production of biomass fuels to date has been small in relation to potential agricultural production of this kind.

Methane emissions largely arise from livestock farming and management of farmyard manure. The number of animals, particularly of beef cattle, therefore does much to determine the size of emissions. Dairy cattle numbers fell in the 1990s, from 576,000 in 1990 to 449,000 in 1999. This has reduced methane emissions from dairy cattle by approximately 20 per cent. The number of beef cattle rose prior to EU membership, and total methane emissions from livestock farming remained more or less the same throughout the 1990s.

The steps taken to improve manure management practices are intended to rationalise activities and reduce nitrogen losses. The changeover from solid manure to slurry management, partly with the help of investment grants, tends to increase methane emissions but reduce those of nitrous oxide. It is difficult to determine the overall effect, but greenhouse gas emissions, calculated as carbon dioxide equivalent emissions, have probably remained virtually unchanged, or have risen slightly.

Emissions of nitrous oxide from manure management and from agricultural land mainly results from the use of farmyard manure and artificial fertilisers, although nitrogen-fixing crops, green fertilisers and cultivation as such also produce emissions. The use of nitrogenous fertilisers varied in the 1990s, but seen over the period as a whole, sales have remained virtually unchanged. This is partly because the environmental tax was levied on artificial fertilisers throughout the period. The overall change in nitrous oxide emissions from fertilisers over the period is therefore very small.

Since it was introduced in 1995 – 1996, large sums have been paid in environmental support for grazing land and an open agricultural landscape. The area of permanent grazing land is estimated to have increased by about 30 per cent in the 1990s.

Increased grazing of nitrogen-poor semi-natural grazing lands tends to reduce emissions of nitrous oxide because the manure falling on such land releases less nitrous oxide than when animals graze on seeded grassland. However, the various forms of environmental support have relatively little impact because only about 20 per cent of manure dropped naturally by cattle falls on natural pastures. During the period 1996 – 1999 environmental support for restoration of wetlands was applied for in respect of approximately 3,000 hectares of wetlands, small lakes and ponds. This may produce a slight rise in emissions of nitrous oxide, but this is not included in the present calculation method. To some extent, it is a matter of redistributing nitrous oxide emissions within aquatic systems, and the net effect is uncertain.

3.2.4 Measures and instruments in the field of forest policy

The forest impact on the Swedish carbon dioxide balance in a number of quantitatively important ways. One is indirectly, when forest fuels and wood-based waste replace fossil fuels. Another is by way of an increase in the carbon sink in biomass and soils. In addition, wood is used as a raw material instead of materials whose manufacture or decomposition gives rise to greenhouse gas emissions or large-scale energy use (plastics, cement, aluminium, other metals).

The current increase in the carbon sink in forest biomass is occurring because the felling rate is not as great as the rate of forest growth. Swedish forests currently fix approximately 7,000 – 8,000 ktonnes of carbon per year (equivalent to 26,000 – 29,000 ktonnes of carbon dioxide). An increasing proportion of forest industry products are used as fuel after use and possible reuse.[107] Thus, timber felling contributes to higher biomass fuel production and use and hence lower use of fossil fuels. Timber that is not felled adds to the carbon sink.

Because trees grow slowly in the first 10 – 15 years of their life, the current increase in the carbon sink is primarily the result of forestry and regeneration practices in the decades prior to the 1990s (see the section on forests in Chapter 1). If no further regeneration steps had been taken after 1989, this would only reduce sink growth by less than 10 per cent by 2010. However, after the first 10 – 15 years, the growth rate increases and the carbon dioxide removal rate rises rapidly.

A greater proportion of broadleaf trees has been encouraged and approved since 1994 in order to achieve nature conservation objectives and safeguard biodiversity. This will probably reduce forest growth somewhat in the long term, as compared with a continued marked preponderance of coniferous trees. This is because broadleaf trees generally have a lower rate of stemwood growth than the best kind of coniferous trees on various soils.

Swedish EU membership has not had any pronounced effect on Swedish forest policy, since the EU does not have a common forestry policy.

The rules of consideration etc in the Silvicultural Act[108]
Those engaged in forest management must also take account of other public interests.

Many of the detailed forest management regulations following from the forest policy adopted in 1979 were abolished in 1994. These include the clearing and thinning obligation. Grants for drainage ditches, construction of forestry vehicle roads and replanting in certain regions were also abolished. Deep cultivation was banned. Broadleaf species are approved for regeneration to a greater extent. Protection of areas in the form of reserves, biotope protection and nature conservation agreements was strengthened in the 1990s, and priority has been given to ensuring that forest owners are aware of natural areas deserving protection. New general guidelines in 1991 introduced tougher restrictions on the use of nitrogenous fertilisers in

---

104 ISO – the International Organization for Standardization. ISO 14000 is a series of standards to help companies and organisations to develop and implemented a structured approach to environmental issues. These internationally recognised methods are a way of constantly improving the company or organisation's environmental performance.
105 Swedish Board of Agriculture Report 2000:21
106 Statistics Sweden, Fertilisers in agriculture 1996/97, Na 30 SM 9803
107 Energiläget 2000 ("The energy situation in 2000"). National Energy Administration (1TWh = 0.1 Mtonnes C = approx. 0.5 million cubic metres)
108 Swedish Code of Statutes 1993:533 Act Amending the Silvicultural Act (Swedish Code of Statutes 1979:429). Gov. Bill 1992/93:226, report 1992/93:JoU15, rskr. 1992/93:252
109 Swedish Code of Statutes 1991:2, replacing 1984:3

regions with elevated nitrogen deposition.[109] Since 1993 very few permits have been granted for the digging of new drainage ditches in forest soils. This followed from an amendment to the Nature Conservancy Act[110], now enshrined in the Environmental Code.

Deep cultivation is no longer practised in Sweden. The area of deep cultivated forest land declined from the mid-1980s up to the ban in 1994. Some 2,500 hectares were still deep cultivated in 1990. The method is considered potentially to increase the amount of carbon released. It is difficult to say what effect the ending of deep cultivation has had on carbon dioxide removals and emissions. A rough estimate is a saving of 200 ktonnes of carbon (equivalent to about 730 ktonnes of carbon dioxide) in soils in the 1990s, as compared with the situation if deep cultivation of 2,500 hectares a year had continued. However, deep cultivation did produce good regeneration and growth, which means that increased forest biomass would in time probably have counterbalanced the decreased carbon content in the soil. In other respects, soil scarification since the 1980s has largely conformed to the area felled, with a time lapse of a few years. In other words, somewhat more scarification took place at the beginning and end of the decade. Since the 1980s the area scarified has increased three to fourfold as compared with the 1950 and 1960s. In the past more use was made of controlled burning as a scarification method. Controlled burning probably causes a greater reduction in the carbon content of the soil than present scarification methods (harrowing and screefing).

National Board of Forestry recommendations for forest fuel extraction

The National Board of Forestry has said that the main contribution made by Swedish forests to the efforts to combat climate change should be the replacement of fossil fuels and raw materials with forest product-based substitutes.[111] This applies provided that extraction of fuel in the form of logging residues is carried out in a sustainable and environmentally friendly way, taking account of the needs of forest-dwelling species.[112] Annual consumption of Swedish forest and wood fuels has increased by approximately 20 – 25 TWh since 1990. If this energy had instead been produced using coal, annual carbon dioxide emissions would have been 6.6 – 8.3 Mtonnes greater. The National Board of Forestry did not advocate any specific measures to increase fixing of carbon dioxide in biomass or soil humus in the 1990s. This would either have only created a temporary sink or it would have created maintenance costs after the incremental effect had ceased. In neither case is it possible to calculate a final cost per kilogram of carbon dioxide kept out of the atmosphere, and it is therefore difficult to compare the measure with the cost of reducing fossil fuel use.

The single most important factor behind the increased use of forest fuels is the advent of the carbon dioxide tax in 1991. The National Forest Recommendations for forest fuel extraction were revised in the latter part of the 1990s, the result being fewer restrictions on extraction itself, but a recommendation that ash be returned to the forest.[113]

Increased extraction of logging residues reduces the amount of litter decomposing on the forest floor. This effect is temporary and will be negligible in the long term. Increased extraction of logging residues reduces the risk of nitrogen leaching in south-western Sweden and hence probably also the risk of nitrous oxide emissions.

Protected areas etc

Between 1990 and 1995 forest reserves totalling some 184,000 hectares of productive forest were created, accompanied by a ban on further commercial forestry. In addition to this there is biotope protection and areas protected under nature conservation agreements.

These totalled approximately 1,700 hectares and 1,800 hectares, respectively, at the end of 1997. Voluntary areas larger than 0.5 hectares demanding care, which are not felled, totalled 230,000 hectares the same year. Areas less than 0.5 hectares demanding care are left standing under the Silvicultural Act or sometimes voluntarily. These areas total 7,000 hectares (Silvicultural Act protection) and 3,000 hectares (voluntary protection) each year, ie, 5 per cent of the total area felled.

Timber volume will probably increase in protected areas, although it will probably also vary, depending on the extent of storm damage, forest fires, insect attacks etc. As long as there is a large surplus of timber production, however, the net sink increase resulting from the creation of reserves will be limited, since felling on other land is expected to increase.

Additional to the above areas are areas of forest in parts of Sweden where regeneration is difficult, where regeneration felling is not allowed, since regeneration cannot be assured.

This area totals some 230,000 hectares. There are an additional 3.4 million hectares of forested non-productive land (eg, mires and areas of outcropping bedrock), where only a few trees may be felled, subject to very restrictive conditions.[114]

Environmentally-related certification of forestry
Approximately half of Sweden's forests are environmentally certified. At the end of 2000 some 10 million hectares of forest had been certified in accordance with the FSC (Forest Stewardship Council) standard. A further 1.3 million hectares had been certified under the PEFC (Pan-European Forest Certification) scheme. Some of the actions taken within the forest certification framework may result in a somewhat lower rate of forest growth, eg, voluntary protection of forest with restrictions on forest management and an increased proportion of broadleaf trees. Moreover, under current regulations, controlled burning of a certain proportion of the clear-cut area is supposed to take place. This will increase the area undergoing controlled burning, which was about 150 hectares in 1994 and about 1,000 hectares in 1998. According to one estimate, an average of about 8 tonnes of carbon per hectare (equivalent to around 28 tonnes of carbon dioxide) is lost as a result of controlled burning. There are also studies indicating that a certain reduction in growth often occurs after intense controlled burning. However, a considerable number of endangered species may benefit from an increased area of burnt forest.

Tighter restrictions on the use of nitrogenous fertilisers on forest soils
An increased supply of nitrogen increases the quantity of humus and hence the quantity of carbon in the soil. This in turn means a higher growth rate, which increases timber volume as well as biomass fuel potential. Tighter restrictions on the use of nitrogenous fertilisers on forest soils were introduced in 1991. One result is that fertiliser is not normally used on forest soils south of Lake Mälaren. These new restrictions came about as the result of growing awareness of how nitrogen deposition increases the risk of large-scale nitrogen leaching from forest soils. The normal fertiliser dose for forest growing on firm ground is 150 kg N/ha. This dose is sometimes repeated once or twice at intervals of 6 – 8 years, particularly in northern Sweden. The area receiving nitrogenous fertiliser decreased from about 130,000 hectares a year in the mid-1980s to around 70,000 hectares a year in 1990 and about 20,000 – 25,000 hectares a year between 1992 and 1997. Studies have shown that a fertiliser dose of 150 kg N/ha causes a temporary growth of the mor layer in soil of an average of approximately 1.3 tonnes of carbon per hectare (equivalent to 4.8 tonnes of carbon dioxide per year).[115] However, the dose must be repeated at regular intervals (perhaps every other decade) if the increased mor layer is to be retained.

Assuming that the area receiving fertiliser in 2000 was as large as that in 1997, the reduction in fertiliser use in the 1990s nonetheless meant that a total of 600 ktonnes of carbon (equivalent to 2,200 ktonnes of carbon dioxide) was not fixed in soils in the 1990s.

3.2.5 Measures and instruments in the field of environmental policy, not including waste policy

Local Investment Programmes for ecological sustainability
Parliament decided in 1997 to provide funding for "Local Investment Programmes for ecological sustainability" (LIPs). The total appropriation for 1998 – 2003 is estimated at SEK 7.2 billion. Funding will be allocated to those municipalities whose LIPs best contribute to ecological adjustment. The stated criteria are that the programmes should:

- reduce the burden on the environment;
- increase the efficiency with which energy and other natural resources are used;
- encourage the use of renewable raw materials;
- increase reuse and recycling;
- help to conserve and enhance biodiversity;
- safeguard our cultural heritage; and
- help to improve the circulation of plant nutrients in an ecocycle.

The programmes should also help to create jobs. In addition, funding is available for municipalities to carry out information and public education campaigns relating to the programme. In total, almost half of all municipalities in Sweden have received funding under the scheme. Climate-related funding up to February 2001 is estimated to account for SEK 2,629 million of the total figure of approximately SEK 5.3 billion granted under the investment scheme. Grants in the climate and energy area have primarily been given for investment in the following:

---

[110] Swedish Code of Statutes 1964:822. Nature Conservancy Act. Gov. Bill 1964:148; 3LU 1964:41, rskr. 1964:371. Statute repealed in 1999.

[111] Jordbruket och skogsbruket som resurs i klimatarbetet ("Agriculture and forestry as a resource in combating climate change") (1993). National Board of Forestry dnr 601/93 SA 10.04

[112] Skogsbränsle, hot eller möjlighet? – vägledning till miljövänligt skogsbränsleuttag ("Forest fuels, a threat or an opportunity? – A guide to environmentally friendly extraction of forest fuels"). National Board of Forestry 2001. ISBN 91-88462-48-x

[113] Rekommendationer vid uttag av skogsbränsle och kompensationsgödsling ("Recommendations for abstraction of forest fuels and compensatory use of fertilisers"). Notice 2-2001, National Board of Forestry

[114] Gov. Bill 1997/98:158. Evaluating achievement of forest policy

[115] Forest Impact Analyses 1999. National Board of Forestry 2000, ISSN 1100-0295

- Energy saving in residential and other properties.
- Utilisation of surplus heat for use as district heating.
- Expansion of district and local heating, mainly for use of biomass fuels.
- Conversion of oil-fired boilers in individual houses to heating based on renewable energy sources.
- Extraction of methane for heating or as a motor fuel by digestion of sewage sludge or household waste.
- Renewable motor fuels and vehicles for goods and passenger transport.
- Development of cycleway networks.
- Measures in the field of solar energy, wind power and hydropower.

These investments are currently in progress, and final reports have only been presented for a limited number of programmes. However, the application material submitted by municipalities, and responses to a questionnaire sent to them, provide an indication of the extent of the environmental impacts of the grants authorised to date. According to municipal application documentation, a reduction of 1,600 ktonnes carbon dioxide equivalent emissions will be achieved (see Table 3.4).

The programmes include measures to extract or digest waste for biogas and use it for energy purposes or as a motor fuel. Once the measures have been decided, a study is planned into the way the biogas measures break down between collection of methane that would otherwise have leaked from landfill, and methane production. Current data is far too uncertain to use as the basis for a quantitative assessment. Accordingly, the above table does not include the effect of reduced methane emissions.

According the questionnaire responses given by municipalities, investments completed in 2000 will reduce carbon dioxide emissions by 700 ktonnes and save 390 GWh of electric energy. If it is assumed that this electric energy will replace gas combination power or coal-fired condensing power, a further carbon dioxide saving of 100 – 300 ktonnes will be achieved. The scheme has not yet been concluded and further carbon dioxide emissions are expected.

Table 3.6
Climate-related projects under local investment programmes (LIPs) for ecological sustainability.

Project	Investment grants SEK millions per year	Estimated emission reduction ktonnes CO_2 equivalent emissions
Changeover to renewable energy	1,278	951
Measures in the transport sector	507	108
Improving energy efficiency	496	470
Biogas plants and waste management	347	43
Total	2,628	1,572

Source: Ministry of the Environment

Increased consideration of the environmental dimension in public administration

The government has delegated responsibility for integrating concern for the environment in all sectors of society in a number of bills.[116] Sectoral responsibility formed part of the basis for environmental policy in the 1990s. This applies both to legislation and to development of instruments used in ecocycle policy, such as producer responsibility.

Specific sectoral responsibility for ecologically sustainable development means that each government agency is responsible for taking steps to achieve this development in its own sector. The agency's responsibility includes identifying its own role and the way activities in that sector influence progress made towards ecological sustainability, producing material in the form of potential sectoral objectives and measures and describing their socio-economic implications, striving to ensure implementation of the measures, continuously monitoring developments in its field of responsibility and working with others and informing them about progress being made in the sector. Production of background material should form a basis for quantifying sectoral objectives, where these are appropriate.[117]

Environmental management systems are being developed in public administration, both at government agencies and at the Cabinet Office. Environmental management constitutes a systematic approach to the environmental dimension and gives clear guidelines and objectives in the form of central management documents, defined divisions of responsibility, procedures for monitoring progress and reporting of results. Environmental management systems have been shown to be an effective way of integrating environmental considerations in activities or operations. At present, 138 agencies have been instructed by the government to implement environmental management systems. More being so instructed in 2001. It is still difficult to assess the environmental impacts of environmental management systems.[118]

General rules of consideration in the Environmental Code

The fundamental provisions of the Environmental Code[119] essentially apply to all human activities that are potentially harmful to the environment. The general rules of consideration are most central. They impose a duty to ensure that activities are conducted and measures taken so as to avoid harm to human health or the environment. Sound management of land, water and other must also be promoted. Unless otherwise provided, the provisions of the Environmental Code apply to all operations and measures affecting the environment. The mere risk of harm is sufficient to create an obligation to take precautionary measures.

Since the purpose of the Environmental Code is to promote sustainable development, the scope for imposing conditions, already existing under the Environment Protection Act[120], has now been substantially widened.

The following general rules of consideration set forth in the Environmental Code are of particular relevance to greenhouse gas emissions.

- The "sound management" principle requires that the potential for reuse and recycling must be exploited, and that use of renewable energy sources is to be given priority. The main aim of the rule is to conserve raw materials and energy.
- The "product choice" (or "substitution") principle imposes an obligation to choose the chemical product or biotechnology organism representing least risk to human health and the environment.
- The "best available technique" (BAT) principle means that commercial operations must use the best available technique or technology to avoid damage. It must be technically and economically feasible to use the technique on an industrial scale in the industry in question.
- The "reasonableness" rule means that the obligations to take measures imposed by the rules of conside ration described above apply insofar as it is not unreasonable to meet them. When considering this issue, account must be taken of the benefit of the precautionary measures placed in relation to their cost. Environmental quality standards must not be disregarded when weighing up these factors. It is the operator's duty to show that the cost of a given measure is not environmentally justified, or that it is unreasonably onerous.

The impact of the general rules of consideration on greenhouse emissions has not been quantified. In addition to these general rules of consideration, there are rules governing certain types of operations, such as peat abstraction, agriculture, fuel characteristics, handling of chemical products, waste.

Regulations issued under the Environmental Code may be used to promote achievement of the climate objective. General regulations governing hazardous activities may be issued, eg, to reduce the impact on climate of an entire sector or to regulate a cross-sectoral issue.

This possibility has not yet been used, however.

Operating permit procedures under various environmental laws

Traditional permit procedures are a tried and tested instrument, which have been found to be effective in reducing other kinds of emission and which now also apply to greenhouse gas emissions.

All industrial operations in Sweden are subject to the Environmental Code, and also to a substantial proportion of EC legislation. The IPPC Directive[121] governs emissions and other environmental impacts caused mainly by large energy and industrial plants (including those already in existence). The directive is also intended to harmonise technical standards within the community and thereby prevent industrial companies from choosing to operate or move to member states where environmental standards are lower. Under the IPPC Directive, emission limit values and other conditions must be set individually by interpreting the overall requirement that BAT be used. The aim of integrated environmental permit procedures is to allow permit decisions reflecting that which is best for the environment as a whole. The IPPC Directive also governs energy use at industrial facilities and lays down efficiency requirements.

As was previously the case[122], the authority con sidering the permissibility of hazardous activities can attach conditions to the operating permit. Specific conditions relating to climate are rare, one reason being that there is legislation specifically designed to prevent greenhouse gas emissions. Some permits formerly granted by the National Licensing Board for Environment Protection under the Environment Protection Act reflect a desire to prevent further emissions of greenhouse gases. However, wind power operations, which are advocated as a way of reducing the impact on climate caused by the energy sector, are also classified as a hazardous activity.

---

[116] Gov. Bill 1987/88:85. Environmental policy in the 1990s. Gov. Bill 1990/91:90 A good living environment 117 Gov. Bill 2000/01:130. Swedish environmental objectives – subsidiary objectives and strategies

[117] Gov. Bill 2000/01:130. Swedish environmental objectives – subsidiary objectives and strategies

[118] Government communication 2000/01:38 Sustainable Sweden – evaluating the effectiveness of measures to achieve ecologically sustainable development

[119] Swedish Code of Statutes 1998:808. Environmental Code. National preparatory works; Gov. Bill 1997/98:45, report 1997/98:JoU20, rskr. 1997/98:278

[120] Swedish Code of Statutes 1969:387. Environment Protection Act. Repealed 1 January 1999. Gov. Bill 1969:28, 3LU 1969:37; rskr. 1969:281

[121] Directive 96/61/EC

[122] Under the Environment Protection Act 1968:387

There are four instances of permit decisions between 1992 and 1997 in which conditions were stipulated for nitrous oxide emissions. Apart from specific emission conditions, actual emissions were also influenced by other permits granted by the National Licensing Board for Environment Protection. One example was a permit for burning fossil fuels, which was for a limited time and stipulated maximum fossil fuel quantities. The use of peat as a fuel has also been regulated in terms of carbon dioxide emissions. Conditions have also been imposed in relation to collection and burning of landfill gas (methane).[123]

One example of a permit procedure under the Natural Resources Act[124] was expansion of Stockholm-Arlanda Airport, involving construction of a third runway. The government permit decision stipulated that the Civil Aviation Administration should take steps to minimise total emissions of carbon dioxide (and other substances) from operation of the airport, as well as terrestrial traffic to and from the airport. As a guide, it was stated that emissions in 2000 ought not to exceed those in 1990. The Civil Aviation Administration was also ordered to submit annual emission reports to Stockholm County Administrative Board.[125] This permit decision was a factor contributing to the construction of the railway link between Stockholm and Arlanda Airport.

The effects of the Environmental Code (or the Environment Protection Act) in terms of greenhouse gas emissions have not been evaluated. Bearing in mind the limited number of permits to which specific climate-related conditions have been attached, it is considered that the Environmental Code has so far had a limited effect in comparison with other instruments.

The Refrigerants Ordinance

Use of HFCs for certain applications in Sweden is governed by the HFCs Ordinance, by the Swedish EPA regulations governing refrigeration and heat pump units ("the Refrigerants Ordinance"[126]), and by the regulations governing the handling of fire-fighting equipment containing halons etc[12]7. Use and emissions of fluorinated greenhouse gases, particularly those governed by the Kyoto Protocol, are on the increase. One reason for this is that Sweden has chosen to quickly replace ozone depleting substances, which has resulted in a rapid increase in the use of HFCs.

Efforts made by the refrigeration industry to reduce leakage from refrigeration units have reduced emissions from 25 – 30 per cent of the installed quantity of refrigerants in the early 1990s to around 3 – 5 per cent. One of the main instruments for reducing and preventing refrigerant emissions is the introduction of compulsory inspection of new and existing refrigeration units containing HCFCs, HFCs or other refrigerants.

Current inspection procedures are as follows:

- Installation inspection when new units become operational.
- Annual site inspections (ie, at least once a year).
- Inspections in conjunction with service and repair of refrigeration systems.
- These inspections may only be performed by refrigeration companies possessing the necessary permit, ie, accredited inspection bodies.

Another important instrument is the duty to report for those operating refrigeration units.

The operator must submit the results of annual inspections and an annual report on relevant refrigerant handling at the same site to the regulatory authority.[128]

The effectiveness of the Refrigerants Ordinance in reducing greenhouse gas emissions has not yet been evaluated.

3.2.6 Measures and instruments in the field of waste policy

Measures and instruments to reduce the quantity of organic waste going to landfill reduce the potential for methane formation. These measures only take effect in the long term, since methane production declines slowly. The estimated combined effects of measures to reduce methane emissions to the atmosphere are presented below. It is difficult distinguish between the effects of various measures, as they act in concert and sometimes overlap.

Ban on landfilling burnable and organic waste

The most significant instrument for limiting waste going to landfill is the ban in the Public Cleansing Ordinance on landfilling sorted burnable waste.[129] This ban enters into force in 2002; preparations are already being made. The landfill ban will be extended to cover organic waste as from 2005.[130] These two instruments are expected to substantially reduce methane emissions by 2010. Methane emissions from landfill sites will eventually fall still further.

The EC Landfill Directive was adopted in April 1999.[131] The directive has now been incorporated in Sweden legislation by the Landfill Ordinance (2001:512), which entered into force in July 2001.[132] The directive provides a minimum requirement of a 35 per cent reduction in biologically degradable household waste going to landfill as compared with 1995. The preamble of the directive states that measures taken to reduce landfilling of biologically degradable waste should also aim to encourage separate collection of that waste.[133] However, the Swedish landfill bans go further than the Landfill Directive.

Municipal public cleansing regulations under the Environmental Code
Under the Environmental Code, every municipality must have public cleansing regulations governing waste management and a waste plan for reducing the quantity of waste and degree of hazard it poses. This planning has done much to help municipalities improve their environmental performance and involve municipal inhabitants in waste sorting and similar activities. A national waste strategy is intended to provide a coherent approach to waste management.[134]

Municipal public cleansing charges
Municipalities are entitled to charge for public cleansing. These charges are levied on households, indirectly via housing companies or directly on householders, and are set in the form of a municipal public cleansing charge. Differential charges, intended to reduce waste quantities, are common. The charge per tonne of household waste, both for larger properties and individual households, is 5 – 6 times higher in the municipality with the highest charges than it is in that with the lowest. Notwithstanding the introduction of the landfill tax in 2000, a number of municipalities made the same charge or lowered the charge between 1999 and 2000.

Installation of gas recovery equipment at landfill sites
The first landfill gas recovery unit began operating in the 1980s; their number rose steadily throughout the following decade. A statutory requirement that methane gas be collected will be introduced when the Landfill Directive becomes law in Sweden. Another way of preventing methane emissions is to cover the landfill surface with a methane oxidising layer. The efficacy of this method varies depending on landfill structure and climate. Some doubts remain as to efficacy and further research is needed.

At present there are no instruments designed to influence net emissions of carbon dioxide in the waste sector. The forthcoming landfill bans will probably increase the total quantity of waste going to incineration. Some waste fractions, particularly plastics, originate from fossil oils and their incineration will therefore generate carbon dioxide. At present there are no reliable figures on the percentage of waste originating from fossil oils.[135] In 2000 the government appointed an expert to carry out a study into the possibility and appropriacy of introducing an incineration tax on waste as a supplement to the landfill bans.

3.2.7 Local measures to combat climate change

Apart from central government efforts in the field of energy and climate, there are also local and regional initiatives. A description is given below of working being done at a number of "challenger municipalities", the Swedish regional energy offices and as part of the EU renewable energy "Campaign for take-off".

Twelve regional energy offices
Twelve regional energy offices have been set up in Sweden with the help of part-funding from the EU SAVE programme. In most cases, the principals and providers of part-funding are municipalities, the Swedish Association of Local Authorities and/or county administrative boards and county councils. The first offices started operating in 1996. It is estimated that local funding totals at least SEK 14 million. The EU has contributed approximately the same amount. The general task of regional energy offices is to ensure that energy issues are taken into account in the region. Their services include:

- energy supply, including renewable energy;
- recycling energy from waste;
- conservation by local authorities, private enterprise, cooperative societies and individuals;
- small and medium-sized companies, including construction and installation companies;
- creation of regional systems from local resources (firewood, small-scale hydropower and solar energy);
- the public and private service sectors;
- development, city and housing planning;
- municipal and regional administrative infrastructure:

[123] Swedish EPA 2000. Report on carbon dioxide and other greenhouse gases to the EU under Council Decision 1999/296/EC

[124] Swedish Code of Statutes 1987:12. Conservation of Natural Resources Act. Gov. Bill 1985/86:3, BoU 1986/87:3; rskr. 1986/87:34

[125] Government decision 15 August 1991

[126] Code of Statutes of the Swedish EPA 1992:16. Swedish EPA regulations on refrigeration and heat pump units containing CFCs, other CFCs, halons, HCFCs and HFCs ("The Refrigerants Order").

[127] Code of Statutes of the Swedish EPA 1993:7. Swedish EPA regulations on the handling of fire extinguishers containing halons etc

[128] Swedish EPA, summary of the 1998 report on the use of CFCs/HCFCs/HFCs as refrigerants in Sweden. September 2000. Also Ordinance on environmental penalty charges, Swedish Code of Statutes 1998:950

[129] Swedish Code of Statutes 1998:902 Public Cleansing Ordinance. EGTL194/75, p 39; EGTL135/96, p 32

[130] ibid.

[131] Directive 1999/31/EC

[132] Ordinance 2001:512, decided on 7 July 2001

[133] Government instruction to the Swedish EPA, 29 June 2000

[134] Government communication 1998/99:63

[135] It should be mentioned that landfilled waste whose carbon content is of biogenic as well as fossil origin may give rise to emissions of methane, and that the Kyoto Protocol stipulates that these emissions must be included in the national emission inventories. If the same waste is instead recycled by incineration for energy extraction, only carbon dioxide emissions from the fraction of the waste of fossil origin is included.

buildings, public lighting, car and bus fleets, water supply and sewage systems;
- supply of independent energy advice.

The "Challenger Municipalities" project

The Swedish Society for Nature Conservation (SNF) started a project entitled "Challenger Municipalities" in 1998. Fifteen or so municipalities applied to participate in the project jointly with local branches of SNF in each municipality. Säffle, Övertorneå, Lund, Växjö and Stockholm were selected; Stockholm was replaced by Uppsala following the 1998 general election. The aim of the project is for the municipalities ultimately to stop using fossil fuels. Methods of achieving this include improved energy efficiency, reduced transport requirements and less use of fossil fuels for heating and transport. The idea is that efforts to achieve this should be made on the basis of local conditions and that the municipalities should serve as an example to other municipalities. The project is being partfunded by the National Road Administration. The table below shows the targets each municipality is trying to achieve. The project was concluded in 2001.

Table 3.7
Action by the "Challenger Municipalities" to reduce carbon dioxide emissions.

Municipality	Base year	Target year	Target
Lund	1995	2005	25% reduction from road traffic
		2050	75% reduction
Säffle	1995	2025	50% reduction
Växjö	1993	2025	50% reduction
Uppsala	1990	2010	25% reduction from traffic
Övertorneå	1990	2020	50% reduction

Source: Swedish Society for Nature Conservation

Municipal climate objectives

92 of Sweden's 289 municipalities had adopted greenhouse gas emission reduction objectives by early 2000.[136] 62 of them has set a specific percentage target and year. No analysis has yet been made of the feasibility of these objectives or the measures being taken to achieve them. If the objectives are achieved, it is estimated that the total emission reductions in these municipalities will be about 4,500 ktonnes a year by 2010.[137]

Table 3.8
Costs and effects of conversion projects under AIJ[139].

Country	No. of projects	Total cost SEK millions	Accum. reduction of CO_2 during life of the projects, ktonnes	Cost per reduced tonne CO_2 (SEK)
Estonia	9	57	1,311	43
Latvia	14	59	1,229	48
Lithuania	8	54	625	87
Russia	8	41	508	81
All	**39**	**211**	**3,675**	**57**

[1] Total cost = investment costs + transaction costs as described above.

Source: National Energy Administration

Table 3.9
Costs and effects of measures for distribution of district heating under AIJ.

Country	No. of projects	Total cost SEK millions	Accum. reduction of CO_2 during life of the projects, ktonnes	Cost per reduced tonne CO_2 (SEK)
Estonia	9	17	190	87
Latvia	5	14	71	203
Lithuania	1	1	4	370
Russia	0	0	0	0
All	**14**	**32**	**265**	**122**

[1] Total cost = investment costs + transaction costs as described above.

Source: National Energy Administration

Swedish members of the Renewable Energy Partnership

Seven Swedish municipalities are participating as "Renewable Energy Partners" in the EU Campaign for take-off.[138] These are the five "Challenger Municipalities", together with Gotland and the part of Malmö municipality included in Bomässan 2001 Housing Exhibition.

3.2.8 The Climate Convention pilot programme for AIJ and other measures taken outside Sweden

Sweden has long had an investment programme to promote energy efficiency and renewable energy in the Baltic States and other parts of eastern Europe. These projects were subsequently incorporated in the Climate Convention pilot programme for activities implemented jointly (AIJ). Total funding of SEK 627 million is being provided for these purposes between 1993 and 2002.

The aim of the programme is to reduce emissions of carbon dioxide and other substances affecting climate, to improve the efficiency of energy systems in the Baltic States, and to introduce renewable sources of energy. To date over 70 projects have been initiated by Swedish authorities, of which 64 have been reported to the UN Climate Convention Secretariat as "pilot projects for activities implemented jointly". The total cost of the 64 projects is put at SEK 271 million, of which SEK 197 million is being provided by recipient countries and SEK 74 million by Sweden. The total reduction in carbon dioxide emissions is estimated at 4,000 ktonnes. The projects have been funded by favourable loans to the recipient countries; Sweden has also paid for consultancy costs, eg, preliminary studies. Loans to plant owners or the like generally extend over 10 years, with two years of interest-only payments. The aim is that the projects should repay the investment cost more quickly than the loan term.

The projects comprise boiler conversions, ie, change-over to biomass fuels, upgrading of the district heating network, and energy-efficiency improvements in buildings. On average, boiler conversion projects are expected to repay their costs over five years. The repayment period for heat distribution projects varies between 2 and 12 years, depending on the extent to which new pre-insulated district heating pipes are needed. The measures solely intended to improve energy efficiency in buildings repay their costs in 7 – 9 years, whereas renovation work deemed necessary to achieve efficient energy use in buildings takes 16 – 20 years to pay for itself.

[136] The figure given for the number of municipalities with climate objectives has been taken from a publication entitled Miljoeko, No. 1/2000. The figures are based on that publication's annual questionnaire sent to Swedish municipalities, which is then used to rank the municipalities' environmental performance.

[137] The calculation has been made by the Swedish Society for Nature Conservation

[138] The figures given on the number of municipalities is from the EU Commission's website: http://europa.ue.int/comm/energy/en/renewable/idae_site/deploy/tabla_sweden_all_title.html, 18 August 2001

[139] Also distribution measures in a few cases

Table 3.11
All projects

Country	No. of projects	Accum. reduction of CO_2 during life of the projects, ktonnes	Cost per reduced tonne CO_2 (SEK)
Estonia	21	1,531	58
Latvia	22	1,306	61
Lithuania	9	629	88
Russia	12	538	87
All	**64**	**4,004**	**67**

Table 3.10
Costs and effects of measures in buildings to improve efficiency under AIJ.

Country	No. of projects	Total cost SEK millions	Accum. reduction of CO_2 during life of the projects, ktonnes	Cost per reduced tonne CO_2 (SEK)
Estonia	4	15	29	527
Latvia	3	6	5	1,170
Lithuania	0	0	0	0
Russia	4	6	29	196
All	**11**	**27**	**63**	**428**

[1] Total cost = investment costs + transaction costs as described above.

Source: National Energy Administration

The costs are broken down into investment and transaction costs. Investment costs are the investment made by a donor country in the recipient country. (In Sweden's case, this investment is financed by way of loans, which are to be repaid.) Transaction costs consist of consultant support and administrative costs and, in some cases, also forgiveness of loans or unpaid interest. Tables 3.8 – 3.10 show the cost per unit of emission reduction over the lifetime of the projects per country and project category. The projects run for between 10 and 25 years. Costs include investment and transaction costs. These figures are only a rough guide and give an indication of the upper limits of actual reduction costs.

The AIJ projects concluded to date show that it is possible to implement projects meeting the criteria for the flexible mechanisms, ie, that they are cost-effective and that major emission reductions can be achieved with fairly modest means.

Further AIJ pilot phase projects cannot be carried out because new projects must take place as creditable projects under a forthcoming national climate investment programme.

However, the National Energy Administration is completing a few projects decided prior to 1999 but which, for various reasons, could not be started until after that year.

The programme has been continuously evaluated by local experts and independent consultants and has attracted international attention because it has been cost-effective and worked well. The programme has attracted attention not only because of greenhouse gas emission reductions, but also because of other positive effects, both in Sweden and in recipient countries. The programme has had a beneficial effect on attitudes to environmentally friendly energy supply and use among people involved in, or coming into contact with, the programme in recipient countries. Attitudes have changed and knowledge (eg, about the UN Climate Convention) has improved. Moreover, the programme has had a positive influence on the development of a domestic market for energy products, particularly biomass fuels and biomass fuel-burning boilers. The programme has also helped to establish long-term cooperation between Swedish companies and companies in recipient countries, which includes joint operations in other markets. A further favourable effect of the programme has been to enhance relations between Swedish and Baltic ministries and public authorities.

Other international climate policy programmes

Sweden is working together with the World Bank on two programmes involving measures to protect the climate. In the first, Sweden is supporting the World Bank Prototype Carbon Fund (PCF), providing funding of about SEK 90 million. The PCF aims to produce creditable emissions reductions from projects within the scope of AIJ and the Clean Development Mechanism (CDM), and to heighten public awareness of this. The other programme is CDM-assist, which aims to develop the CDM itself.

Sida is funding energy-related projects as part of the development assistance it supplies to central and eastern Europe. These mainly involve consultancy services, preliminary studies, seminars and the like. For instance, just over SEK 18 million was spent on projects of this kind in the district heating sector in Latvia, Lithuania and Russia in 1998 and 1999. Almost SEK 8 million was spent on improving energy efficiency in Poland, Russia and Ukraine.

Swedish agencies are conducting a number of projects funded out of the "Baltic billion", which was earmarked for helping to develop industry and trade with countries in the Baltic region. The first billion funded energy projects, eg, district heating projects and sulphur removal projects. Parliament allocated a further billion kronor in 1998. This is to be used to develop trade and industry in the Baltic region over a five-year period (1999 – 2003).

These additional funds are to be used to implement the support measures recommended by the Baltic Commission to meet the needs of trade and industry. The government is delegating responsibility for carrying out these measures to government agencies and bodies in receipt of government funding. The programme focuses on seven topic areas, of which environmental technology/environmentally-driven growth is one. The funds are also to be deployed in the energy sector, among other things to improve the efficiency of heating supply in Riga and Vilnius.

Some of the development assistance provided by Sida takes place in cooperation with the World Bank. These two, together with other Swedish parties, have contributed funding for district heating improvements in Estonia's three largest cities (Tallinn, Tartu and Pärnu), as well as modernisation of small and medium-sized combustion units. The programme required funding of approximately SEK 600 million, of which Sweden provided SEK 100 million in the form of credit and paid for consultancy services and institutional development. These projects formed part of scheduled investments in eastern Europe by the World Bank from 1991 to around 1998.

3.2.9 Forthcoming measures

According to Climate Convention guidelines, countries must specify the measures or instruments they plan to introduce to reduce greenhouse gas emissions. A considerable number of studies have been made in recent years to examine the scope for reducing emissions of greenhouse gases. This section deals with measures the government has decided on in decisions or policy statements. It does not include measures proposed by official commissions, public authorities or NGOs but not yet dealt with by the government.

Tradable permits

At the government's instigation, a special study has been made into the possibility of introducing a system of tradable permits in Sweden.[140] The study also examines issues raised in an EU Commission green paper proposing an EU system of trade in permits for companies producing combined power and heat and for energy-intensive industries. Commission work on an EU system continues. Sweden is supporting this process. The government has recently appointed a parliamentary commission of enquiry to examine outstanding issues concerning tradable permits and other flexible mechanisms.[141]

Project-based mechanisms under the Kyoto Protocol

The energy policy decision of 1997 included the allocation of funds for climate-related measures in other countries. Funding has so far focused on AIJ pilot projects. The government is planning to use the remainder for project-based mechanisms under the Kyoto Protocol.

The National Energy Administration is currently drawing up a strategy for implementing the flexible mechanisms. Among other things, the administration will present an analysis of suitable partners with which to enter into agreements and the potential for cooperation with various countries. The further National Energy Administration programme is named SICIP (Swedish International Climate Investment Programme).

Sweden will be working with the World Bank to prepare investment projects suitable for the Clean Development Mechanism (CDM) under the Kyoto Protocol. The first priority will be to identify a potential CDM project as part of the World Bank's "CDM assist" programme for Africa, which also focuses on measures to develop capacity.

Continuing moves towards green taxation

The Green Tax Commission report[142] considered that there was scope for a further shift towards green taxation over the next fifteen years equal to the shift effected in the 1980s and 1990s. In spring 2000 parliament decided that green taxation changes totalling some SEK 30 billion were to be made between 2000 and 2010.

To continue the move towards green taxation, a number of areas will first have to be further examined. These include tax relief for energy-intensive industry and industries operating in the face of international competition, and also taxation of the transport sector.

Two parallel commissions of enquiry are examining these issues. They are the Swedish Committee on Energy Taxation of the Business Sector[143], and the Swedish Road Traffic Taxation Commission.[144] As far as the latter area is concerned, the aim is to increase the overall environmental effect of road traffic taxation. The government has also decided that certain aspects of waste taxation are to be examined.[145]

Green certificates combined with a quota system to promote renewable electricity production

As may be seen from earlier sections, Sweden has introduced a number of instruments to promote the production of electric energy from renewable sources. The premises on which subsidies in this area are based have changed in a number of respects. Sweden has deregulated its electricity market in line with the principles of market economics so as to improve competition between electricity suppliers. This has also altered the situation in relation to the instruments employed. Electricity prices for end users have fallen since the electricity market was reformed in 1996. This means lower revenues per kilowatt hour for suppliers and producers. Consequently, the need for financial support for small-scale and often environmentally friendly electricity generation has increased in many instances, notwithstanding the cost reductions that have been made.

The advent of the Kyoto Protocol has brought the spotlight to bear on measures to support renewable energy forms so as to reduce electricity production based on fossil fuels. The EU has started work on drafting a directive giving renewable energy sources access to the single electricity market. The aims of the directive are based on the Commission white paper on renewable energy sources, which sets a target of a 12 per cent market share for these sources within the union as a whole by 2010, compared with the current

140 Swedish Government Official Report SOU 2000:45

141 Directive 2001:56. A system and regulations for the flexible mechanisms of the Kyoto Protocol

142 Swedish Government Official Report SOU 1997:11

143 Directive 2001:29

144 Directive 2001:12

145 Directive 2001:12

figure of 6 per cent.

In the light of the above, parliament has decided in 2001 to establish a new system to promote renewable electricity production, scheduled to take effect on 1 January 2003. The system will be based on trade in certificates combined with an obligation to include in the supply or purchase of electricity a certain proportion of renewable energy meeting certain environmental criteria.

Trade in certificates combined with quotas will constitute a system of support financed within the market, which will increase its durability. The model will also create business opportunities for market players and create a market dynamic that will provide scope for cost-effectiveness and technological development without disturbing the workings of the electricity market. The government considers these to be important objectives of a future support system. The aims of the support system should be to:

- promote the creation of new electricity production from renewable energy sources meeting certain environmental criteria;
- encourage technological development and cost-effectiveness;
- create reasonable conditions for existing plants;
- avoid disruption of the operation of the electricity market;
- create a stable regulatory framework, regardless of the state of national finances
- facilitate international harmonisation.

A special study is being made to examine the technical issues and propose necessary legislative amendments.[146]

Planning objectives for wind power production

In the finance bill of spring 2000[147], the government pledged that it would present a proposed appropriate planning objective for development of wind power to parliament at a later date. An important part of adjusting the energy system is to create the right economic conditions for renewable electricity production. Wind power has a key role to play in this process and can also help to achieve several of the national environment quality objectives set by parliament in 1999.[148] Being properly prepared for further development of wind power is therefore of strategic importance. The government considers that a planning objective for wind power may serve as a suitable tool for achieving this end.

The government has instructed the National Energy Administration to propose areas on land and out to sea that are particularly suitable for wind power plants, and to propose planning objectives for wind power. The government has also decided to appoint a working group to carry out a study on the general potential for siting wind power plants in marine and mountain areas.

The National Energy Administration has proposed that the planning objective for wind power expansion be set at 10 TWh over a period of 10 – 15 years. A planning objective for wind power is defined as an annual production volume to serve as a target and the basis for necessary planning, to enable large-scale development of wind power in Sweden. The National Energy Administration report has now been referred to various bodies as part of the consultative process. A national planning objective is to be broken down at regional level to serve as an operative basis for the county administrative boards in their planning and in municipal planning for wind power. It is essential that the potential offered by wind power is systematically incorporated in general municipal planning.

Development of terrestrial and coastal wind power stations at sites with the right wind conditions will continue, primarily along the coasts of Sweden. Large wind power stations out to sea will have to be built to achieve sufficient electricity production. Limitations in transmission capacity and other factors mean that large-scale establishment of wind power in the mountains and other parts of northern Sweden will require heavy investment in the grid.

Tools to aid public procurement in the field of energy

Public procurement in Sweden totals some SEK 300 billion a year, of which about SEK 100 billion comprises products and SEK 200 billion services and contracting. One task of the Ecologically Sustainable Procurement Commission[149] is to produce common Internet-based tools for the entire public sector, which are to serve as models for ecologically sustainable procurement. The following are some of the premises on which the commission is working:

- The tool must serve as an aid/guide when setting environmental standards in public procurement. These standards must be high, and the tool must be designed within the confines of current laws.
- Public organisations themselves decide the environmental standards to be included in the tool, although manufacturers, suppliers and environmental organisations must be given the opportunity to express their opinion of relevant issues and important matters of principle concerning the content of, and alterations to, the tool.
- The environmental standards set by the tool must be high and follow developments in environmental

knowledge and know-how. The commission therefore proposes that a scientific council be established for quality assurance of these standards.

A working group has evaluated the effect of introducing energy efficiency requirements in public procurement and has drafted guidelines for procurement of high-energy equipment, taking account of aspects such as quality requirements, occupational health and safety, operation and financial considerations. Procurement information has so far been produced for pumps, fans, lighting, ventilation, refrigeration compressors and compressed air. These guidelines are intended to help purchasers and, among other things, have been based on calculation formulae for life-cycle energy costs. It has been estimated that the effect of setting more stringent energy efficiency standards will reduce the electricity requirement by 2 TWh after 10 years, which may reduce carbon dioxide emissions by 700 – 1,700 ktonnes a year by 2010.

Improved industrial energy efficiency
Over the last decade, it has become increasingly common in Sweden and other countries for companies or trade associations to conclude some form of "environmental agreement" with the state, with a view to limiting the environmental impact caused by trade and industry. These agreements are usually combined with some form of sanction that will be triggered if commitments are not met, eg, legislation in the area, higher environmental taxes or charges. Several projects are currently in progress at a number of public authorities and agencies to examine the scope for using environmental agreements between industry and the state as a means of reducing environmental impact from the private sector.

Dialogue with trade and industry
The task of the Environmental Advisory Council, made up of representatives from parliament, trade and industry and other areas of society, is to formulate strategies for developing ecologically sustainable trade and industry by initiating a dialogue with parts of that sector. The council has chosen to initiate this dialogue with a number of companies in the sectors "Building/ Housing" and "Future trade". The aim is that the companies will voluntarily agree to take certain development steps and, where necessary, also present proposals as to how the government can help them to do so.

The results of the dialogue were presented to the government in December 2000.[150] The dialogue contains a joint "vision" for a sustainable construction and property sector, further objectives to be achieved and a strategy for achieving the objectives and realising the vision. The vision is not a forecast of future developments; it is the dialogue team's view of a desirable scenario in 2025. Priority areas are greater efficiency in use of energy and resources, the indoor environment and choice of materials. Proposed objectives include no fossil use in the sector by 2025 and a reduction of at least 30 per cent in energy use. Seven priority areas have been identified by analysing obstacles to, and the potential for, achievement of sustainable development. The seven areas are:

1. Sustainable social development
2. Use of best available techniques and development of new technologies
3. Procurement on the basis of a life-cycle perspective and an holistic approach
4. Coordination of the building and maintenance process
5. Classification of commercial/industry premises and housing
6. Investment in research and development
7. Marketing of environmental solutions

Further efforts in this field will be made by working groups made up of representatives of the parties. The aim is to reach agreement on specific action with representatives from the sector by early 2002.

Energy declarations for housing
A number of energy labelling projects are currently in the initial phase. The National Board of Housing, Building and Planning and the National Energy Administration will be examining and submitting proposals for energy labelling of housing and windows, and will also be producing better and more accurate calculation programmes via procurement of technology, for example.

The Malmö City Tunnel and investments in infrastructure
An infrastructure investment bill was put before parliament in September 2001. One of the projects concerned is the Malmö City Tunnel, which will form part of the public transport system in Skåne, in the far south of Sweden. It will link existing county railways to create a coordinated system. Construction will take about five years.

---

146 Directive 2000:56

147 Gov. Bill 1999/2000:100

148 Swedish environmental objectives. Gov. Bill 1998/99:145

149 Government committee (M 1998:01)

150 Tänk nytt, tänk hållbart – att bygga och förvalta för framtiden ("New thinking, sustainable thinking – building and administering for the future"). Environmental Advisory Council 2000: http:www.sou.gov.se/mvb/

3.2.10 Measures and instruments having a counterproductive effect

The objectives of different policy areas may have conflicting aims. Even when interests are weighed together, the result may be that action is taken in one area, even though it may adversely effect the prospects of achieving objectives in another area.

Some measures and instruments that have been introduced in various policy areas for reasons unconnected with carbon dioxide emissions may thus give rise to higher emissions of greenhouse gases. Two examples of this are given below.

Tax relief on journeys to and from work
Gross tax relief on journeys to and from work totalled SEK 7 billion in 2000. Income tax relief is available on expenses exceeding SEK 7,000 (SEK 6,000 in 1996 and 1997). This tax subsidy helps to create a flexible labour market by cutting the cost to the individual of taking work some distance from his place of residence. Travel costs are thus reduced. This applies particularly to those travelling by car, since the cost of public transport seldom exceeding SEK 7,000 a year. This may then serve as an incentive to travel by road, which causes more carbon dioxide emissions.

Transport subsidy
Since the 1970s a transport subsidy has been paid to companies in certain sectors in sparsely populated rural areas for their transport of semi-finished or fully finished products that have undergone significant processing within the area. The reason for the subsidy is the additional transport costs incurred by companies in certain regions.[151] Like tax relief on journeys to and from work, the transport subsidy may act as a stimulus for transport, leading to higher carbon dioxide emissions. The environmental impact of the transport subsidy has not been studied. 99 per cent of this subsidy was paid to the mining, quarrying and manufacturing sectors in 1993 and 1995. The total cost of this subsidy varied between SEK 250 – 400 million in the 1990s.

3.3 Discontinued measures and instruments

Discontinued measures and instruments that limited emissions or increased removals of greenhouse gases. In the 1990s there were a number of traffic-related taxes that had some environmental impact, although they are considered to have had little impact on carbon dioxide emissions.

Environmental tax on domestic air traffic[152]
was introduced on 1 March 1989 and abolished on 31 December 1996 because it was not considered to conform to EC regulations on taxation of mineral oil products.[153] The tax had been brought in to reduce hydrocarbon (HC) emissions and NO_x emissions from air traffic. It was levied on each flight at a rate of SEK 1/kg of aviation fuel used and SEK 12/kg of hydrocarbons and nitrogen oxides emitted. This tax generated revenues of SEK 196 million in 1993, falling to SEK 186 million in 1995.

151 National Audit Office RRV 1998:6. Impact of subsidies on ecologically sustainable development – three case studies

152 Swedish Code of Statutes 1998:1567. Environmental Tax on Domestic Air Traffic Act. Gov. Bill 1988/89:39, 1988/89:SkU10, rskr. 1988/89:79

153 Council Directive 92/81/EEC of 19 October 1992 on harmonising the structures for sales taxes on mineral oils

Table 3.12
Table summerising measures and instruments affecting emissions of greenhouse gases

Measure/Instrument	Activities affected [6]gases	Main greenhouse concerned	Type of instrument[1]	Status of measure[2]	Agency responsible	Estimated effect measured in CO_2 equivalent emissions/year[5] 1995	2000	2005
Energy tax	Affects energy use in all sectors	CO_2	T	O (57-)	RSV			
Carbon dioxide tax		CO_2	T	O (91-)	RSV			
VAT on energy		CO_2	T	O (90-)	RSV	1,000	5,000	ca 8,000
Taxes on electricity production		CO_2	T	O	RSV			
Energy and environmental tax exemption on biomass fuels, inc. peat		CO_2	T	O (94-)	RSV			
Exemption from energy tax for use of electricity and fuel by manufacturing industry		CO_2	T	O	RSV			
A number of taxes on electricity production	Affects generation of electricity using certain fuels	CO_2	T	O				
Reform of the electricity market	Makes the electricity market more a part of the market economy and involves joint egulation of the North European electricity markets	CO_2	T	O (96-)	STEM[3]	N.I.U.	N.C.[4]	N.C.
Special pilot project exemptions for biomass motor fuels	Makes biomass fuels more competitive	CO_2	T	O	F-dep STEM	N.I.U.	55	N.C.
Environmentally differentiated charges for shipping and air traffic	N.C.	N.C.	T	O (98-)	N.C.	N.I.U.		
Tax on landfill (described elsewhere in table as part of waste programme)	Waste generation and management	CH_4	T	O (00-)		N.I.U.		
Gradual shifts in tax emphasis	Economic instruments are reviewed to increase the impact of taxation on environmental behaviour	CO_2	T	O	F-dep	N.C.	N.C.	N.C.

Table 3.12
Table summerising measures and instruments affecting emissions of greenhouse gases

Measure/Instrument	Activities affected	Main greenhouse [6]gases concerned	Type of instrument[1]	Status of measure[2]	Agency responsible	Estimated effect measured in ktonnes CO_2 equivalent emissions/year[5 6] 1995	2000	2005
Investment grants for biomass fuel-based combined power and heating	Increase renewable electricity generation	CO_2	T	O (98–02)	STEM	N.I.U.	490–820	490–820
Investment grants for wind power and small-scale hydropower Operating subsidies for small-scale electricity generation Environmental bonus for wind power	Increase renewable electricity generation	CO_2	E E T	O (98–02) O (00-) O (95-)	STEM STEM RSV	N.I.U. N.I.U.	170–414	170–414
Conversion from electric heating to district heating	Reduce electricity consumption	CO_2	E	O (98–02)	STEM	N.I.U.	88–236	88–236
Conversion of electric heating to other individual heating		CO_2	E	O (98–02)	LS	N.I.U.	34–81	34–81
Information, education etc	Reduce energy consumption	CO_2	I	O (98–02)	STEM	N.I.U.		
Procurement of new energy technology			E	O (98–02)	STEM	N.I.U.	200–400	200–400
Testing, labelling and certification			E	O (98–02)	KOV	N.I.U.		
Measures to develop electric heating supply in southern Sweden	Need to compensate for electricity shortfall caused by closure of Barsebäck	CO_2	E	O (98–01)	DESS	N.I.U.	70	70
Municipal energy planning	Reduce energy consumption etc	CO_2	R	O (77-)	STEM	N.C.	N.C.	N.C.
Planning, Building and Housing Act	Reduce energy consumption etc	CO_2	R	O	BoV	N.C.	N.C.	N.C.
Environmental Code in relation to environmental impacts of an infrastructure project	Assess impact on climate	CO_2	R	O	NV	N.C.	N.C.	N.C.
Standards for energy use in residential and commercial properties, inc. planning permission	Reduced energy consumption	CO_2	R	O	BoV	N.C.	N.C.	N.C.

Table 3.12
Table summerising measures and instruments affecting emissions of greenhouse gases

Measure/Instrument	Activities affected	Main greenhouse [6]gases concerned	Type of instrument[1]	Status of measure[2]	Agency responsible	Estimated effect measured in ktonnes CO_2 equivalent emissions/year[5 6] 1995	2000	2005
Comprehensive municipal planning	Reduce energy consumption by urban and regional planning	CO_2	R	O	BoV	N.C.	N.C.	N.C.
64 projects under the climate convention pilot programme for joint implementation (AIJ)	Improve the energy efficiency of the Baltic energy systems and develop the flexible mechanisms	CO_2	E	O (98–02)	STEM	NC.	220	220
Participation in World Bank Carbon Fund and CDM Assist	Develop the flexible mechanisms under the Kyoto Protocol	CO_2	E	O	N-dep	N.C.	N.C.	N.C.
Development assistance in neighbouring countries	Improve the energy efficiency of the Baltic energy systems	CO_2	E	O (98-)	Sida	N.I.U.	N.C.	N.C.
Promotion of growth and employment in the Baltic region in energy and other sectors	Improve the energy efficiency of the Baltic energy systems	CO_2	E	O (96-)	UD, Sida, STEM	N.I.U.	N.C.	N.C.
Measure-oriented research and development	New fuels, new technology etc	CO_2	R&D	O (98–04)	STEM, FORMAS,	N.I.U.	N.C.	N.C.
Local investment programmes for ecological adjustment (LIP)	Municipal adjustment to achieve ecological sustainability	CO_2	E	O (98–03)	M-dep	N.I.U.	1600	N.C.
Greater consideration of the environmental dimension in public administration	Greater consideration of the environmental dimension in administration and goverment decision making	CO_2	M	O	M-dep	N.C.	N.C.	N.C.
General environmental factors to be considered under the Environmental Code	Establish certain fundamental principles governing all activities	CO_2	R	O (99-)	NV	N.C.	N.C.	N.C.
Permit application procedures under various environmental laws	Integrated considertion of environmental factors in permit application procedures	CO_2	R	O	NV	N.C.	N.C.	N.C.
The Refrigerants Order	Governs the use of refrigerants, including halocarbons	Halocarbons	R	O	NV	N.C.	N.C.	N.C.

Table 3.12
Table summerising measures and instruments affecting emissions of greenhouse gases

Measure/Instrument	Activities affected	Main greenhouse [6]gases concerned	Type of instrument[1]	Status of measure[2]	Agency responsible	Estimated effect measured in ktonnes CO_2 equivalent emissions/year[5 6] 1995	2000	2005
Investment programmes for ecological building	Reduce energy consumption	CO_2	E	O	BoV	N.C.	N.C.	N.C.
Further development of environmental management systems at government agencies	Reduce environmental impact of state activities	E.B.	V/N	O (96-)	Reg.	N.C.	N.C.	N.C.
Sectoral integration	Clarify responsibility for the environment	E.B.	R	O	NV	N.C.	N.C.	N.C.
Collection of landfill gas	Reduce methane evaporation	CH_4	V/N	O (94-)	Kom, LS			
Ban on landfill of organic waste	More stable landfills and use of waste as a resource	CH_4	R	PI (05-)	NV			
Ban on landfill of sorted burnable waste	Improvement in disposal of all burnable waste	CH_4, CO_2	R	PI (02-)	NV	0	193	781
Waste Tax Act	Reduce the quantity of landfilled waste	CH_4	T	O (00-)	NV			
Landfill Directive	Compulsory collection of landfill gas	CH_4	R	O (01-)	NV			
Environmental Code requirements vis-à-vis municipal waste plans	More efficient waste management	CH_4	R	O (91-)	NV			
Grants for home solar heating systems	Increase the use of solar energy	CO_2	E	O (00–01)	LS	N.I.U.	3–5	3–5
Heat insulation of buildings	Clarification of requirements for calculating floor and roof temperature. Tougher requirements for thermal bridges	CO_2	R	O (99-)	BoV	N.C.	N.C.	N.C.
"Swan" criteria for oil burners	Nordic eco-labelling has produced "Swan" criteria for oil burners with an output of up to 120 kW	CO_2	R	O	–	N.C.	N.C.	N.C.
Investment grants for ecological building	Reduce energy consumption etc	CO_2	E	O (01–03)	F-dep BoV	N.I.U.	N.C.	N.C.

Table 3.12
Table summerising measures and instruments affecting emissions of greenhouse gases

Measure/Instrument	Activities affected	Main greenhouse [6]gases concerned	Type of instrument[1]	Status of measure[2]	Agency responsible	Estimated effect measured in ktonnes CO_2 equivalent emissions/year[5 6]		
						1995	2000	2005
Start-up grants for energy forests	Cultivation of energy forest	CO_2	E	O	SJV	150	150	N.C.
Environmental factors to be considered under the Silvicultural Act	Sustainable forestry	CO_2	R	O	SKS	N.C.	N.C.	N.C.
National Board of Forestry recommenda-tions on forest fuel abstraction	Optimise biomass fuel abstraction	CO_2	R	O	SKS	N.C.	N.C.	N.C.
Protected areas etc	Protect certain forest ecosystems	CO_2	R	O	SKS	N.C.	N.C.	N.C.
Environmentally-related forestry certification	Sustainable forestry	CO_2	M	O	SKS	N.C.	N.C.	N.C.
Tighter restrictions on use of nitrogenous fertilisers on forest soils	Reduce nitrogen lea-ching from forest soils	N_2O	R	O	SKS	N.C.	N.C.	N.C.
Procurement of etha-nol-petrol hybrid cars	Increase the scope for using biomass motor fuels	CO_2	V/N	O (99-)	NUTEK	N.C.	N.C.	N.C.
Promoting development and use of IT and traffic information methods	Reduce fuel consumption etc	CO_2	R&D	O (95-)	VV	N.C.	N.C.	N.C.
"Green Car", a joint project run by the Swe-dish state and the automobile industry	Reduce fuel consumption	CO_2	R&D	O (00–06)	N-dep	N.I.U.	N.C.	N.C.
"Transport Quality Assu-rance" and "Economical Driving" transport pro-jects	Reduce fuel consumption etc	CO_2	M	O (00-)	VV	N.I.U.	N.C.	100
Use of renewable energy to run railways	Reduce impact of transport system on climate etc	CO_2			SJ	N.C.	N.C.	N.C.
Joint programmes for development of more environmentally compatible vehicles	Reduce fuel consumption etc	CO_2	P	O (00–05)	NUTEK	N.I.U.	N.C.	N.C.
Greater investment in tramway infrastructure	Make trams more competitive	CO_2	M	O	Banverket	N.C.	N.C.	N.C.

Table 3.12
Table summerising measures and instruments affecting emissions of greenhouse gases

Measure/Instrument	Activities affected	Main greenhouse [6]gases concerned	Type of instrument[1]	Status of measure[2]	Agency responsible	Estimated effect measured in ktonnes CO_2 equivalent emissions/year[5 6] 1995	2000	2005
Energy declarations for apartment buildings	Better overview of the energy status of Swedish buildings	CO_2	R	P (01–02)	BoV	N.C.	N.C.	N.C.
Individual metering of heating and hot water	Reduce energy consumption by increasing awareness of individual use of heating and hot water	CO_2	V/N	P	BoV	N.C.	N.C.	N.C.
Individual metering and charges for heating and hot water	Reduce energy consumption	CO_2	M	O	BoV	N.C.	N.C.	N.C.
Twelve regional energy offices	Reduce energy consumption etc	CO_2	I	O	STEM	N.C.	N.C.	N.C.
The "Challenger Municipalities" project	Begin phasing out use of fossil fuels in five municipalities	CO_2	M	O	VV	N.C.	N.C.	N.C.
Climate objectives set by Swedish municipalities	Reduce impact on climate	CO_2	M	O	–	N.C.	N.C.	N.C.
Swedish members of the Renewable Energy Partnership	Increase use of renewable fuels	CO_2	M	O	–	N.C.	N.C.	N.C.
Encouraging the introduction of environmental management systems in small and medium-sized businesses	Some local funding, free telephone advice, seminars and help, eg, in achieving EMAS registration	CO_2	I	O (96-)	NUTEK	N.I.U.	N.C.	N.C.
Measures no longer in use								
Environmental tax on domestic air traffic	Reduce emissions of HC and NOX from domestic air traffic	CO_2 CO_4	T	D/(89–96)		N.I.U.	N.I.U.	N.I.U.
Measures having the opposite effect								
Tax relief on journeys to and from work	Increase the scope for distance working	CO_2	E	O				
Regional transport subsidies	Alleviate the impact of cost differences for long-distance transport from companies in regional support areas	CO_2	E	O		N.C.	N.C.	N.C.

Table 3.12
Table summerising measures and instruments affecting emissions of greenhouse gases

Measure/Instrument	Activities affected	Main greenhouse [6]gases concerned	Type of instrument[1]	Status of measure[2]	Agency responsible	Estimated effect measured in ktonnes CO_2 equivalent emissions/year[5 6] 1995	2000	2005
Measures not yet implemented								
Trade in emission rights	Increased use of management by objectives in climate policy	CO_2	E	P	STEM	N.I.U.	N.I.U.	N.C.
Project-based mechanisms under the Kyoto Protocol	Prepare for the Kyoto Protocol flexible mechanisms	CO_2	E	P	STEM	N.I.U.	N.I.U.	N.C.
Continuing shifts in the emphasis of taxation	Increase the effects of the tax system on environmental behaviour	CO_2	T	P (02–10)	F-dep	N.I.U.	N.I.U.	N.C.
Quota-based trade in certificates	Stimulate production of renewable electricity	CO_2	R	P (03)	STEM	N.I.U.	N.I.U.	N.C.
Planning objectives for wind power production	Improve the scope for a dramatic expansion of wind power use in Sweden	CO_2	M	P	STEM	N.I.U.	N.I.U.	N.C.
Public procurement in the energy field	Reduced energy consumption	CO_2	V/N	P	STEM	N.I.U.	N.I.U.	N.C.
Improving energy efficiency in industry	More efficient energy use	CO_2	V/N	P	STEM	N.I.U.	N.I.U.	N.C.
Dialogue with trade and industry	Adjustments in trade and industry to achieve ecologically sustainable development	CO_2	V/N	P	Miljövårds-beredningen	N.I.U.	N.I.U.	N.C.
Malmö City Tunnel	Improve railway traffic through Malmö	CO_2	M	P	Banverket	N.I.U.	N.I.U.	N.C.

1 The guidelines classify instruments as follows: Economic (E), Tax (T), Voluntary or Negotiated measures (V/N), Regulation (R), Information (I), Education (Ed), Research (R&D), Miscellaneous (M).

2 The following symbols are used to describe the status of instruments:
O = ongoing (with the year of introduction and conclusion where possible);
D = measure discontinued (with the year it was discontinued);
PI = measured planned and decided but not yet implemented (with the year it will take effect);
P = measure proposed by the government but with no decision to implement.

3 Joint Nordic deregulation. The National Energy Admininstration administers the Swedish part.

4 Emissions in the joint Nordic electricity market have increased by up to 8,000 ktonnes carbon dioxide. The environmental impact ought not to be negative in the long term, however.

5 N.C. means not calculated and N.I.U. means not in use at the time.

6 The interval in the effect calculations depends on whether it is assumed that substituted/saved electricity comes from natural gas combination power plants (the lower figure), or coal-fired condensing power plants (the higher figure).

Names and abbreviations used in the fifth column:
RSV = National Tax Board
STEM = National Energy Administration
F-dep = Ministry of Finance
LS = County administrative boards
KOV = Swedish Consumer Agency
DESS = Commission on Energy Supply in South Sweden
BoV = National Board of Housing, Building and Planning
N-Dep = Ministry of Industry and Trade
Sida = Swedish International Development Cooperation Agency
UD = Ministry for Foreign Affairs
M-dep = Ministry of the Environment
NV = Swedish Environmental Protection Agency
Reg. = Swedish government
Kom = Municipalities
SJV = National Board of Agriculture
SKS = National Board of Forestry
NUTEK = Swedish National Board for Industrial and Technical Development
Miljövårdsberedningen = Environmental Advisory Council
Banverket = National Rail Administration

References

Bills
Bostadspolitik för hållbar utveckling. ("Housing policy for sustainable development") Government Bill 1997/98:119. Ministry of the Interior, Stockholm, 1998.

Government Finance Bill 2001, 2000/01:1. Ministry of Finance, Stockholm, 2000.

En god livsmiljö ("A good living environment"). Government Bill 1990/91:90. Ministry of the Environment, Stockholm 1991.

En uthållig energiförsörjning ("A sustainable energy supply"). Government Bill 1996/97:84. Ministry of Industry and Trade, Stockholm, 1997.

Infrastrukturinriktning för framtida transporter ("The focus of infrastructure for future transport"). Government Bill 1996/97:53. Ministry of Transport and Communications, Stockholm, 1996.

Klimat i förändring? Om åtgärder mot klimat påverkan m.m. ("A Changing Climate? Measures to combat climate change") Government Bill 1992/93:179. Ministry of the Environment and Natural Resources, Stockholm, 1993.

Med sikte på hållbar utveckling ("Aiming for Sustainable Development"). Government Bill 1993/94:111. Ministry of the Environment and Natural Resources, Stockholm, 1994.

Government Bill 1985/86:1. Förslag till ny plan- och bygglag ("Proposed new Housing, Building and Planning Act). Riksdagen 1985.

Government Bill 1985/86:3. Förslag till lag om hushållning med naturresurser m.m ("Proposed Conservation of Natural Resources Act"). Swedish Parliament, Stockholm, 1985.

Government Bill 1987/88:85 om miljöpolitiken inför 1990-talet ("Environmental policy in the 1990s"). Fritzes förlag, Stockholm, 1988.

Government Bill 1987/88:90 om energipolitik inför 1990-talet. ("Environmental policy in the 1990s"). Fritzes förlag, Stockholm, 1988.

Government Bill 1994/95:54 Ny lag om skatt på energi, m.m. ("New Energy Tax Act"). Ministry of Finance, Stockholm, 1994.

Government Bill 1996/97:176. Lag om kärnkraftens avveckling ("Nuclear Power Phase-Out Act"). Ministry of Industry and Trade, Stockholm, 1997.

Government Bill 1997/98:45. The Environmental Code. Ministry of the Environment, Stockholm, 1997.

Transportpolitik för en hållbar utveckling ("Transport Policy for Sustainable Development"). Government Bill 1997/98:56. Ministry of Transport and Communications, Stockholm, 1998.

Svenska miljömål ("Swedish Environmental Objectives"). Government Bill 1997/98:145. Ministry of the Environment, Stockholm 1998.
Government Bill 1997/98:158 Uppföljning av skogspolitiken ("Monitoring Achievement of Forest Policy").

Government Bill 1998/99:84. Lag om skatt på avfall ("Waste Tax Act"). Ministry of Finance, Stockholm, 1999.

Government Bill 1999/2000:100. 2000 års ekonomiska vårproposition ("Spring 2000 Finance Bill"). Ministry of Finance, Stockholm, 2001.

Government Bill 1999/2000:105. Vissa punktskattefrågor ("Certain Selective Purchase Tax Issues"). Ministry of Finance, Stockholm 2000.

Government Bill 2000/01:121. Vissa frågor inför den allmänna fastighetstaxeringen år 2003, m.m. ("Certain Issues Concerning the General Property Tax Assessment in 2003"). Ministry of Finance, Stockholm

Government Bill 2000/01:140 Reformerade regler för bostadstillägg till pensionärer m.fl. ("Reform of Regulations Governing Housing Supplement for Pensioners and Others"). Ministry of Health and Social Affairs, 2001.

Government Bill 2000/01:26 Bostadsförsörjningsfrågor m.m ("Housing Supply Issues"). Ministry of Finance, Stockholm, 2000.

Government Communications
Government Communication 1999/2000:114. En miljöorienterad produktpolitik ("An Environmental Product Policy"). Ministry of the Environment, Stockholm, 2000.

Government Communication 1999/2000:13. Hållbara Sverige - uppföljning av åtgärder för en ekologiskt hållbar utveckling ("Sustainable Sweden - determining the effectiveness of measures to achieve ecologically sustainable development"). Ministry of the Environment, 2000.

Government Communication 2000/01:38. Hållbara Sverige - uppföljning av åtgärder för en ekologiskt hållbar utveckling ("Sustainable Sweden - determining the effectiveness of measures to achieve ecologically sustainable development"). Ministry of the Environment, 2001.

Government Communication 1998/99:63 En nationell strategi för avfallshanteringen ("A National Waste Management Strategy"). Ministry of the Environment, Stockholm, 1999
Swedish Government Official Reports

Bilen, miljön och säkerheten ("Motor Cars, Environment and Safety"). Swedish Government Official Report 1997:126, Interim Report by the Swedish Road Traffic Taxation Commission. Fritzes offentliga publikationer, Stockholm, 1997.

Biobränslen för framtiden ("Biomass Fuels for the Future"). Swedish Government Official Report 1992:90 Final Report by the Biomass Fuel Commission. Allmänna förlaget, Stockholm, 1992.

Förslag till svensk klimatstrategi ("Proposed Swedish Climate Strategy"). Swedish Government Official Report 2000:23 Final Report by the Government Commission for Measures Against Climate Change. Fritzes offentliga publikationer . Stockholm, 2000.

Handla för att uppnå klimatmål! ("Emission Trading - A Way of Achieving the Climate Goal"). Swedish Government Official Report 2000:45 Final report by the Commission of Enquiry to examine the feasibility of making use of the flexible mechanisms of the Kyoto Protocol in Sweden. Fritzes offentliga publikationer . Stockholm, 2000.

Likformig och neutral fastighetsbeskattning (Uniform and Neutral Property Taxation"). Swedish Government Official Report 2000:34. Final report by the Property Taxation Commission. Fritzes offentliga publikationer . Stockholm, 2000.

Skatter, miljö och sysselsättning ("Taxes, Environment and Employment"). Swedish Government Official Report 1997: 11 Final Report by the Swedish Green Tax Commission. Fritzes offentliga publikationer, Stockholm, 1997.

Other references

National Rail Administration, Civil Aviation Administration, National Maritime Administration and National Road Administration. Travikverkens gemensamma miljörapport 2000 ("Swedish Transport Authorities' Joint Environmental Report 2000").

National Board of Housing, Building and Planning, God bebyggd miljö. Miljökvalitetsmål 11 ("A Good Urban Environment. Environmental Objective 11") National Board of Housing, Building and Planning report, Karlskrona, 1999.

National Energy Administration, Det kortsiktiga programmet för omställning av energisystemet -i en föränderlig värld ("The near-term programme for adjustment of the energy system in a changing world"). National Energy Administrations rapport ER4:2001, Eskilstuna, 2001.

National Energy Administration, Elmarknadsrapport 2001:1 ("Electricity Market Report"). National Energy Administration. ER8:2001, Eskilstuna, 2001.

National Energy Administration, Klimatpolitik i EU ("Climate Policy in the EU"). National Energy Administration Report EB 6:2001, Eskilstuna, 2001.

National Energy Administration. Energimyndighetens klimatrapport 2001 ("National Energy Administration Climate Report 2001") ER 13:2001. National Energy Administration, Eskilstuna, 2001.

National Energy Administration. Fjärrvärmen på värmemarknaderna ("District Heating in the Heating Markets"), National Energy Administration Report ER 19:2000. Eskilstuna, 2000.

National Energy Administration. Energiläget 2000 ("The Energy Situation in 2000"), National Energy Administration Report ER 19:2000. Eskilstuna, 2000.

EU Commission green paper on greenhouse gas emissions trading within the European Union. 08/03/2000 COM(2000)87. EU-kommisionen, Bryssel, 2000.

Ministry of Finance. Utvärdering av Skatteväxlingskommitténs energiskattemodell ("Evaluation of the Swedish Green Tax Commission Energy Tax Model"). Ds 2000:73. Fritzes offentliga publikationer, Stockholm, 2001.

Federation of Swedish Industries. Klimatboken. Industrins grundsyn på klimatfrågan ("The Climate Book - Industry's basic view of the climate issue"). Stockholm, 1999

Swedish Board of Agriculture, Swedish Environmental Protection Agency, National Heritage Board. Miljöeffekter av EU:s jordbrukspolitik. Rapport från projektet CAP:s miljöeffekter år 2000 ("Environmental Impacts of EU Agricultural Policy"). Report 2000:21. Swedish Board of Agriculture, Jönköping 2000.

Ecocycle Commission. Biomassa - en nyckelresurs ("Biomass - a Key Resource"). Ecocycle Commission Report 1998:20. Ministry of the Environment, Stockholm, 1998.

MEPC 2000. MEPC 45/8 - Study of Greenhouse Gas Emissions from Ships

Environmental Technology Commission 2000:17

Environmental Technology Commission Report 2000:1. IT-baserade lösningar med potential att minska utsläpp av växthusgaser - en översikt ("IT-based solutions with potential for reducing greenhouse gas emissions")

Environmental Technology Commission 2000:2 Svenska produkter som minskar koldioxidutsläpp ("Swedish productions that reduce carbon dioxide emissions")

Swedish Environmental Protection Agency,. Miljöskatter i Sverige ("Swedish environmental taxes"). Swedish Environmental Protection Agency publications. Stockholm, 1997

Swedish Environmental Protection Agency. Deponiskatten -tidiga effekter av ett styrmedel ("Landfill tax - early effects of an instrument"). Report 5151. Swedish Environmental Protection Agency publications. Stockholm, 2001

Swedish Environmental Protection Agency. Rapportering av koldioxid och andra växthusgaser till EU enligt Council Decision 1999/296/EC ("Reporting carbon dioxide and other greenhouse gasese to the EU under Council Decision 1999/296/EC"). Swedish Environmental Protection Agency, 2000

National Audit Office. Subventioners inverkan på en ekolgiskt hållbar utveckling. -tre fallstudier ("The effect of subsidies on ecologically sustainable development - three case studies"). Nationa Audit Office Report 1998:6. Stockholm, 1998.

National Audit Office. Kunden är lös! -konsumenternas agerande på de omreglerade el- och telemarknaderna ("Customer on the Loose! - consumer behaviour in the deregulated electricity and telecommunications markets"). National Audit Office Report 2000:20, Stockholm, 2000.

National Tax Board. Skattestatistisk årsbok 1998 ("Tax Statistics Yearbook 1998"). National Tax Board, Stockholm, 1998.

Statistics Sweden, Miljöskatter och miljöskadliga subventioner, Miljöräkenskaper ("Environmental taxes and environmentally harmful subsidies, Environmental Accounts") Report 2000:3. Statistics Sweden. Örebro, 2000.

National Board of Forestry. Jordbruket och skogsbruket som resurs i klimatarbetet ("Agriculture and forestry as a resource in efforts to combat climate change") (1993). National Board of Forestry journal No. 601/93 SA 10.04

National Board of Forestry. Rekommendationer vid uttag av skogsbränsle och kompensationsgödsling ("Recommendations for abstraction of forestr fuels and compensatory use of fertilisers"). Notice 2-2001, National Board of Forestry. Jönköping, 2001.
National Board of Forestry. Skogliga KonsekvensAnalyser 1999 ("Forest Impact Analyses 1999"). National Board of Forestry. Jönköping, 2000. ISSN 1100-0295.

National Board of Forestry. Skogsbränsle, hot eller möjlighet? - vägledning till miljövänligt skogsbränsleuttag ("Forest fuels, a threat or an opportunity? - A guide to environmentally friendly extraction of forest fuels"). National Board of Forestry. Jönköping, 2001. ISBN 91-88462-48-x.

Steurer, A., Jaegers, T., Todsen, S. Environmental taxes in the EU. Eurostat report Statistics in focus. Economy and finance no 2000:20. Luxemburg, 2000.
Stiftelsen Miljømerking i Norge. Miljømerking av Oljebrennere og oljebrenner/kjel kombinasjon ("Ecolabelling of oil burners and oil/coal combination burners") Kriteriedokument 5. October 2000 - 5. November 2004 Version 4.0. Nordic Eco-labelling. Stiftelsen Miljømerking i Norge, OSLO, 2000

UNFCCC guidelines on reporting and review, UNFCCC/CP/1999/7. UNFCCC Secretariat, Bonn 1999.

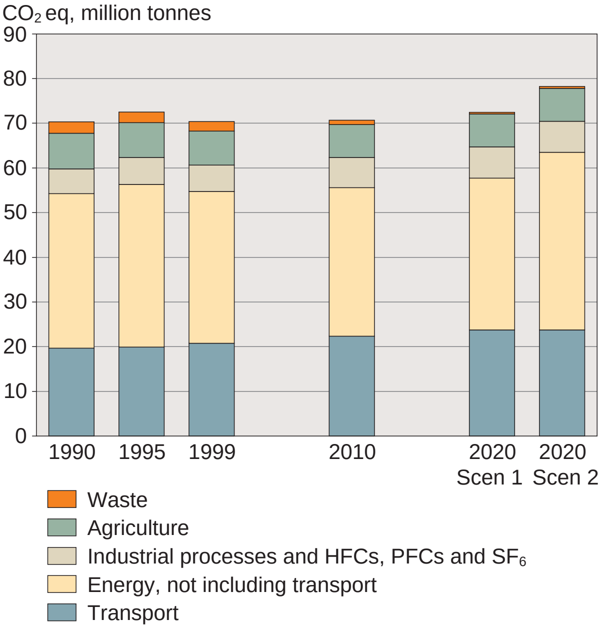
4 Projections and the combined effects of policy and measures

4.1 Projections and scenarios

Three main models have been used for projections and scenarios in the Third National Communication under the Climate Convention:

- Economic-technical models for energy use (National Energy Administration) and energy supply (MARKAL) combined with analytical models for future transport demand (SIKA's passenger and goods transport model).
- Spreadsheet models in which expert assessments are made of future changes in premises (activity data and emission factors). Emissions are quantified using IPCC/UNFCCC methodology.
- Statistical analyses and supplementary expert assessments.

Figure 4.1 Total emissions of greenhouse gases in 1990, 1995 and 1999, and projected emissions of greenhouse gases in 2010 and 2020. Broken down by sector (not including land use, forestry and international transport)



Scenario 1 2020 assumes the possibility of reinvestment in nuclear power

Scenario 2 2020 assumes only a 40-year lifespan for nuclear reactors

Source: Information on emissions of greenhouse gases 1990 – 1999: Swedish Environmental Protection Agency

4.1.1 Total emissions of all greenhouse gases

Total Swedish greenhouse gas emissions, not including land use, forestry and international transport, increased only negligibly between 1990 and 1999 (by less than 0.1 per cent). Normal-year-corrected emissions of greenhouse gases fell by approximately 1.6 per cent during the same period.

Normal-year-corrected emissions are not expected to have risen at all by 2010. Analyses indicate that emissions will remain largely unchanged to 2010. After 2010 greenhouse gas emissions are expected to increase more rapidly. According to the model analyses, a key factor influencing the size of the increase between 2010 and 2020 is the rate at which nuclear power is phased out after the two Barsebäck reactors are shut down. If cost-effective reinvestment in nuclear power is allowed (Scenario 1), it is estimated that total emissions will rise by about 3.0 per cent between 1990 and 2020. If every nuclear power plant is allowed to remain in operation for a maximum of 40 years, the increase in total emissions is expected to be approximately 11 per cent between 1990 and 2020. The relative emissions of greenhouse gases from different sectors will change, as will the relative emissions of the various gases.

Carbon dioxide removal resulting from land use and forestry is heavily depending on the rate of felling. Losses of carbon dioxide from cultivation of organogenic soils remained virtually constant in the 1990s and are not expected to change in the future either. The carbon dioxide sink in forest biomass varied during the 1990s along with the rate of forest felling. It is expected that the forest biomass sink between 2000 and 2010 will be in line with the mean figure between 1998 and 2000 in the analyses presented in this chapter. On this basis, carbon dioxide removals are expected to remain unchanged to 2010. Due to uncertainties as to the future rate of felling, no figures are given for carbon dioxide removals in the forestry and land-use sectors in 2020.

Emissions from international transport increased by around 70 per cent between 1990 and 1999. This trend is expected to continue, but at a slower rate. Emissions are expected to have increased by 115 per cent between 1990 and 2010 and by 155 per cent

Table 4.1
Total emissions and removals 1990 – 1999 and projected emissions and removals of greenhouse gases to 2020, broken down by sector, expressed as ktonnes carbon dioxide equivalent emissions per year

Sector/year	1990	1992	1994	1996	1998	1999	2010	2020 Scen 1	2020 Scen 2
EMISSIONS									
The energy sector	54,268	53,121	57,410	60,909	56,359	54,727	*55,568*	*57,743*	*63,506*
including transport	19,677	19,918	19,464	19,757	20,352	20,759	*22,354*	*23,734*	*23,734*
Industrial processes and fluorinated gases	5,568	5,535	5,685	6,114	5,949	5,958	*6,974*	*7,278*	*7,278*
Agriculture (not inc. land use)	7,991	7,758	7,998	7,819	7,850	7,599	*7,369*	*7,369*	*7,369*
Waste	2,554	2,607	2,406	2,367	2,284	2,147	*966*	*407*	*407*
Total emissions	70,381	69,010	73,499	77,209	72,442	70,431	*70,877*	*72,798*	*78,561*
REMOVALS									
Forestry (not inc. land use)	24,100	27,100	30,100	26,100	28,100	28,100	*28,100*		
Land-use changes and forestry	20,292	23,353	26,305	22,269	24,331	24,305	*24,305*		
OTHER									
Emissions from international air traffic and shipping	3,989	5,053	5,263	5,536	6,958	6,853	*8,600*	*10,200*	*10,200*

Note 1: Discrepancies created by rounding up or down mean that the above figures do not tally exactly with those given in the text.
Note 2: Scenario 1 assumes the possibility of reinvestment in nuclear power; Scenario 2 assumes only a 40-year lifespan for nuclear reactors
Note 3: Carbon dioxide removals are shown with a plus sign in the table.
Note 4: No analyses of CO2 removals in 2020 are presented, owing to the large element of uncertainty.

between 1990 and 2020. All projections are uncertain, however, and dependent on numerous assumptions. The findings should therefore be treated with caution.

4.1.2 Carbon dioxide emissions from the energy sector, including transport

Emissions of carbon dioxide from energy supply and use[1] (the energy sector) currently account for approximately 80 per cent all Swedish greenhouse gas emissions, not including land-use changes and forestry or international transport. Emissions have fallen by about 40 per cent since 1970, mainly owing to a changeover from oil to electric and other forms of energy. Emissions rose by about 1 per cent in the 1990s.

The view of future carbon dioxide emission trends from the energy sector is a "business-as-usual" scenario. Accordingly, the analysis is based on the current energy and environmental policy framework, and it is presumed that other assumptions, such as greater efficiency, will be in line with the historical trend. Assessments of technical developments and possible technological breakthroughs are based on current knowledge of the rate at which various technologies may be developed. The scenarios presented in this study are based on a large number of assumptions, each of which involves a degree of uncertainty. It has been necessary to make a number of simplifications. The results must therefore be treated with caution. A more detailed description of the model and assumptions on which the calculations are based is given in Appendix 4. In connection with this Third National Communication, the National Energy Administration has made an extensive study of scenarios for future carbon dioxide emissions from the energy sector. A more detailed description of the scenarios is given in the Agency's background report.[2]

Scenario calculations based on numerous assumptions

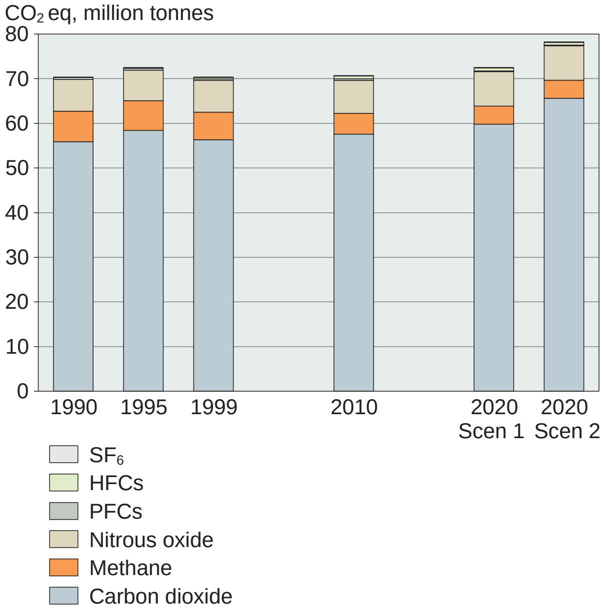
The scenario calculations and future emission levels depend on several factors: the extent of economic growth, fuel prices, the rate and nature of technological developments, and changes in the political framework. A description of some central assumptions in the scenario calculations is given below.

The political framework

The scenario calculations are based on political decisions taken within the framework of current energy, traffic and environmental policy. As a result, the calculations are affected by current energy, traffic

[1] The energy sector includes emissions from combustion at power and district heating plants, as well as industry, combustion for domestic heating and transport.

Figure 4.2
Total emissions of greenhouse gases in 1990, 1995 and 1999, and projected emissions of greenhouse gases in 2010 and 2020. By gas (not including land use, forestry and international transport)



Scenario 1 2020 assumes the possibility of reinvestment in nuclear power
Scenario 2 2020 assumes only a 40-year lifespan for nuclear reactors

Source: Information on emissions of greenhouse gases 1990 – 1999: Swedish Environmental Protection Agency

and carbon dioxide taxes. Current energy and carbon dioxide taxes are shown in Appendix 4c. As regards the transport sector, aside from traffic infrastructure already in operation, the scenario only includes planned but not completed rail and road investments where construction is set to start before 2002.

Under the current energy policy decision, 2010 is no longer seen as the deadline for the phasing out of Swedish nuclear power. Instead, the intention is that this form of energy will be phased out in an economically and environmentally sustainable manner. Legislation providing for the phasing out of nuclear power was enacted in December 1997. That law empowers the government to decide that the right to operate a nuclear reactor is to terminate at a given point. The operating permit for the Barsebäck No. 1 reactor expired on 30 November 1999. The power output of that reactor was 600 MW. Swedish nuclear power will continue to be phased out provided that replacement electricity can be generated and consumption reduced to compensate for the production shortfall. The government thinks it will be possible to

[2] National Energy Administration Climate Report 2001. ER 13:2001
[3] Government communication 2000/01:15

Table 4.2
Total emissions and removals 1990 – 1999 and projected emissions and removals of greenhouse gases to 2010, broken down by greenhouse gas in line with the IPCC classification, ktonnes carbon dioxide equivalent emissions per year (not including emissions from solvents and international travel)

Gas/year	1990	1992	1994	1996	1998	1999	2010	2020 Scen 1	2020 Scen 2
CO_2 emissions	55,883	54,847	59,122	62,890	58,031	56,347	*57,742*	*60,145*	*65,908*
CO_2 removals, land use and forestry	20,292	23,353	26,305	22,269	24,331	24,305	*24,305*		
CH_4	6,811	6,879	6,725	6,630	6,375	6,172	*4,664*	*4,048*	*4,048*
N_2O	7,165	6,785	7,118	7,103	7,335	7,112	*7,410*	*7,714*	*7,714*
PFCs	440	414	390	343	306	329	*336*	*177*	*177*
HFCs	1	4	47	141	303	375	*632*	*636*	*636*
SF_6	81	82	97	103	92	96	*93*	*78*	*78*
Total emissions, not including land use and forestry	70,382	69,011	73,499	77,210	72,442	70,431	*70,877*	*72,798*	*78,561*

The table may contain some errors due to rounding up/down.
Note: No analyses of CO2 removals in 2020 are presented, owing to the large element of uncertainty.

Source: Swedish Environmental Protection Agency

shut down the second Barsebäck reactor by the end of 2003.[3] The scenarios assume shutdown of that reactor before 2005.

Two potential courses the Swedish energy system could take are presented for the period 2010 – 2020. Under the first alternative, nuclear power continues to be generated until the reactors have been in operation for 40 years. This has been a premise on which assessments have been made over the last ten years. The conditions for operation altered when the electricity market was reformed. This means that the nuclear reactors can continue in operation longer than 40 years if profitability can be maintained and operating permits are granted. This is illustrated in the form of a second alternative, in which the reinvestment that would be necessary for continued operation is made. The scenarios studied are:

- Scenario 1: possibility of reinvestment in nuclear power and operation on market terms. Thus, an assessment is made of the reinvestment costs required for continued operation. Electricity prices will only rise slightly in this scenario.

- Scenario 2: the lifespan of existing nuclear reactors is confined to 40 years. This means that reactors (apart from Barsebäck No. 2, which will be shut down before 2005) will begin to be shut down in 2012. A total of six reactors will be shut down during the period.

The Swedish energy policy programme includes measures over a five-year period to stimulate use of renewable energy sources. The support on offer includes investment grants for biomass fuel-based combined power and heating, wind power and small-scale hydropower. Operating subsidies for wind power and small-scale hydropower and tax incentives for wind power are also available. All these subsidies expire at the end of 2002.

It is assumed that a system of trade in certificates for electric energy from renewable sources will replace the present subsidies as from 2003. The scenarios assume that this system represents a subsidy for electricity generated from renewable energy sources of SEK 0.15/kWh. The National Energy Administration considers that this represents a reasonably good approximation of the future system of subsidies.

Political packages of measures that may be introduced as part of a new climate strategy have not been included in the assessments. A political process is currently under way that is expected to result in a coherent Swedish strategy and action programme to control and reduce emissions of carbon dioxide and other greenhouse gases. A parliamentary commission presented a proposed strategy in 2000, and the government is expected to present a bill in autumn 2001.

The electricity market

It is assumed that the common European electricity market will be fully in place. It is further assumed that current energy and environmental policy apply in the Nordic countries, as will current taxes, charges and other regulations. Grid transfer capacity for electric energy from Sweden to other countries in 2020 are assumed to be as at present.

It is assumed that a certain amount of new electricity generation capacity will be built in Sweden.

It is assumed that potential net imports via existing grid connections will decrease up to 2020. There is plentiful electricity generation capacity in the north European electricity (eg, Denmark and Germany) at present. However, since individual countries have reformed their electricity markets, power companies have started to reduce capacity. This has also occurred in Sweden. In addition, the owners of the Swedish nuclear power plants have substantially cut production in recent years. Over a time horizon of almost 20 years, it is reasonable to assume that the north European electricity market will be in equilibrium, ie, that production capacity will be adjusted to meet demand.

Introduction of new technologies

Insufficient information is available on costs and timing of the introduction of potential breakthrough technologies or wide-ranging system changes. Accordingly, it has not been assumed that widespread introduction of new methods of energy conversion will occur in the market.

Some technologies are already fairly well established. These have been included in the energy system scenarios up to 2020. These include certain steam and gas turbine processes, heat pumps and wind power. However, several technologies used for electricity generation, heat production and transport have some

Table 4.3
Forecast economic growth, annual percentage change

	1997–2010	2010–2020
GDP	1.9	1.1
Industrial production	2.3	2.1
Private sector spending	2.4	1.9
Public sector spending	1.2	0.8
Exports	3.5	2.9

Source: National Institute of Economic Research chance of approaching commercial availability in the coming decades. These include microturbines, fuel cells, solar cells, solar heating and various biomass fuel-based technologies. The trend in the transport sector is towards improving flexibility so that different propulsive systems or fuels can be used in the same vehicle during a transitional phase.

Economic growth

Energy use is affected by economic growth. This applies particularly in the industrial and transport sectors. The link is not as pronounced in the housing sector. The following table shows forecasts for GDP, industrial production, consumer spending, public spending and exports.

During the period 1997 – 2010 it is assumed that GDP will rise by an average of 1.9 per cent per year. This rate of growth is in line with Sweden's growth rate in the 1970s and 1980s. It is assumed that the economy will grow more slowly between 2010 and 2020, at an average rate of 1.1 per cent per year. It is thus assumed that the growth in GDP will be considerably lower than the historical rate. This is mainly due to demographic assumptions. The number of people of working age will begin to decline in 2008, and it expected that the number of people in work and mean number of hours worked will decline accordingly. However, the productivity trend is expected to be fairly good, which will bolster GDP growth.[4]

National Institute of Economic Research estimates indicate that the growth in industrial production will average 2.3 per cent a year between 1997 and 2010, and 2.1 per cent a year between 2010 and 2020. This is in line with the 1980s but lower than the growth rate of recent years following the recovery from the recession of the early 1990s. These estimates also show that industry is moving towards a more knowledge-intensive structure. This suggests that less energy-intensive industry is expected to expand more than energy-intensive sectors.

Considerable growth in consumer spending is expected, particularly in the first decade. A comparison with the historical trend shows that the forecast is higher than the growth rate in the 1970s and 1980s, and significantly higher than in the 1990s. On average, consumer spending is growing faster than GDP. Thus, it represents a growing proportion of total consumption.

Table 4.4
Import prices for crude oil, coal, natural gas and the dollar exchange rate in 1997, 1999, 2010, 2020.

	1997	1999	2010	2020
Crude oil, USD per barrel	19.1	18.25	17	22.5
Coal, USD per tonne in harbour	44.1	32.6	42	42
Natural gas, USD per Mbtu	2.3	1.7	2.6	3.5
Exchange rate	7.6	8.27	7.5	8.26

Source: International Energy Agency, European Energy Outlook to 2020

Fuel prices

The assumptions as to import prices for fossil fuels and the dollar exchange rate are shown in the following table. Consumer prices have been calculated on the basis of import prices for unrefined fossil fuels and are given in Appendix 4.

An estimate of the future world market price of crude oil, made by the International Energy Agency (IEA) forms the basis for estimating retail prices for petrol, diesel and heavy and light fuel oils.

In the near term, the oil price is governed by fluctuations in demand and production levels, particularly in the Gulf States. Prices are currently fluctuating widely. However, the forecast prices are average prices for 1997 – 2010 and 2010 – 2020, respectively.

In the longer term, as in the scenarios presented here, prices are governed by more fundamental factors, such as total global supply and demand. The oil price is expected to rise towards the end of the scenario period. According to the IEA, one reason for this is that non-OPEC production will be declining as reserves become exhausted. This will give the OPEC countries a greater share of the market, which is expected to push the price up.

Although production is expected to start falling in some regions, the IEA thinks that overall global oil supply will not be a limiting factor in the coming decades.

The cost of exploratory drilling, as well as pumping and distribution, has fallen sharply in recent years, a trend that is expected to continue. The price of crude oil is therefore expected to have fallen to 17 dollars a barrel by 2010. However, as some oil reserves become exhausted and others are more inaccessible, drilling will become more expensive.

This is expected to be a factor driving prices upwards between 2010 and 2020.

These forecasts involve a large element of uncertainty. It is difficult to ascertain the actual size of oil reserves, and the course of the global economy and total demand for oil are difficult to estimate.

The forecast price of coal is also based on IEA assumptions. Coal prices are expected to remain fairly stable between 1997 and 2020, not to follow oil prices. One reason for this is that the world's main coal producing countries are taking steps to increase coal

[4] National Institute of Economic Research

production. Coal prices fell sharply in the 1980s and 1990s, but are now expected to steady at around USD 42 per tonne, a somewhat higher level than the floor reached in 1999.

There is no definite world market price for natural gas. This is because gas distribution systems are confined to a number of different regions. Northern Europe is one. Import prices for natural gas are based on a price forecast made by the EU: "European Union Energy Outlook to 2020". The price of natural gas is expected to rise slowly between 1997 and 2010. But demand is expected to rise steeply after 2010. This will necessitate import of gas from regions such as Russia and north Africa, which will lead to higher distribution costs and sharply higher prices.

There is insufficient information about costs and the timing of large-scale introduction of liquid natural gas (LNG). Future prospects for this fuel have therefore not been taken into account in the calculations.

Biomass fuel prices have been fairly stable for a long time. It is thought that this will continue. Expected changes in the market situation are that refined biomass fuels will increase their market share because they have greater energy potential than unrefined fuels of this kind. There remains significant unexploited potential for pellet production. Price changes can therefore be expected to be small.

Relatively expensive unrefined wood fuels – whole-tree chips, by-products and recycled wood – will face competition from sorted burnable waste that cannot be landfilled as of 2002. Whole-tree chips already face strong competition from cheaper by-products and recycled wood. No account has been taken of the restrictions on the use of recycled wood etc that may be imposed as a result of the recently adopted EC Waste Incineration Directive.

All in all, this will increase polarisation in the biomass fuels market, where the refined wood fuels and the cheapest range of unrefined fuels will gain ground at the expense of the most expensive unrefined biomass fuels.

The price of district heating varies from one place to another owing to differing production conditions. The average price of district heating is expected to remain unchanged up to 2020 because biomass fuel prices, which account for a large proportion of district heating, are also expected to remain static.

Future electricity prices

The Swedish electricity market has undergone far-reaching changes in recent years, both in terms of structure and of organisation. This is because the market has been reformed and opened up to competition. These changes have made it more difficult to predict electricity price trends. Moreover, the Swedish electricity market is influenced by developments in neighbouring electricity markets in the Nordic region and elsewhere around the Baltic, ie, in Germany, Poland, the Baltic States and in north-western Russia. Changes are also continuously occurring in these countries. A further factor affecting the Swedish electricity market is the EC directive on a single electricity market.[5]

When assessing the future electricity market it is assumed that competition at the production and sale stages will intensify. Some of Sweden's neighbours (such as Germany and Denmark) currently have considerable overcapacity in their power generation systems.

The electricity markets in these countries have been reformed, and the EC directive on a single electricity market suggests that there will be a European electricity market where competition prevails. Market mechanisms cause actors in the market to reduce their overcapacity in various ways. In twenty years' time the electricity market is expected to be in a state of equilibrium, which means that current levels of overcapacity will be a thing of the past.

It is difficult to say how additional energy requirements will be met since the north European electricity markets will become increasingly integrated. The integrated market provides new scope for greater use of existing electricity generating capacity and development of new power supplies.

In an efficient electricity market, the electricity price will be determined by the marginal cost of production. This varies over the year and from year to year, depending on supply, demand and the structure of the system.

The short-term marginal cost of electrical energy at any given time is determined by the variable cost of the most expensive type of power in use at the time, as well as a "scarcity cost component" reflecting the supply capacity of the production system. The short-term marginal cost varies over the year. In the Nordic electricity market, it is currently determined by the variable cost of coal-fired condensing power in Denmark during the peak demand season.

The long-term marginal cost is determined by the total production cost, ie, both fixed and variable costs. In the future, when increased electricity consumption renders it necessary to make more use of more expensive existing forms of energy, the short-term marginal cost will rise. When this cost reaches the same level as the long-term marginal cost, it will become cost-effective to develop new electricity production capacity.

The long-term marginal cost will vary, depending on

[5] EU 3638/1/96: "European Parliament and Council Directive 96/92/EC on common regulations for the single electricity market"

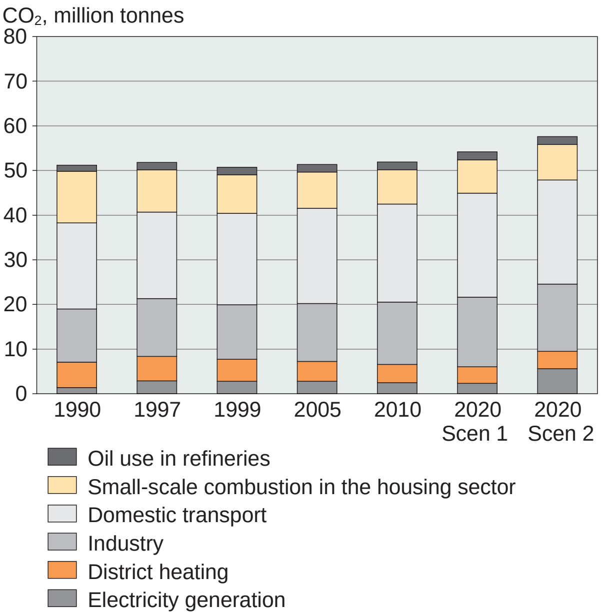
[6] The production cost varies depending on the assumptions made as to conversion efficiency and operating time.

the form assumed by the future electricity production system. In Scenario 2, where existing nuclear reactors are assumed to have a lifespan of 40 years, the new natural gas combination power is at the margin and will therefore determine the marginal cost. This cost has been estimated at SEK 0.30 – 0.35/kWh[6] for a natural-gas fired combination condensing power plant. This cost calculation assumes that natural gas prices will have risen by 2020. In Scenario 1, where it is assumed that the working life of existing nuclear power plants will be extended by reinvestment, electricity production from renewable energy sources and, at times, nuclear power plants, represents the marginal cost. The cost of generating electricity from renewable energy sources includes a subsidy of SEK 0.15/kWh.

Import of electrical energy is restricted in the scenarios. Hence, the price of imported electricity does not have much impact on the system price in Sweden. It is assumed that the north European market will be in equilibrium in 2020.

The system price for electric power in 2020 has been set on the basis of this rationale. The price represents a mean figure derived from the total cost for the electricity generation technologies at the margin during the year. A system price of SEK 0.30/kWh is assumed in the scenario assuming a 40-year lifespan for nuclear power. The system price has been set at SEK 0.23/kWh in the scenario assuming reinvestment in nuclear power. These prices are higher than those prevailing in the period 1997 – 2001.

Figure 4.3 National carbon dioxide emissions from energy supply and use, not including international shipping and air traffic



Scenario 1 assumes the possibility of reinvestment in nuclear power

Scenario 2 assumes only a 40-year lifespan for nuclear reactors

Source: National Energy Administration

Emissions of carbon dioxide from the energy sector and the various sub-sectors

Carbon dioxide emissions from the energy sector are expected to have risen by 2020, to varying degrees, depending on the assumptions made about Swedish nuclear power. Emissions are expected to remain largely the same up to 2010. Emissions under the alternative scenarios have been estimated for the later period (2010 – 2020).

Changes in the energy sector are described for five sub-sectors (not including fuel refineries). Energy is used in the industrial sector, housing and service sector and transport sector. In addition to these "user" sectors, the district heating and electricity generation sectors are described. The housing and service sector includes energy use in the land (and water) use sector (agriculture, forestry and fisheries), and energy use in the construction sector, street and road lighting, waste water and sewage treatment plants. Emission figures do not include international transport under the transport sector. These are presented separately.

Carbon dioxide emission trends differ from one sub-sector to another. Emissions are rising in the transport and industrial sectors but falling from the district heating sector and from energy use in the housing sector. Emissions from energy generation fall somewhat in the scenario assuming continued operation of nuclear power plants. In the scenario where nuclear power is phased out after 40 years, these emissions are expected to double.

Increasing industrial emissions

Industrial emissions of carbon dioxide are expected to have risen by about 20 per cent (ie, by 2.7 million tonnes) by 2020, from the base year 1997. In Scenario 2, where a phase-out of nuclear power begins after 40 years, the rise in emissions is expected to be somewhat lower. This is because some of the most energy-intensive industries and companies are expected to cease production or move it abroad. This means that electricity consumption in particular will fall, although the use of fossil fuels and district heating will also decline somewhat.

In the near term, production volumes determine industrial energy use, particularly in the energy-intensive industries. In the longer term, total industrial energy consumption is influenced by a number of factors, such as technological developments, energy prices and structural changes. The scenario estimates assume average industrial growth of 2.3 per cent a year between 1997 and 2010, and 2.1 per cent between 2010 and 2020. This is in line with the 1980s but lower than the growth rate of recent years following the recovery from the recession of the early 1990s. Growth in individual sectors will involve further structural changes. The energy-intensive industries' share of total industrial production is expected to decline over the scenario period. It is assumed that rationalisation will take place when investments are made in new production capacity and that there will also be ongoing rationalisation in conjunction with reinvestment and improvement of existing production facilities.

Structural changes and greater energy efficiency will mean that industrial energy use will increase more slowly than production. Industrial production is expected to increase by 65 per cent over the whole scenario period, during which energy consumption is expected to rise by about 20 per cent.

The importance of different forms of energy varies from industry to industry. Coal and coke are used by the iron and steel industry in particular, and these fuels represent over half of that industry's energy use. Biomass fuels play an important part in the timber, pulp and paper industries; oil is used in most sectors. Electric energy is also widely used in all industries and predominates in metal production, chemicals, engineering and mining. The pulp and paper industry uses more energy than any other industry, both in absolute terms and in relation to the value its produces.

The scenario calculations are based on increased use of all forms of energy. The use of biomass fuels in the pulp and paper industry is expected to increase at the expense of oil.

This trend slows somewhat, particularly in the latter part of the scenario period. This is because it is cost-effective for the forest products industry to sell biomass fuel (residual fuel) to other sectors. The incentive for this exists in that manufacturing industry pays 35 per cent of the standard carbon dioxide tax. Use of oil in industry will therefore become relatively cheaper than in other sectors, except for the electricity generation industry.

Electricity consumption is expected to have risen by just under 9 TWh by 2020 in Scenario 1 (reinvestment in nuclear power), where electricity prices are largely unchanged, and by just under 6 TWh in Scenario 2 (40-year lifespan for nuclear reactors), where prices will rise as the phase-out of nuclear power begins. The

[7] These calculations were made as part of work done for the Government Commission for Measures Against Climate Change. For a more detailed description, see the book Energi och Klimat i Sverige - Scenarier 2010 ("Energy and Climate in Sweden – Scenarios 2010"), National Energy Administration, 4:2000.

Table 4.5
Carbon dioxide emissions by sector, 1990, 1997 and 1999, and in scenarios up to 2020 (million tonnes) (See also Appendix 4)

	1997 Base year	2005	2010	2020(1)	2020(2)	1997–2010 %	2010–2020(1) %	2010–2020(2) %
Electricity generation	2.9	2.8	2.5	2.3	5.6	-14	-5	126
District heating	5.5	4.9	4.1	3.7	3.9	-25	-10	-5
Industry	12.9	12.2	14.0	15.6	15.1	8	12	8
Transport, not including international shipping and air traffic	19.4	20.5	22.0	23.3	23.3	13	6	6
Housing, service etc	9.5	8.6	7.7	7.5	8.0	-19	-3	3
Fuel refineries	1.7	1.7	1.7	1.8	1.8	4	3	3
Total	51.8	50.7	51.9	54.2	57.6	0.2	4.4	11
Total according to Statistics Sweden[1]	52.1	51.7						
International shipping	4.3	4.8	5.6	6.6	6.6			
International air traffic	1.9	2.2	3.0	3.6	3.6			

1 Not including fugitive emissions
Scenario 1 assumes the possibility of reinvestment in nuclear power
Scenario 2 assumes only a 40-year lifespan for nuclear reactors

Note 1: National Energy Administration estimates of carbon dioxide emissions in 1997 differ somewhat from joint estimates made by the environmental statistics department at Statistics Sweden and the Swedish EPA. This is partly due to the method of breaking down fuel use between various sectors, and also the use of different statistical sources (the statistics are updated from preliminary to final).

Note 2: The total figure is not always an exact sum of the sector figures. This is because the latter have been rounded up or down.

Source: National Energy Administration

increase in electricity consumption will mainly occur in electricity-intensive industries such as pulp and paper, iron and steel and other metal processing and manufacture.

Energy use and emissions of carbon dioxide from the industrial sector will depend on the extent of growth in various industries. A margin of uncertainty has been used when estimating industrial growth. A minimum figure of 1.7 per cent a year and a maximum of 3.0 per cent a year have been used.[7] The difference in energy consumption between the two extremes is 18 TWh, and the difference in electricity consumption is 8 TWh. Carbon dioxide emissions are expected to fall by about half a million tonnes at 1.7 per cent growth, and rise by the same amount if annual growth is 3.0 per cent. This may be compared with estimated total emissions from the industrial sector in 2010 (14 million tonnes carbon dioxide).

When the Government Commission on Measures Against Climate Change (the Climate Commission) formulated a new proposed climate strategy in spring 2000, a number of estimates were made of the effects higher carbon dioxide taxes would have on industrial energy consumption and carbon dioxide emissions.[8] Its calculations show that the impact of raised carbon dioxide taxes depends on whether the present reduced tax rates for industry are retained after the tax rises. The reduced rates take the form of the "0.8 per cent" and "1.2 per cent rule". The 1.2 per cent rule will cease to apply on 31 December 2002. The effect of the 0.8 per cent rule (which applies to certain industrial sectors (see Chapter 3.2) is that when the carbon dioxide tax paid by a company reaches 0.8 per cent of its gross sales, the company pays a sharply reduced rate of tax thereafter. If this rule remains in place, the estimates indicate that carbon dioxide emissions will only fall marginally, notwithstanding much higher carbon dioxide taxes. The impact of the carbon dioxide tax on corporate behaviour wanes when companies begin to receive tax rebates.

Changes in the relative use of energy forms in the housing sector (housing, services etc)

Emissions from housing and services etc are expected to fall by 20 per cent between 1997 (the base year) and 2020. This represents 2 million tonnes of carbon dioxide. In the scenario where electricity prices rise because of the phase-out of nuclear power (Scenario 2), emissions will still decrease, but more slowly: by approximately 15 per cent.

Almost 90 per cent of the energy consumed in the housing and service sector is used in, homes and commercial/industrial premises. Energy is used to heat indoor areas and water and to operate machinery. Other use occurs in the land-use sectors, in holiday homes and in other services, including the construction sector and street and road lighting. Since much of the energy consumed in the sector is used for heating, prevailing outdoor temperatures have an enormous impact on consumption. "Normal-year correction" has been used to achieve a more valid comparison between the years.

Estimates of energy use in the housing and service sector are based, among other things, on assumptions about the total quantity of housing and commercial/industrial premises, energy prices, investment costs, technological developments, consumer spending and public spending. Account has also been taken of the time lapse during which consumers and companies adjust to new conditions.

The total heated indoor area is of great significance to energy use in the housing and service sector. Construction of new buildings and extensions to existing ones change the total heating area in the sector and hence also heating requirements. More household electricity and electric power for machinery is also needed as indoor space increases.

Total energy consumption in the housing and service sector is expected to increase by approximately 5 TWh between 1997 (the base year) and 2020. However, consumption is expected to increase more slowly between 1997 and 2010 than in the latter part of the scenario period. Increased energy consumption is principally ascribed to a higher rate of construction and increased use of electric power to operate appliances.

A marked change in the breakdown between various forms of energy is expected. This will impact carbon dioxide emissions. Electricity and district heating are expected to be used much more up to 2010, whereas oil consumption is expected to decline. The increase in electricity and district heating use is expected to continue up to 2020, albeit at a slower pace; oil consumption is expected to continue falling, but more slowly. Wood fuel use is expected to increase in the latter part of the scenario period, particularly the use of pellets.

This is mainly because this is expected to be financially advantageous, and because user attitudes are expected to become more positive.

Heat pump use is expected to increase during the scenario period. 6.5 TWh of heat was produced by heat pumps in 1997. Heat production from this source is expected to have risen to 10 TWh by 2020. Heat pumps are virtually always electric and generate 2 – 3 times more thermal energy than the electric power they consume. The thermal energy generated by heat

[8] Energi och Klimat i Sverige – Scenarier 2010 ("Energy and Climate in Sweden – Scenarios 2010"), National Energy Administration, 4:2000.

pumps is not included in the figures for total energy use in the sector. The energy used for heat pump operation is included, however.

In Scenario 2, where nuclear phase-out begins after 40 years of operation, it is expected that a higher electricity price will reduce electric heating and increase oil consumption, as compared with Scenario 1. The price of electric heating will rise by about 10 per cent, including taxes.

Energy consumption in the housing sector and resulting carbon dioxide emissions will depend on the assumptions made. A margin of uncertainty has been calculated, showing the difference in energy consumption between "low case" and "high case"[9]. The calculation produces a difference of 14 TWh between the two cases. The assumptions that vary are increase/ decrease in the size of heated areas, the assumption as to improved conversion efficiency and the rise/fall in specific net consumption for heating, household electricity and operating power.[10] In the "high case", it is thought that the main increase will be in the use of district heating and electricity. Carbon dioxide emissions from small-scale combustion in the housing sector are therefore expected to rise by only 0.3 million tonnes.

These are also the forms of energy that will mainly be affected in the "low case". Carbon dioxide emissions from small-scale combustion are expected to fall by 0.3 million tonnes.

As the carbon dioxide tax has been raised, there has been a relatively substantial fall in emissions from the housing sector (small-scale heating). This is mainly because the oil used for heating is being replaced by other forms of energy. Use of biomass fuels and district heating is expected to continue to rise dramatically. Some of the emissions will therefore be transferred to the district heating sector. In the housing and service sector, the length of time a tax has been in place has a bearing on its impact on energy consumption. The main effect of raising carbon dioxide tax occurs when an heating system needs replacing, since this is a costly step, which is rarely taken before the system is worn out, almost irrespective of the fuel price. A higher tax rate may encourage conversion to an alternative type of heating arises when an existing system is replaced.

Emissions from the transport sector continue to rise

Carbon dioxide emissions from the transport sector are expected to increase by 20 per cent by 2020. This represents a rise of 3.9 million tonnes of carbon dioxide, compared with 1997. These estimate do not include emissions from international shipping and air traffic.

Emissions from international transport are expected to have increased by over 60 per cent by 2020, ie, by 4 million tonnes carbon dioxide, of which bunker fuels for internationalshipping make up half, ie, approximately 2 million tonnes. However, these figures are uncertain, since fuel use varies depending on the relative prices charged by ports in different countries.

Emissions of carbon dioxide from the transport sector are influenced by journey length, the mode of transport and fuel used and by efficiency of energy use. In the latter part of the scenario period (2010 – 2020), the rise in emissions is expected to slow as GDP growth is more modest as compared with the period up to 2010. The transport sector is currently almost solely reliant on fossil fuels. Use of alternative fuels, such as ethanol, methanol, rape methyl ether (RME), biogas and natural gas, is currently only negligible in relation to total fuel use. On the basis of instruments currently in use, it is expected that fossil fuels will also predominate in 2020.

But alternative fuels may be used more widely in certain limited areas, such as public transport in urban areas, for example.

The estimates of future energy use in the transport sector are based on existing political decisions. Accordingly, it is assumed that current energy and environmental taxes will apply throughout the scenario period, and, aside from traffic infrastructure already in operation, the scenario only includes planned but not completed rail and road investments where construction is set to start before 2002.

Passenger transport

Travel increased steadily in the latter half of the 20th century. The greatest growth sector is car travel. The scenario up to 2010 indicates a further increase of 26 per cent in the total passenger transport distance compared with the base year (1997), and an additional increase of 11 per cent by 2020. The motor car is by far the main mode of transport in Sweden today, accounting for more than three quarters of the total passenger transport distance.[11] The scenario up to 2020 suggests that the greatest increase in passenger transport, in absolute as well as relative terms, will be by motor car. Air travel is also expected to increase substantially up to 2020, even more, in fact, than car travel between 2010 and 2020. The demand for air travel is closely correlated to economic growth and it is assumed that continued growth in consumer

[9] These calculations were made as part of work done for the Government Commission for Measures Against Climate Change. For a more detailed description, see the book Energi och Klimat i Sverige – Scenarier 2010 ("Energy and Climate in Sweden - Scenarios 2010"), National Energy Administration, 4:2000.

[10] "Specific net use" refers to use per square metre of floor area for heating and operating commercial/industrial premises. "Household electricity" refers to electricity consumption per household.

[11] Number of person journeys multiplied by their length

purchasing power will fuel further rapid growth in air travel. Rail traffic is expected to increase almost as much as road traffic up to 2010, but much more slowly between 2010 and 2020. This is largely due to the assumption that the scenario does not include new investment in infrastructure additional to that commenced in 2001, and that rail traffic is kept at 2010 levels.

Growth in passenger transport is closely linked to economic growth. Of particular importance are the assumptions as to growth in disposable earnings, employment levels, population size and structure, and the cost of various forms of transport. The number of cars per 1,000 inhabitants is expected to have risen by 22 per cent between 1997 and 2010, and by a further 11 per cent by 2020. This will impact on the projection in the form of a further dramatic rise in car traffic. The estimated average cost per kilometre of driving a car is expected to have fallen by about 14 per cent by 2010. This assumes that average car fuel consumption will fall as a consequence of compliance with the ACEA agreement.[12] It has been assumed that the cost per kilometre will remain unchanged after 2010.

However, new technologies, such as flexible fuel and fuel cell technologies, which may be developed during the period, are not expected to have any commercial impact on the market. It is assumed that petrol prices will remain unchanged throughout the period. It is assumed that the cost of travelling by train and bus will remain the same at today's prices up to 2010, but that air travel will become somewhat more expensive. The number of domestic departures by aircraft and train is expected to have risen by 2010. The number of bus departures is expected to remain the same.

Goods transport

Goods transport increased more or less in line with the growth in GDP in the 1950s and 1960s. Growth in recent decades has been lower, but the rate of increase remains significant. No form of goods transport dominates the way that the motor car dominates passenger transport. Goods transport methods compete and complement one another.

Most movements of goods from sender to recipient require a combination of several kinds of goods transport. Road freight accounted for just over 40 per cent of all goods transport (measured in tonne kilometres) in 1997. Rail freight had a share of 20 per cent and shipping 35 per cent. In terms of weight, air freight has a negligible share of the market, but this sector is more important in value terms.

In the scenarios, total goods transport is expected to increase by 25 per cent by 2010, and by a further 18 per cent by 2020. The total distance/weight of goods transported is primarily influenced by economic growth. Assumptions about GDP, industrial production and employment are highly significant. The rate of growth of goods transport depends on growth in the physical volume of goods transported, as well as the value of goods per unit weight. An ever increasing proportion of the increasing quantity of goods transported is moved by road. Road freight's market share is expected to have risen to 46 per cent by 2010 and to nearly 50 per cent by 2020. The
relatively large increase in road freight's share of all goods transport largely follows from the fact that the industries whose goods are usually carried by road, ie, refined and processed products, are expected to experience above average growth. Since infrastructure measures that have already been decided will significantly improve conditions for terrestrial means of transport, these are expected to grow more than freight carried by sea, relatively speaking.

It is assumed that truck fuel consumption will improve in line with the historical trend, although total overheads for goods transport are expected to remain unchanged, on average. The cost savings generated by greater fuel efficiency are expected to be counterbalanced by other cost increases. As for the railways, specific investments in rail freight capacity are expected to reduce delays.

Since goods transport is expected to increase and road freight's share of that transport is expected to grow, diesel consumption is expected to increase fairly considerably during the scenario period. Consumption is particularly expected to increase in the years up to 2010.

This is due to a relatively substantial increase in the number of diesel-driven motor cars, and a dramatic increase in the proportion of diesel-driven light commercial vehicles.

Consumption of aviation fuel is also expected to rise sharply. Petrol consumption is not expected to increase as much. This is partly because the number of diesel-driven motor cars is expected to rise and partly because automobile fuel efficiency is expected to improve at a fairly rapid rate.

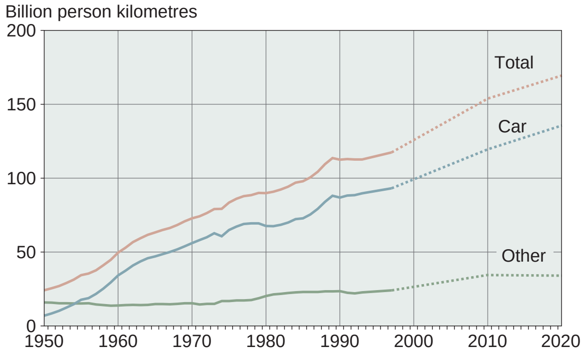
A number of sensitivity analyses have been made to determine how sensitive the scenario results are

[12] The voluntary agreement entered into between the EU Commission and the European Automobile Manufacturers Association (ACEA) to reduce carbon dioxide emissions from new automobiles by 25 per cent by 2008 compared with 1995. EU Commission Recommendation 1999/125/EC

[13] These calculations were made as part of work done for the Government Commission for Measures Against Climate Change. For a more detailed description, see the book Energi och Klimat i Sverige – Scenarier 2010 ("Energy and Climate in Sweden – Scenarios 2010"), National Energy Administration, 4:2000.

[14] ACEA - the European Automobile Manufacturers Association. The ACEA agreement is a voluntary agreement entered into between the EU Commission and the automobile industry in Europe, Japan and Korea to reduce carbon dioxide emissions from new automobiles by 25 per cent by 2008 compared with 1995.

Figure 4.4
Growth in total passenger transport distance between 1950 and 1997, with projection for 2020, person kilometres, billions.



Source: SIKA

to changes in the premises forming the basis for the estimates.[13] Calculations have been made for a "high" and "low" annual rate of growth in consumer spending.

Similarly, calculations have been made for a "high" and "low" annual rate of growth in industrial production. The effect on energy consumption of anticipated compliance with the ACEA agreement is also examined.[14]

The ACEA agreement assumes considerable significance in the calculations. The annual rate of improvement in efficiency is estimated to average 0.75 per cent up to 2020, compared with 0.2 per cent a year without the agreement. This represents about 2 million tonnes of carbon dioxide emissions during the scenario period. The assessment of the rate of efficiency improvement without the ACEA agreement is based on the historical trend.

Improvements in fuel efficiency in the 1980s and 1990s have largely been negated by more powerful engines, larger and heavier vehicles and more optional extras, such as air conditioning.

The calculations made earlier for the Climate Commission with regard to various levels of tax on fossil fuels show the sensitivity of petrol and diesel consumption to price changes.

A tax increase of SEK 0.6 per kg carbon dioxide is estimated to reduce petrol and diesel consumption by 2 and 1 per cent, respectively, compared with the equivalent scenario calculation in which carbon dioxide tax was SEK 0.37 per kg[15]. This tax rise represents an 11 per cent rise in the petrol price and a 10 per cent rise in the diesel price of SEK 0.10 compared with 1997 prices. A tax rise of SEK 1.44 per kg carbon dioxide represents a 39 per cent rise in the petrol price and 53 per cent rise in the diesel price compared with 1997 prices. These rises are expected to reduce petrol

[15] The carbon dioxide tax was raised by 1 January 2001 and is now SEK 0.53 per kilogram carbon dioxide.

Table 4.6
Total traffic and transport distances for passenger and goods transport up to 2020

Traffic and transport distance	1990	1997 Base year	1999	2010	2020	Increase 1997–2010	Increase 2010–2020
Total traffic (vehicle kilometres, billions)							
Automobile	61.4	65.8	68.4	87.3	99.5	33 %	14 %
Bus	1.0	1.2	1.2	1.3	1.2	8 %	-5 %
Truck	1.8	2.3	2.3	3.2	4.2	41 %	28 %
Light commercial vehicle	5.3	5.0	5.7	7.0	9.0	41 %	28 %
Total passenger transport (person kilometres, billions)							
Automobile	86.9	93.1	96.9	119.7	135.6	29 %	13 %
Bus	12.4	13.9	14.6	15.0	14.3	8 %	-5 %
Rail	6.5	6.9	7.6	8.7	8.9	26 %	2 %
Domestic air traffic	5.2	3.8	4.3	4.7	5.5	24 %	18 %
Total goods transport (tonne kilometres, billions)							
Truck	27.5	34.4	34.0	47.4	54.0	38 %	26 %
Rail	18.4	18.4	18.2	20.3	21.1	10 %	7 %
Sea	25.6	29.0	27.9	34.8	37.5	20 %	14 %

Source: SIKA

Table 4.7
Sensitivity analyses for petrol and diesel use

Assumption (Main scenario assumption in brackets)	Deviation (%) from main scenario[1]
Petrol use	
Private consumption (2.4% per year)	
2.8% per year	3.3
2.0% per year	-3.0
Improved fuel efficiency, including the ASEA Agreement (-13%)	
- not including the ASEA Agreement (-3%)	11.3
Diesel use	
Growth in industrial production (2.3% per year)	
3.0% per year	6.5
1.7% per year	-5.1

1 Refers to energy use

Source: National Energy Administration

consumption by 11 per cent and diesel consumption by 12 per cent.

Petrol and diesel consumption have hitherto been fairly insensitive to price changes. In other words, consumption has continued to rise rapidly despite rising prices. The calculations use price elasticities reflecting the historical situation. However, it may be that prices are now so high that price rises are beginning to have a greater effect, particularly on fuel consumption for private car use.

Sharp increase in use of biomass fuels for district heating production

Carbon dioxide emissions from the district heating sector are set to fall by approximately 30 per cent (1.8 million tonnes) between 1997 and 2020, even though district heating production is expected to increase. Total energy consumption is expected to increase by nearly 20 per cent between 1997 and 2020. The largest increase will occur in the first part of the period, when consumption in the housing sector will rise by just over 5 TWh. The reason that emissions will nonetheless fall is that there will be a considerable increase in the use of biomass fuels for district heating production. By 2020, use of biomass fuels is expected to represent a supply of approximately 40 TWh, which is just over 85 per cent of total fuel supply. Relative fuel prices will make it cost-effective to use biomass fuels. In particular, relative prices will be affected by energy and carbon dioxide taxes. Biomass fuels are not taxed, whereas fairly heavy levies are imposed on fossil fuels. In addition, the price of biomass fuels is expected to remain constant, whereas fossil fuel prices are expected to rise somewhat.

Apart from further substitution of fuels at existing plants, more biomass-fuel powered combined power and heating plants are expected to be built when old hot water distribution stations are decommissioned.

Heat supply from electric boilers is expected to decline. Electricity price levels will make it unprofitable to invest in new electric boilers. To some extent, it is also expected that electric boilers will be shut down prematurely because the production cost will be too high.

The large heat pumps currently in use will have become fairly old and will require reinvestment to extend their lives, or they will have to be replaced by fresh capacity. Higher electricity prices will influence heat pump profitability. The scenarios assume that some new plants will be built and reinvestment will take place. Nonetheless, district heating supplied using heat pumps will decrease. This will particularly apply in Scenario 2, where electricity prices are assumed to rise more.

Emissions of carbon dioxide from the energy generation sector

Carbon dioxide emissions from energy generation will have decreased somewhat by 2010.

This also applies up to 2020 in Scenario 1, which assumes reinvestment in nuclear power.

In Scenario 2, where nuclear power is phased out after 40 years, these emissions are expected to double, compared with the base year (1997).

Electricity generation capacity at nuclear power plants will fall by about 4 TWh by 2005 owing to the closure of the second Barsebäck reactor. The other reactors will remain operational during the period to 2010. Assuming a lifespan of 40 years, the first reactor will then be shut down in 2012.

Potential net import of electric energy in a normal year has been limited in the scenarios.

As is the case today, it is assumed that the electricity market will have a "system-regulating" function. Some of the surplus grid capacity must be available to counterbalance temporary surpluses and shortages in the systems. The quantities of electricity bought and sold will vary over the year and between years, depending on factors such as temperature, precipitation and fluctuations in the economic climate. In the long run, current production capacity is expected to fall in the deregulated electricity market. As a result, electricity generation capacity in neighbouring countries is expected to fall. Ultimately, this will limit Sweden's ability to import electricity. It is assumed that fresh production capacity will be created where there is a demand.

It will be possible to control carbon dioxide emissions even though electricity consumption is expected to increase because electricity generated from renewable sources is expected to become increasingly cost-effective. Biomass-fuel powered combined power heating production and wind power are expected to benefit from the system of subsidies available for energy from renewable sources. This is expected to reduce costs. The calculation assumes a subsidy of SEK 0.15/kWh. Imported electricity is also expected to help meet additional demand for power. Net import of electricity is expected to be about 4 TWh in 2010 and 2020. The system of subsidies is also expected make it cost-effective to rationalise existing hydropower capacity and to build small-scale hydropower stations. Overall, this is expected to increase hydropower production capacity by just over 3 TWh during a normal year.

Combustion-based electricity generation is expected to increase, particularly at combined power and heating plants. The greatest increase is expected to be at plants of this kind connected to the district heating network, although industry is also expected to generate more electricity. Greater use of district heating will increase the scope for combined power and heating production in the district heating network, while subsidies for electricity generated from renewable energy sources are expected to make it cost-effective to invest in biomass-fuel-based combined power and heating plants instead of heating plants. The expected rise in industrial production is expected to provide greater scope for producing electric energy. Some of this may also be ascribed to the subsidy of SEK 0.15/kWh for electricity produced from renewable energy sources, which is expected to make it cost-effective to produce electricity using biomass fuels. The use of these fuels to generate electricity is expected to increase fairly rapidly. In 1997 fossil fuels (ie, oil, coal and natural gas) made up just over 70 per cent of all fuels used for electricity generation, and biomass fuels accounted for 28 per cent. Biomass fuel use is expected to have risen to 46 per cent by 2010 and to about 65 per cent by 2020.

Wind power generation is expected to have increased to approximately 4 TWh by 2020 in the scenario involving reinvestments in nuclear power (scenario 1), and to just over 10 TWh the same year in the scenario when the nuclear reactors are phased out after 40 years (scenario 2). Terrestrial wind power is now a well-established technology and falling costs, anticipated rising revenues and a system of subsidies are expected to stimulate its expansion. Marine wind power is more expensive at present because its installation is more complicated. Consequently, real expansion of this form of wind power will take time. The technology will not be competitive unless electricity prices are high, and for this reason only in Scenario 2 is marine wind power expected to have expanded substantially by 2020.

The demand for fresh production capacity in Scenario 1, where nuclear power is phased out after 40 years is also expected to be met by increased generation of electricity at natural gas-fired combination condensing power plants. Carbon dioxide emissions from electricity generation are therefore expected to increase sharply in this scenario.

The quantity of natural gas-based electricity generation is partly dependent on the natural gas price assumed for calculation purposes. The scenario calculations assume that gas prices will rise fairly steeply between 2010 and 2020. If they are lower, marine wind power will not enter the arena according to the calculations; more natural-gas based production is expected to be created instead.

Subsidies for electricity generation from renewable energy sources

Electricity generation from renewable energy sources increases in the scenarios. This is affected by the subsidy of SEK 0.15/kWh included in the calculations. The subsidy covers biomass fuel-based electricity generation, wind power and investments and development of hydropower, and approximates the situation under the forthcoming system of trade in certificates from renewable energy sources.

A government committee has been set up to design a system of trade in certificates from renewable energy sources. The price of the certificates, ie, the subsidy paid for electricity from renewable energy sources, will depend on the proportion of all energy use it is required should come from renewable sources. Moreover, the price will vary over both the short and the long term. However, it is too complicated to take account in the scenario calculations of short and long-term price changes. It has been assumed that the figure of SEK 0.15/kWh will apply throughout the scenario period.

Sensitivity analyses show that a higher subsidy than that assumed in the calculations would not affect the scenario outcome to any great extent. This is because sizeable amounts of electricity from renewable sources are expected to enter the system even at a subsidy level of SEK 0.15/kWh. Even if the subsidy is expected to be raised, there are factors limiting the potential amount of electricity from these sources. For example, wind power expansion is limited by the carrying capacity of the grid and would also require adaptation to cope with more rapidly regulated production capacity. Electricity generation at biomass fuel-based combined power and heating plants is limited by the heat demand, and small-scale hydropower is limited by planning restrictions.

A lower subsidy would primarily affect marine wind power, since this costs more than the other options. Marine wind power enters the scenario when electricity prices rise (Scenario 2). Sensitivity analyses have been performed using the MARKAL model[16] to test how a lower subsidy might affect the scenario results. The calculation shows that a reduction in the subsidy level from SEK 0.15/kWh to SEK 0.10/kWh would not have much effect on the electricity production system. Terrestrial wind power will have declined somewhat by 2010.

The scenario calculations are not affected in 2020. The effect will be greater if the subsidy level is set at SEK 0.05/kWh. In 2010 7 TWh of electricity production from renewable energy sources is lost in the alternative where nuclear reactors are decommissioned after 40 years, and 5 TWh is lost in the alternative where nuclear power production continues.

The greatest difference is that new wind power will not be constructed. Most of the shortfall will be covered by increased import of electricity and electricity generation at natural gas-fired condensing power plants. No marine wind power will be introduced at a subsidy level of SEK 0.05/kWh in Scenario 2, where nuclear reactors are decommissioned after 40 years. Production at natural gas-fired condensing power plants will increase instead. In Scenario 1, where reinvestments in nuclear power is allowed, marine wind power will not be introduced at any of assumed subsidy levels.

The importance of electricity import

Net import in 2020 is limited to 4 TWh in the scenarios. To illustrate the potential impact of this import on carbon dioxide emissions, a calculation has been made assuming a net import of zero in 2020. The 4 TWh that is expected to be imported is instead assumed to be generated at natural gas-fired condensing power plants. This would result in 1.4 million tonnes additional carbon dioxide emissions by 2020.

Situation after 2020 in the scenario where nuclear power production is phased out for 40 years (Scenario 2)

Scenario 2 involves decommissioning four reactors in addition to Barsebäck 2, which will be shut down before 2020. Under this scenario, the remaining reactors will be shut down between 2020 and 2025. Making the same assumptions as in the scenario calculations to 2020, fossil fuel-based electricity production would replace the lost nuclear power capacity after 2020. Carbon dioxide emissions would therefore rise sharply after 2020.

Changes in electricity production impact on the electricity supply system

The scenario calculations for the period to 2020 assume that changes will occur in electricity generation capacity. These changes will affect the electricity supply system, particularly in terms of the retained balance between output and demand.

Shutdown of reactors after 40 years will necessitate closure of reactors from 2012, which will require

[16] There are several dimensions of the function of an electricity certification system that MARKAL is unable to describe. In reality, certificate prices will be influenced by investor expectations of the certification system, eg, how long-term it is, how much will be demanded of current production, changes in certificate prices over time and technological developments. MARKAL does not incorporate these uncertainties, since the model has a perfect overview of the future. This means that caution must be exercised when interpreting the model results. For a more detailed description of the sensitivity calculations, see the background report entitled "Beräkningar med MARKAL – Underlag till Energimyndighetens Klimatrapport" ("Calculations using MARKAL – Data for the National Energy Administration Climate Change Report 2001, ER 15:2001.

Emissions of carbon dioxide from the energy sector

Table 4.8
Emissions 1990 – 1999 and projected emissions of carbon dioxide from the energy sector to 2020 in ktonnes (Gg)

Gas/year	1990	1992	1994	1996	1998	1999	2010	2020 Scen 1	2020 Scen 2
Energy total, CO_2	51,713	50,649	54,739	58,307	53,608	52,022	52,532	54,365	60,128
Comprising transport, CO_2	18,738	19,032	18,561	18,834	19,481	19,886	21,432	22,717	22,717
International transport, CO_2	3,989	5,053	5,263	5,536	6,958	6,853	8,600	10,200	10,200

Scenario 1 assumes the possibility of reinvestment in nuclear power

Scenario 2 assumes only a 40-year lifespan for nuclear reactors

Note: The figures for emissions from the energy sector have been adjusted as compared with the percentage changes given in the National Energy Administration scenarios for 1997 – 2010 and 2010 – 2020, but based on the absolute figures submitted by Sweden under the climate convention in April 2001.

creation of substantial replacement capacity. All reactors will have been shut down by 2025. The scenario in which nuclear reactors have an operational life of 40 years assume that new capacity in the form of natural gas-fired combination condensing power plants will be built. This would greatly increase natural gas consumption. Total natural gas consumption in 2020 in Scenario 2 is expected to be 24 TWh, which is within the capacity of the existing main gas pipeline in the south of the country.

The high level of wind power production (just over 10 TWh) expected in Scenario 2 will also make great demands of automatic power supply regulation systems. A sizeable proportion of the electricity generated will be determined by wind conditions and production will therefore vary, which will require readily available reserve capacity to ensure that output can meet demand when it is not possible to generate electricity using wind power.

Comparison with the second Swedish National Communication under the Climate Communication

In the Second Swedish National Communication (NC2) in 1997, it was estimated that carbon dioxide emissions from the energy sector would rise by 10 per cent between 1995 and 2010.

The new assessment in the Third National Communication is that carbon dioxide emissions from the sector will remain largely unchanged between 1997 and 2010. A comparison between emission trends in the various sub-sectors reveals that the main differences will be in the district heating and energy generation sectors.

As regards the assumptions on which the projections are based, the differences are fairly small with regard to economic growth and future fuel prices. But the carbon dioxide tax is higher in the projections made for the Third National Communication (NC3), which makes biomass fuels cheaper than fossil fuels. The consumption tax on electric energy has been raised, as has the carbon dioxide tax paid by industry. The projections in the Second National Communication assumed that industry paid 25 per cent of the carbon dioxide tax, now raised to 35 per cent in NC3. The overall tax payable on petrol and diesel has been raised somewhat.

NC3 assumes a subsidy of SEK 0.15/kWh for electricity generation from renewable energy sources (for hydropower this includes expansion of small-scale hydropower and efficiency improvements at existing hydropower stations). Only operating subsidies for wind power were included in NC2. The estimated cost of developing various technologies has been updated. Among other things, this affects the estimated future cost of wind power. Normal year production of hydropower has been revised and is expected to be higher.

Table 4.9
Emissions of carbon dioxide from the energy sector – comparison between NC2 and NC3

Comparison (% per year)	NC2	NC3
Electricity generation and district heating	1.8	-1.9
Industry	0.2	0.6
Housing	-1.0	-1.7
(Small-scale heating)		
Domestic transport	0.9	1.0

Source: National Energy Administration

With regard to carbon dioxide emissions from transport, NC3 assumes compliance with the ACEA agreement. This commitment was not included in NC2.

NC3 also assumes shutdown of the second reactor at Barsebäck. An "average" reactor had been decommissioned in NC2. The reactor actually shut down was Barsebäck 1.

The altered premises for the scenarios affected the outcome in the following way.

- NC3 assumes that biomass fuel use will increase by 11 TWh between 1997 (the base year) and 2010. The figure in NC2 was 8 TWh (base year 1995).
- Hydropower production is expected to be 2.6 TWh higher in 2010 in NC3. This is an effect of the subsidy for electricity generated from renewable sources, and also an upward revision of normal year production. Wind power is expected to produce 2.5 TWh more electric energy in 2010 in NC3. Biomass fuel use is also expected to increase in NC3 compared with the scenarios presented in NC2.
- Import of electric energy in 2010 is expected to rise from 2.7 TWh in NC2 to 4 TWh in NC3.
- NC3 expects oil consumption for heating in the housing sector to have declined by 2010, compared with the scenarios presented in NC2, whereas district heating use is expected to increase.
- Total emissions from the transport sector are expected to increase at approximately the same rate in the scenario calculation as in NC2. However, fuel use trends differ substantially, particularly those for petrol and diesel. Petrol use is expected to rise much more slowly in NC3 than in NC2. But diesel use is expected to increase much more rapidly in the calculations for NC3 compared with those made in NC2. International air traffic is expected to increase more than its domestic counterpart in NC3.

4.1.3 Emissions of methane and nitrous oxide from the energy sector (including transport)

Emissions of methane and nitrous oxide from energy supply and use (the energy sector) represent about 3.8 per cent of total Swedish emissions of greenhouse gases, not including land-use changes and forestry or international transport.

Projected emissions from the energy sector are based on an analysis of emissions during 1990 – 1999 using regression analysis for the linear trend and other explanatory variables relating to economic macro-variables or activity data. Emissions have been broken down into the energy sector (not including transport) and transport. Expert assessments have been made of the trend to 2010 and 2020 on the basis of trends and analysis results.

Methane emissions

Emissions of methane from the energy sector (not including transport)

Emissions of methane from the energy sector (not including transport), depend on the amount of combustion, as well as the design of boilers and fuels and the kind of treatment technology used (if any). Small-scale combustion is a fairly major source, since this kind of burning is often incomplete.

According to the latest figures reported by Sweden under the Climate Convention (April 2001), methane emissions rose by a mean figure of 0.21 (+/-0.05)[17] ktonnes per year between 1990 and 1999 (ie, by 1.5 per cent a year). This was partly due to increased use in the district heating sector of biomass fuels, which have a higher emission factor for methane than oil does. The emission factors for combustion – particularly for small-scale combustion – are uncertain. The same emission factor for methane emissions from small-scale combustion is used for the years 1990 to 1999. The specific emission factor (kg methane per kJ energy) for small-scale combustion has probably fallen over time thanks to the new, more efficient, combustion technologies that have come onto the market. One consequence of this is that VOC emissions fell between 1990 and 1999.

The trend indicated by the statistical analysis for 1990 to 1999 is probably misleading, since the present calculations could not account of the effects of new technology and new fuels for small-scale combustion. A conservative expert opinion[18] is that methane emissions will not increase in future, ie, emissions will be about 15 ktonnes in 2010 and 2020. The Climate Commission[19] report suggests that methane emissions from the energy sector (not including transport) will increase from about 16 ktonnes in 1990 to 19 ktonnes by 2010, which is an increment of about 0.15 ktonnes a year.

Methane emissions from transport

Methane emissions from transport depend on total transport distance and weight transported, changes in engine combustion technology and use of treatment techniques such as catalytic conversion. Catalytic converters substantially reduce emissions of nitrogen oxides and hydrocarbons in exhausts, and to some extent also methane emissions. Methane emissions from transport fell by a mean figure of 4.5 per cent a year between 1990 and 1999.

An analysis of this trend based on logarithmic values for emissions from 1990 to 1999 shows an emission reduction of approximately 5 per cent (+/-0.5 per cent) a year. A projection based on this current trend suggests than annual methane emissions will have fallen to 8.5 ktonnes by 2010, and 5.6 ktonnes by 2020. The Climate Commission thought that methane emissions would fall to 8 ktonnes by 2010.

Total annual methane emissions from the energy sector (including transport) are expected to be 23.5 ktonnes by 2010 and 20.6 tonnes by 2020.

Nitrous oxide emissions

Emissions of nitrous oxide from the energy sector (not including transport)

Emissions of nitrous oxide depend on the amount of combustion, as well as the design of boilers and fuels and the kind of treatment technology used (if any). There is a certain, probably minor, effect derived from the system of charges on nitrogen oxide emissions, the size of the charge depending on NOx emissions. The companies and other activities covered by the system optimise the cost of taking action and the NOx charges, which may to some extent increase nitrous oxide emissions.

Nitrous oxide emissions from the energy sector (not including transport) rose by a mean figure of 0.08 (+/-0.03) per year, which represents an increase of approximately 1.8 per cent per year. A projection based on this current trend suggests than annual nitrous oxide emissions will have risen to 5.8 ktonnes by 2010, and 6.6 ktonnes by 2020. The Climate Commission thought that nitrous oxide emissions would remain constant at 4 ktonnes to 2010.

Nitrous oxide emissions from transport

Nitrous oxide emissions from transport depend on total transport distance and weight, changes in engine combustion technology and use of treatment techniques such as catalytic conversion. Catalytic converters

[17] Standard error (quadratic mean deviation)

[18] Swedish EPA assessment

[19] Swedish Government Official Report SOU 2000:23 Proposed Swedish Climate Strategy

substantially reduce emissions of nitrogen oxides and hydrocarbons in exhausts, but substantially increase emissions of nitrous oxide. Nitrous oxide emissions from transport rose by a mean figure of 0.05 ktonnes (3.2 per cent) a year between 1990 and 1999. Assuming that this current trend continues, annual nitrous oxide emissions will have risen to 2.4 ktonnes by 2010, and 2.9 ktonnes by 2020. The Climate Commission thought that emissions would rise from 3 ktonnes in 1990 to 5 ktonnes in 2010, ie, an increase of approximately 3.2 per cent a year.

Total annual nitrous oxide emissions from the energy sector (including transport) are expected to be 8.2 ktonnes by 2010 and 9.5 ktonnes by 2020.

Comparison with the Second Swedish National Communication under the Climate Convention

In the Second Swedish National Communication in 1997, it was estimated that methane emissions from the energy sector would fall from 35 ktonnes in 2000 to 27 ktonnes in 2010.

It is now thought that emissions will fall from 30 ktonnes in 1999 to 23.5 ktonnes in 2010, ie, roughly the same reduction, but from a slightly different starting point.

In NC2, it was estimated that nitrous oxide emissions from the energy sector would rise from 7.7 ktonnes to 9 ktonnes by 2010. It is now thought that emissions will increase from 6.7 ktonnes in 1999 to 8.2 ktonnes in 2010, ie, approximately the same increase.

4.1.5 Industrial processes and use of halocarbons

Emissions of greenhouse gases from industrial processes and from the use of halocarbons account for around 8.5 per cent of all Swedish emissions of greenhouse gases, not including land use, forestry and international transport.

Industrial processes and emissions of carbon dioxide, methane and nitrous oxide

Projected emissions from industrial processes are based on an analysis of emissions during 1990 – 1999 using regression analysis for the linear trend and other explanatory variables relating to economic macro-variables or activity data. These analyses have been made for individual industries in some cases. The statistical analyses have then been supplemented by expert opinions from public authorities and industry representatives. All estimates of future emissions from industrial processes are uncertain and must be treated with caution.

Carbon dioxide emissions

Carbon dioxide emissions from industrial processes come from the manufacture of iron and steel and also cement and lime. Projections for these two industries have been assessed.

Emissions of carbon dioxide from iron and steel manufacture are expected to increase by about 57 (+/-19) ktonnes per year (ie, by about 2.3 per cent)

4.1.4 Total greenhouse gas emissions from the energy sector

Table 4.10
Emissions 1990 – 1999 and projected emissions of greenhouse gases from the energy sector to 2020 in ktonnes carbon dioxide equivalent emissions/year

Sub-sector/ greenhouse gas Year	1990	1992	1994	1996	1998	1999	2010	2020 Scen 1	2020 Scen 2
Energy total CO_2	51,713	50,649	54,739	58,107	53,608	52,022	52,532	54,365	60,128
Transport CO_2	18,738	19,032	18,561	18,834	19,481	19,886	21,432	22,717	22,717
Energy total CH_4	779	756	736	753	661	634	494	433	433
Transport CH_4	486	455	429	411	341	303	178	118	118
Energy total N_2O	1,776	1,716	1,935	2,049	2,090	2,071	2,542	2,945	2,945
Transport N_2O	453	431	474	512	530	570	744	899	899
Total, sector	54,268	53,121	57,410	60,909	56,359	54,727	55,568	57,743	63,506
Total Transport	19,677	19,918	19,464	19,757	20,352	20,759	22,354	23,734	23,734

The table may contain some errors resulting from rounding up or down.
Scenario 1 assumes reinvestment in nuclear power
Scenario 2 assumes a 40-year lifespan for nuclear reactors

as a linear trend. An analysis using two explanatory parameters, the underlying trend and the production value for the iron and steel industry (SNI 27 and 28[20]) gives the same projection result, albeit with greater uncertainty. A projection of the trend taking account of the future production value of this industry indicates annual emissions from iron and steel manufacture of about 3,560 ktonnes carbon dioxide by 2010 and about 4,130 ktonnes carbon dioxide by 2020. On the basis of answers to a questionnaire sent out to its member companies, the iron and steel industry association (Jernkontoret) has estimated that total iron and steel production may increase by 30 – 40 per cent by 2010. This would result in somewhat higher carbon dioxide emissions than is indicated by a projection of the current trend. It should be emphasised that iron and steel products are typically exported and rises and falls in emissions from the industry are entirely dependent on global market trends. The annual rate of increase in emissions from iron and steel processes is expected to remain the same (approx. 2.3 per cent a year) throughout the period to 2020.

Carbon dioxide emissions from the minerals industry (cement and lime burning) will fall slightly as a linear trend, about 0.7 (+/-10) ktonnes/year, although this figure is not statistically significant. An analysis of the underlying trend and the production value (SNI 26[21]) for this industry for 1990 – 1999 gives the same low degree of explanation. Carbon dioxide emissions from this industry are therefore expected to remain at their mean level during the 1990s (ie, approx. 1,650 ktonnes/year) up to 2020.

Total annual carbon dioxide emissions from industrial processes are expected to increase from about 4,325 ktonnes in 1999 to 5,210 ktonnes in 2010 and 5,780 ktonnes in 2020, which is a percentage increase of about 2 per cent a year. This new estimate may be compared with the Climate Commission's assessment, viz., that carbon dioxide emissions from industrial processes will increase from 3,700 ktonnes in 1997 to 4,300 ktonnes in 2010, ie, a percentage increase of approximately 1.25 per cent a year.

Methane emissions

Methane emissions from industrial processes are small (about 0.41 ktonnes in 1999). An analysis of the linear trend from 1990 to 1999 shows that emissions are increasing by about 0.015 (+/-0.005) ktonnes (ie, about 8 per cent) a year. A projection based on this current trend suggests than annual methane emissions will have risen to 0.5 ktonnes by 2010, and 0.65 ktonnes by 2020.

Nitrous oxide emissions

Nitrous oxide emissions from industrial processes mainly come from the manufacture of artificial fertilisers and nitric acid. An analysis of the linear trend from 1990 to 1999 shows that emissions fell by about 0.03 (+/-0.013) ktonnes (ie, about 1 per cent) a year. A pro jection based on the current trend suggests than annual nitrous oxide emissions will have fallen to 2.1 ktonnes by 2010, and 1.8 ktonnes by 2020.

Emissions of halocarbons (HFCs, PFCs and SF_6)

Swedish emissions of halocarbons rose between 1990 and 1999 by almost 50 per cent, from about 520 to 780 ktonnes carbon dioxide equivalent emissions, which represents approximately 1 per cent of Swedish greenhouse gas emissions. The scenario calculations for emissions of these gases have used the same methods as for determining emissions during 1990 – 1999, ie, a spreadsheet model using activity data and emission factors.

Experts at the Swedish Environmental Protection Agency and industry institutions have arrived at a joint basis for the scenario calculations, ie, input data in the form of activity data and emission factors.[22]

Background information

At present, the largest emissions of halocarbons comprise perfluorocarbons (CF_4 and C_2F_6) from aluminium manufacture. Emissions are expected to fall by half between 1999 and 2020, from 320 to 160 ktonnes carbon dioxide equivalent emissions. This will result when manufacturers comply with more stringent operating permit conditions set under the EU Council Integrated Pollution and Prevention and Control Directive (96/61/EC) ("the IPPC Directive")[23], which is not expected to halve emissions until after 2010.

It is difficult to estimate future use of fluorinated hydrocarbons (HFCs) as a refrigerant, since developments are rapid in the refrigeration field. One factor causing great uncertainty is the extent to which manufacturers will use other refrigerants. It is assumed that the "household refrigerators and freezers" sector will completely change over to using isobutane in new appliances manufactured and sold as from 2005. (In

[20] Svensk Näringslivs Indelning (SNI) (Classification of Swedish Industry), Industry 27: Metal works and metal goods industry; Industry 28: Industry for metal goods, not including machinery and equipment

[21] Svensk Näringslivs Indelning (SNI) (Classification of Swedish Industry), Industry 26: Earth and stone goods industry

[22] Swedish EPA report: Framtida emissioner av fluorerade växthusgaser ("Future emissions of fluorinated greenhouse gases"), Report 5168 Swedish EPA

[23] Council Directive: Integrated Pollution and Prevention and Control 96/61/EC

1999, 80 per cent of appliances contained isobutane, the remainder used HFCs). This changeover is expected to take place at the industry's own initiative and it is assumed that, for some refrigerant applications at least, there is a will not only to abandon CFCs, but to miss out the intermediate stage of using HFCs and go straight on to a technology that neither uses ozone depleting substances nor typical greenhouse gases. It is very difficult to predict how widespread this substitution will be, or what technological advances will be made, for certain applications.

Similarly, there are signs that a general changeover from HFCs to other refrigerants in mobile air conditioning units may take place within the next six years or so.

The assumptions forming the basis for estimates of future emissions are described below in relation to the areas where emissions are greatest.

The total accumulated installed quantity of HFCs in large stationary air conditioning units such as fridges and freezers is expected to increase linearly from about 1,100 tonnes in 1998 to 1,500 tonnes in 2010, and then to remain constant at 1,500 tonnes throughout the remainder of the scenario period. It is further assumed that annual leakage of refrigerants will fall from 7.5 per cent to 5 per cent of the total quantity installed by 2003, and that it will then remain constant at that level.

It is estimated that there were approximately 380 tonnes of HFC-134a installed in air conditioning units in automobiles in Sweden in 1999. The proportion of new cars fitted with these units is expected to rise from 74 per cent in 1999 to 85 per cent in 2005, 90 per cent in 2010, 93 per cent in 2015 and 95 per cent in 2020. Some car manufacturers have stated that in a few years' time all their new models will have air conditioning. On the basis of the Association of Swedish Automobile Manufacturers and Wholesalers' forecast, the number of registered new vehicles will vary between 325,000 and 335,000 new cars per year. Annual leakage is assumed to be 10 per cent and the emission factor when vehicles are scrapped is 15 per cent of the quantity installed.

There is only limited manufacture of plastics and plastic products (insulating material) in Sweden; emissions come mainly from imported products. No dramatic change is expected in the future, although recycling is expected to increase. It is estimated that the average emission when these products are discarded will be approximately 50 per cent of the residual quantity of HFCs in the plastic by 2020, compared with 100 per cent at present.

The quantity of sulphur hexafluoride (SF_6) installed in electrical insulation in Sweden is expected to increase by about 1 per cent per year. Older equipment is considered to have a higher emission factor (1 per cent) than more modern equipment (0.1 per cent). The quantity used in switch manufacture is likely to decline.

Emissions of halocarbons in 2010 and 2020

The scenario calculations for 2020 indicate that emissions from air conditioning systems in cars, trucks and buses will rise particularly sharply, from 100 ktonnes carbon dioxide equivalent emissions in 1999 to 340 ktonnes in 2020. Emissions from large stationary refrigeration, freezing and air conditioning units are expected to increase somewhat over the coming decade as HCFCs refrigerants (which are ozone depleting) are phased out. In most cases, these are still replaced with HFCs. Thanks to better seals, smaller quantities used and other measures, these emissions are expected to fall to around the present levels, ie, 150 ktonnes carbon dioxide equivalent emissions by 2020. Total emissions of fluorinated greenhouse gases are expected to rise from 780 to about 890 ktonnes carbon dioxide equivalent emissions between 1999 and 2020. Estimated actual emissions[24] from all applications to 2020 are shown in Figure 4.5.

Sensitivity analysis

Estimates have also been made using alternative emission factors and trend curves. These may be seen as examples of the effects of stricter adherence to existing legislation, with better regulatory control and more far-reaching voluntary measures taken in various industries to reduce leakage. These estimates represent a low-emission scenario.

It is assumed that the emission factor for leakage of refrigerants from large stationary units will fall further from 5 per cent to 2.5 per cent of the installed quantity between 2003 and 2010 as a result of stricter monitoring and better technical control and other improvements. It is also assumed that quantities of HFCs installed in these units will eventually decrease.

The automobile industry is expected to rapidly move towards the use of carbon dioxide as a refrigerant in vehicle air conditioning units. This would allow some HFC use in these units to be replaced as from 2003, prior to a complete changeover to other refrigerants (probably carbon dioxide) as from 2006.

The overall effect of these assumptions is that emissions of halocarbons would fall in comparison with the basic scenario. Emissions of halocarbons in the low-emission scenario would fall to 919 ktonnes carbon dioxide equivalent emissions by 2010 and 518 ktonnes by 2020.

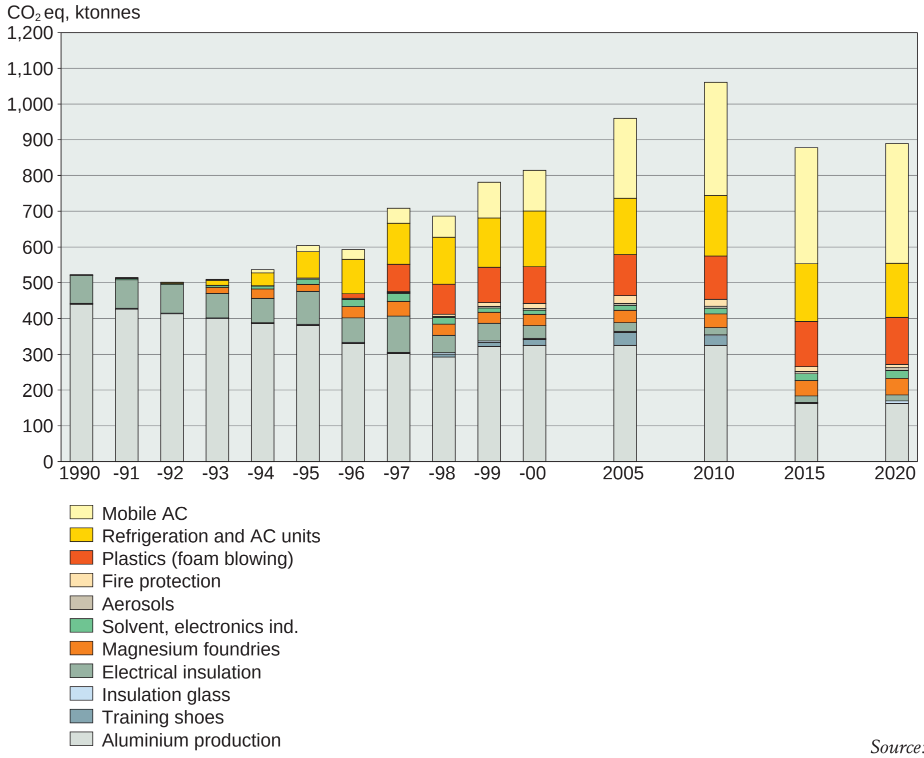


Figure 4.5
Estimated emissions (Tier 2) between 1990 and 2020 from various applications (ktonnes CO_2 equivalent emissions)

Source: Swedish Environment Protection Agency

Total greenhouse gas emissions from the sector

It is estimated that total greenhouse gas emissions from industrial processes and use of halocarbons will increase. The increase is estimated to be approximately 15 per cent between 1999 and 2010, and about 18 per cent between 1999 and 2020.

Comparison with the Second Swedish National Communication under the Climate Convention (NC2)

In NC2 it was estimated that carbon dioxide emissions from industrial processes would increase from 4,600 ktonnes in 2000 to 5,400 ktonnes in 2010, a rise of just over 17 per cent. The new estimate differs slightly from the old one: an increase from about 4,325 ktonnes in 1999 to 5,210 ktonnes in 2010, a rise of 20 per cent. This difference is mainly due to a change between the two communications in the method of classifying emissions into process emissions and energy consumption.

No estimate of future methane emissions was given in NC2.

NC2 estimated that nitrous oxide emissions from industrial processes would rise from 2.3 ktonnes in 2000 to 2.6 ktonnes in 2010, an increase of some 25 per cent. The new estimate is that these emissions will fall from 2.6 ktonnes in 1999 to 2.1 ktonnes in 2010, ie, by about 20 per cent. These two forecasts thus differ considerably. The new estimate is based on statistics produced from environmental reports, whereas the previous one was based on a correlation to growth in GDP.

NC2 forecast that HFCs would increase from approximately 840 ktonnes carbon dioxide equivalent emissions in 2000 to 870 ktonnes in 2010, a rise of just over 3 per cent. The estimate is now that HFC emissions will rise from 375 ktonnes carbon dioxide equivalent emissions in 1999 to 632 ktonnes in 2010, a rise of just over 60 per cent. However, the methods use to arrive at the figures in the NC2 and NC3 differ substantially.

NC2 estimated that FC carbon dioxide equivalent emissions would rise from 490 ktonnes in 2000 to 590 ktonnes in 2010[25]. It is now thought that FC carbon dioxide equivalent emissions will remain constant at around 330 ktonnes between 2000 and 2010. Emissions are then expected to fall to 177 ktonnes in 2020. These differences are explained by the use of a new inventory method for fluorinated greenhouse gases.

It was estimated in NC2 that SF_6 carbon dioxide equivalent emissions would remain constant at 1,200 ktonnes a year between 2000 and 2010. The new forecast is that emissions will fall slightly from a much lower level (96 ktonnes carbon dioxide equivalent emissions in 1999) to 93 ktonnes in 2010, before falling to 78 ktonnes in 2020. These differences are mainly due to use of a new method[26] to estimate the size of emissions, as well as new assessments of technological developments.

[24] Emissions estimated in line with IPCC/UNFCCC guidelines for reporting of halocarbons, Tier 2

[25] It was assumed in the second national communication that all FC emissions comprised CF_4, with a GWP factor of 6,500 for conversion of FC emissions into carbon dioxide equivalent emissions.

4.1.6 The agricultural sector

Methane emissions from the agricultural sector come from livestock farming and, to a lesser extent, from fertiliser, and nitrous oxide from farmyard manure and from soil and water receiving nitrogen in various forms. Land use and land-use changes also influence removal and loss of carbon dioxide from soil. These emissions are presented under "Land-use changes and forestry". In addition, the agricultural sector uses various fuels that generate carbon dioxide emissions, which are presented under "Energy use".

Assumptions

Estimates of emissions from Swedish agriculture are uncertain. This is because methods of performing inventories of emissions need to be refined to take account of Swedish conditions, and also because it is difficult to say how the CAP will develop over the longer term. The EU decided in 1999 to reform agricultural policy (as part of Agenda 2000), which re-presented a continuation of a reform carried out in the early 1990s. The essential features of the 1999 decision will probably remain in place until 2006. It is not possible at present to predict the changes resulting from a new general reform. A projection based on previous reforms would suggest a continued move away from price subsidies towards various forms of direct support.

The forecasts for animal production given below have been taken from a report submitted to the EU Commission.[27] Emphasis is placed on changes in animal production because the vast majority of emissions from agriculture derive from that sector. A central premise of the report is that agricultural policy will remain as decided within the framework of Agenda 2000 until 2010.

In addition to the proviso regarding further agricultural reform in five years or so, the figures given here would be affected by more stringent environmental standards, changes in consumer behaviour and the effects of outbreaks of infectious animal diseases.

The main increases concern pig numbers (+10 per cent) and fattening chickens (+52 per cent) between 1990 (the base year) and 2010. Pig numbers did not change appreciably in the 1990s, however. Fattening

[26] One consequence of the new method is that only actual emissions in Sweden will be included. Earlier estimates assumed that the entire quantity imported into Sweden was immediately released.

[27] Economic Evaluation of Emission Reductions of Nitrous Oxide and Methane in Agriculture in the EU. Contribution to a Study for DG Environment, European Commission by Ecofys Energy and Environment, AEA Technology Environment and National Technical University of Athens. Final Report November 2000

Table 4.11
Total emissions of fluorinated gases in ktonnes to 2020, carbon dioxide equivalent emissions per year

Greenhouse gas Fluorinated gases	1990	1992	1994	1996	1998	1999	2010	2020	Remark
PFCs	440	414	390	343	306	329	336	177	
HFCs	1	4	47	141	303	375	632	636	
SF_6	81	82	97	103	92	96	93	78	
Total	522	500	534	587	701	800	1,061	890	

Source: Report by the Environmental Research Institute to the Swedish Environmental Protection Agency

Table 4.12
Total emissions to 2020 of greenhouse gases from industrial processes, not including their combustion of fossil fuels, ktonnes carbon dioxide equivalent emissions per year

Greenhouse gas	1990	1992	1994	1996	1998	1999	2010	2020
Industrial processes, CO_2	4,170	4,198	4,383	4,783	4,423	4,325	5,210	5,780
Industrial processes, CH_4	4.8	4.9	4.6	4.9	7.1	8.7	10	14
Industrial processes, N_2O	871	832	763	739	818	824	693	594
Fluorinated gases	522	500	534	587	701	800	1,061	890
Total, sector	5,568	5,535	5,685	6,114	5,949	5,958	6,974	7,278

Source: Swedish Environmental Protection Agency

chicken production rose in the 1990s, however, and is expected to increase by approximately the same amount again by 2010.

Dairy cattle numbers are expected to have fallen by 34 per cent between 1990 and 2010, the decrease being evenly split between the decades. The reason for this fairly sharp decline is that the milk quota system is expected to be retained and that total milk production will therefore remain the same. The current yield increases, which may be expected to continue to 2010, means that the number of dairy cattle is expected to fall. If the quota system changes, the competitiveness of milk production in each member state will have a bearing on developments. It is not possible at present to say how this would affect milk production in Sweden.

The decline in dairy cattle numbers will mean something of a decline in total cattle numbers. Specialised beef production is also controlled by a system of quotas, and it may therefore be assumed that the number of calves produced by beef cattle will not increase sufficiently to compensate for the reduced number of calves born to dairy cows. The fall in total cattle numbers between 1990 and 2010 has been estimated at 6 per cent. A rise between 1990 and 1998 means that the fall between 1998 and 2010 will be somewhat larger than 6 per cent.

The expected reduction in ruminant numbers is expected to reduce methane emissions from agriculture, as well as emissions of nitrous oxide from the use of farmyard manure.

However, grazing cattle and sheep are needed to maintain natural pastures of great value in terms of landscape and their biodiversity. The current number of ruminants is needed to achieve the objective of conserving all meadows and pastures under the Swedish environmental quality objective named "A varied agricultural landscape". Their numbers are also needed to conserve Swedish biological diversity and cultural heritage and to achieve the objective of an open and varied cultivated landscape as part of the Swedish environment and rural areas programme. The large number of semi-natural pastures with high biodiversity places Sweden in a unique position in Europe and Sweden also has a particular responsibility to preserve them. Moreover, present livestock numbers are needed to maintain an economically viable agricultural sector.

The number of laying hens is expected to have fallen by 30 per cent between 1990 and 2010, half this decrease occurring in the second half of the period.

Land-use changes in Swedish agriculture are expected to be marginal over the coming 10 – 20 years. Reindeer numbers are also expected to remain at their 1999 level.

Methane emissions

Emissions of methane from agriculture are mainly caused by enteric fermentation in ruminants (principally cows and horses), and, to some extent, reindeer. Future methane emissions from agriculture are uncertain and the figures must be treated with caution.

Methane emissions are expected to fall from 165 ktonnes in 1990 to 161 ktonnes in 1999 and 152 ktonnes in 2010. At present, there are no projections for national agricultural policy and the CAP after 2010. For the purpose of this study, it is therefore assumed that methane emissions from agriculture will remain at their projected levels for 2010.

Nitrous oxide emissions

Emissions of nitrous oxide from agriculture come from farmyard manure (manure management systems) and artificial fertilisers, and also from losses into the air from soil following application of nitrogenous fertilisers. Estimates of future emissions from agriculture are considered to be very uncertain. Emissions of nitrous oxide from farmyard manure (manure management systems) are expected to have fallen from 2.35 ktonnes in 1990 to 2.02 ktonnes in 2010. Emissions from soil are expected to have fallen from 12.24 ktonnes in 1990 to 11.45 ktonnes in 2010. Total emissions from agriculture are expected to fall from 14.6 ktonnes in 1990 to 13.6 ktonnes in 1999 and 13.5 ktonnes in 2010. At present, there are no projections for national agricultural policy and the CAP after 2010.

For the purpose of this study, it is therefore assumed that nitrous oxide emissions from agriculture will remain at their projected levels for 2010.

Table 4.13
Total emissions to 2020 of greenhouse gases from agriculture, not including carbon dioxide emissions from land use, in ktonnes carbon dioxide equivalent emissions per year

Greenhouse gas	1990	1992	1994	1996	1998	1999	2010	2020
Agriculture, CH_4	3,473	3,510	3,578	3,505	3,423	3,382	3,194	3,194
Agriculture, N_2O	4,518	4,237	4,420	4,314	4,427	4,217	4,175	4,175
Total, sector	7,991	7,748	7,998	7,819	7,850	7,599	7,369	7,369

Source: Swedish Board of Agriculture and Swedish Environmental Protection Agency

Total emissions of greenhouse gases from the sector
Total emissions from agriculture are expected to have fallen to 7,369 ktonnes carbon dioxide equivalent emissions by 2010, which level is also expected to prevail in 2020. New methods have been used for NC3, involving, among other things, new emission factors. The new projection has also taken into account predicted changes in agricultural policy between 1997 and 2006.

Comparison with the Second Swedish National Communication under the Climate Convention (NC2)
Methane
NC2 estimated that methane emissions from agriculture would rise from 206 ktonnes in 2000 to 210 ktonnes in 2010, ie, an increase of about 1.5 per cent. The new method used in NC3 gives lower emission levels and takes account of agricultural policy decisions to 2000. In NC3 it is estimated that methane emissions will have fallen from 161 ktonnes in 1999 to 152 ktonnes in 2010, ie, a decrease of just over 5 per cent.

Nitrous oxide
It was estimated in NC2 that emissions of nitrous oxide from agriculture would increase from 0.2 ktonnes in 2000 to 0.3 ktonnes in 2010. Nitrous oxide emissions are now expected instead to have fallen from 13.6 ktonnes in 1999 to 13.47 ktonnes in 2010, a decrease of about 1 per cent. The completely new method of quantifying nitrous oxide emissions used in NC3 produces much higher levels for the period 1990 – 1999. The two assessments are therefore not comparable.

4.1.7 Land-use changes and forestry
Forests are particularly important in Sweden, representing a key resource for the Swedish pulp and paper industry and a major environmental asset. Forests provide renewable energy, currently equivalent to half the fossil fuel use, and they fix carbon dioxide in a growing timber volume, currently equivalent to 40 per cent of carbon dioxide emissions from the energy and industrial sectors. Carbon dioxide emission from agriculture deriving from cultivation of organic soils and lime use are also presented in this section. Peat abstraction can also be included under land use. This did not change between 1990 and 1999, expressed as the area of land used for abstraction.

Forestry and removals of carbon dioxide
The general trend towards greater felling volumes during the 20th century has been more than counterbalanced by increased growth.

Measures/factors contributing to greater forest growth are:

- increase in timber volume (more forest grows more)
- development of forest management methods, eg, scarification, clearing, thinning, use
- of nitrogenous fertilisers
- selection of good genetic material for seedlings
- deposition of nitrogen – the lack of which normally limits tree growth
- afforestation of former agricultural and grazing land
- land drainage
- forest fire-fighting and the ending of slash-and-burn, as a result of which the soil in
- many areas is given the chance to develop a better ability to retain water and nutrients.

Importance of felling rates in relation to carbon dioxide removals by forest and to the biomass fuel supply
In recent decades, Swedish forestry has done much to limit anthropogenic net emissions of carbon dioxide. This has occurred in two ways: (i) increased use of biomass fuels originating in forests has somewhat reduced the burning of fossil fuels; (ii) timber volume has increased and fixed carbon dioxide from the atmosphere. The future trend for these two factors is largely dependent on the action taken to reduce the use of fossil fuels in the energy sector and on the market for paper and timber products.

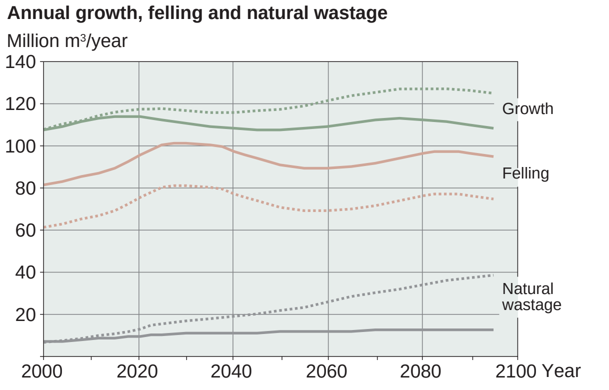
The impact of forestry on emissions and removals of greenhouse gases has been analysed to a degree as part of a scenario analysis (SKA99[28]) performed jointly by the National Board of Forestry, the Swedish University of Agricultural Sciences, the National Energy Administration and the Swedish Environmental Protection Agency. The project involved extensive calculations to determine potential trends in Swedish forest status this century in a number of management/use scenarios. The main scenario in SKA99 was a projection based on forestry conducted in accordance with present forest policy, management aims and nature conservation aims, involving an increase in stemwood felling over time to a level close to the highest possible sustainable level (see diagram). A simplified analysis was also made of the potential effects a felling rate of 20 million cubic metres total volume over bark lower might have on the growing sink in forest biomass and the future potential supply of biomass fuels. The result is shown in the "lower felling rate" scenario (see diagram).

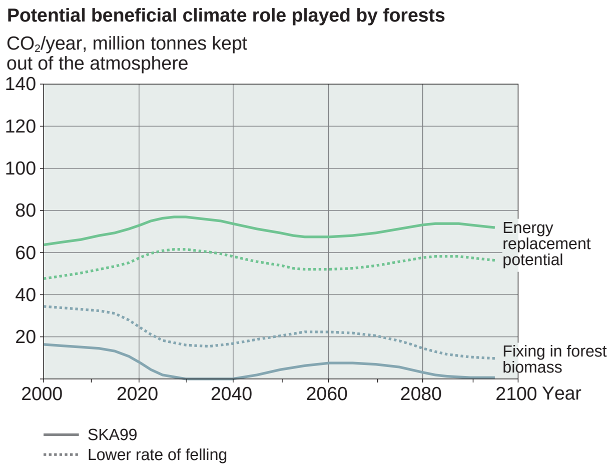
The diagram uses the figure of 75 per cent to approximate the energy in stemwood plus logging residues that is available for energy generation. This assumes that wood and paper products can be used for energy generation at the end of their life, and also assumes that greater use of wood can reduce the need for plastics and raw materials that require more energy for their production. Coal is assumed to be the fossil fuel replaced or avoided.

The main projection in SKA99 assumes that extraction of forest biomass between 2000 and 2020 will be substantially greater than that in the 1990s. This means that removal of carbon dioxide in forest biomass is expected to decrease substantially as compared with the current situation. Assuming a lower rate of felling, more carbon dioxide will be removed by forests (see diagram "lower felling rate"). In the long term, sink growth will be less important, regardless of the felling rate. However, current appraisals indicate a future felling rate in line with that during 1998 – 2000, with some variations owing to fluctuations in the economic cycle. Hence, the carbon sink will be much less affected.

At present, Sweden uses just over half its estimated biomass fuel potential. Some of this potential is now abroad in the form of end-of-life export products. However, much of the unused potential in Sweden is found in uncollected logging residues. The SKA99 "high felling rate" scenario, suggests that the potential supply of biomass fuels will rise as the sink decreases to the same extent in the first decades. Only in the longer perspective does the comparison between the scenarios indicate that the rate of sink growth will slow while the difference in potential biomass fuel supply remains. Forests may thus continue to help reduce the quantity of carbon dioxide entering the atmosphere whatever the rate of felling.

Figure 4.6
Changes in forest state and potential benefit in relation to climate according to (i) the SKA99 scenario ("Forestry in the 1990s"), and (ii) the scenario with a lower rate of felling minus 20 million cubic metres total volume over bark per year. Assumptions – see text.





Source: National Board of Forestry

Impact of lower nitrogen deposition

Nitrogen deposition in the 1990s represented approximately 150,000 tonnes of nitrogen. If this nitrogen had been added in the same way and to the same soils as occurs with the use of fertilisers in forestry, it would have contributed about 15 million cubic metres each year to total forest growth. However, apart from the fact that some nitrogen deposition lands on stands where the growth effect is not as great, the effect of continuous nitrogen input is, for various reasons, not as great as a single large dose at intervals of a few years.

Hence, the effect on growth is probably much less than that mentioned above.

It is essential to reduce nitrogen deposition to minimise acidification to avoid nitrogen saturation and eutrophication, particularly of lakes and seas, among other things.

International agreements on reducing emissions in Europe have therefore been concluded.

If the targets set are achieved, nitrogen deposition over Sweden will have decreased by about 40 per cent between 1990 and 2010. This may be expected to mitigate the impact of deposition on growth and hence also on sink growth.

Sink growth in soils

It is more difficult to make forecasts for carbon dioxide removals by forest soils, since we do not know as much about the quantitative significance of various factors in relation to the carbon sink growth occurring in naturally well-drained ("healthy") forest soils. Some changes in impact and land use that have contributed to the increase in humus quantities, thereby also increasing the carbon content, are forest fire-fighting, afforestation of large areas of grazing and arable land (including land cleared and burnt-over for cultivation), increased nitrogen deposition and denser forests. Hence, continued afforestation of agricultural land

[28] SKA99, Skogliga Konsekvensanalyser 1999. Skogens möjligheter på 2001-talet ("Forest Impact Analyses 1999. Forest potential in the 21st century")

Table 4.14
Total emissions to 2010 of greenhouse gases from land-use changes and forestry, ktonnes carbon dioxide per year. Sinks are shown by a minus symbol.

Greenhouse gas	1990	1992	1994	1996	1998	2010 1)
Forestry CO_2	-24,100	-27,100	-30,100	-26,100	-28,100	-28,100
Agricultural land CO_2	3,808	3,747	3,795	3,831	3,769	3,795
Total, sector	-20,292	-23,353	-26,305	-22,269	-24,331	-24,305

1) Sweden's report to the secretariat of the Climate Convention in August 2000 gave a figure of 17,000 ktonnes per year.
This was based on a scenario that assumed a considerably higher rate of felling than the present one, and is not a forecast of the future forest sink.

and denser forests may increase sink growth in averagely dry forest soils.

More dead wood during decomposition in forests adds to the carbon sink in forest litter.

Likewise, increased removal of forest fuels results in a relative decline during a transition period until a new equilibrium has been established.

The evaluation of the forest biotope survey indicates that sink growth in forest soils has been pronounced, particularly in parts of the country where nitrogen deposition has been high. The results of trials involving fertilisers also show that a nitrogen supplement increases the depth of the humus layer for a time. Lower nitrogen deposition therefore probably reduces sink growth in averagely dry forest soils fairly considerably.

Drainage of forest soils and the drier environment thus created increases decomposition of organic matter and usually reduces methane emissions. Overall, drainage usually increases greenhouse gas emissions. Land drainage has decreased substantially in Sweden and is expected to remain at its present level or decrease further. Some additional drainage continues in connection with expansion of the forest vehicle road network and when ditches are cleared out and made deeper than they were originally. However, there are large areas where old ditches have been left untouched and where the land is becoming boggier. This means that carbon dioxide is fixed in a growing peat layer and also that natural methane emissions recommence.

Total emissions of greenhouse gases from land use and forestry

In addition to carbon dioxide sinks in forest biomass, sinks or removals caused by land-use changes in agriculture and forestry are included in this sector under Climate Convention guidelines. Little is known about the change in carbon fixed in forest soils. Sinks in well-drained soils may be expected to slowly diminish. Emissions from drained forest soils can be expected to decrease more rapidly where the present rate is high and more slowly where the present rate is low. The changes cancel each other out in the main projection.

New figures for emissions of carbon dioxide from agricultural soils have been produced for 1990 – 1999. No major changes in the use of agricultural soils, cultivation methods or crops are expected. Emissions of carbon dioxide are therefore expected to remain at their 1999 level until 2020.

Comparison with the Second Swedish National Communication under the Climate Convention (NC2)

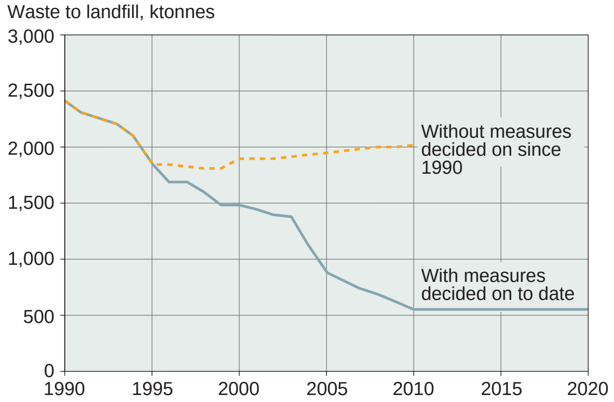
Future forest carbon sinks are heavily dependent on future felling rates. Current forecasts indicate a felling rate in line with that during 1998 – 2000. The future carbon sink in Swedish forests is therefore expected to be approximately the same as that during 1998 – 2000, subject to fluctuations in the economic climate. In NC2 it was estimated that forest sinks of carbon dioxide would decrease from 29,000 ktonnes carbon dioxide in 2000 to 22,000 ktonnes in 2010. This assessment was based on the assumption that the felling rate would increase somewhat.

4.1.8 Waste

Decomposition of organic matter under anaerobic conditions produces methane, some of which may be emitted into the atmosphere. The main emissions in the waste sector are of methane from landfill sites. Other sources are considered minor and have not be included in national emission statistics. Waste contributed about 3 per cent of total greenhouse emissions in 1999.

Future methane emissions from landfill sites have been estimated on the assumption that measures already decided up to 2000 will be implemented, and that account is taken of the effectiveness of those measures. The effects that would arise if no measures were taken between 1990 and 2010 are also shown.

Figure 4.7
Landfilled quantities of household and park waste, sludge and organic industrial waste in the two scenarios.



Source: Swedish Environmental Protection Agency, calculations performed by Statistics Sweden

Assumptions

Emissions of methane from landfill sites have been estimated using the method used to estimate emissions between 1990 and 1999 (see also section 4.3). The estimates are based on historical quantities of landfilled waste and assumptions as to future quantities.

Historical figures have been derived using available national waste statistics and, where there are no such statistics, assumptions have been made about future landfill quantities.

All types of waste with a significant organic content have been considered, including household waste, sludge from municipal sewage works, pulp and paper sludge, park waste and other organic waste from industry. Estimates of future landfill quantities in the two scenarios have been made by the Swedish EPA in consultation with other experts from the waste management industry and universities. The scenario where no measures are taken after 1990 assumes that quantities of landfill will correspond to historical or actual quantities up to 1995. Only after 1995 is it considered that measures taken since 1990 will have had any effect on landfill quantities. The basis for these calculations should be regarded as uncertain, particularly with regard to organic industrial waste.

The diagram below shows landfill quantities in the two scenarios.

In the scenario based on measures currently decided, there will be a sharp decrease in landfill quantities to 2010. The most important measures are:

- Ban on landfilling burnable waste from 2002
- Ban on landfilling organic waste from 2005
- Landfill tax introduced in 2000
- EC Landfill Directive 1999

Table 4.15
Forecast of percentage of gas collected 2000 – 2020

Year	Percentage of gas collected[1]
2000	47
2003	51
2006	54
2008	60
2010	55
2015	50
2020	40

The lack of an alternative to landfill for the various waste types will cause a time lag before the measures take effect. Household waste quantities are expected to have fallen by 55 per cent between 1998 and 2005. The decrease will be small at first, because of a lack of alternative capacity. This shortfall is expected to be two thirds of the increased requirement in 2002. The situation will gradually improve and the problem is expected to have been solved by 2005. There is also expected to be a lack of alternative methods for dealing with sludge from municipal sewage treatment works; full capacity is not expected to be achieved until 2010. Landfilled quantities of other types of waste are expected to have fallen sharply by 2005, and then to remain constant. It should be added that it is not considered possible to reduce the quantity of landfilled organic waste to zero.

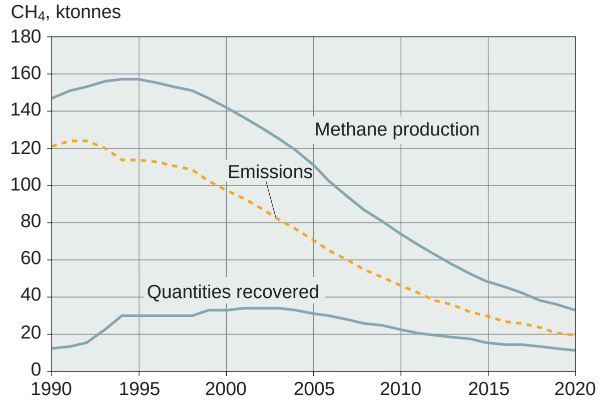
79 per cent of landfilled material was sent to sites with gas collection facilities in 2000. An average of around 60 per cent of gas was recovered there, which gives an overall collection figure of 47 per cent. It is expected that 100 per cent of waste will be landfilled at sites with gas collection facilities in 2008, which will raise the average collection figure to 60 per cent. Collection will become less efficient after 2010 as the organic content of landfilled waste declines as a consequence of the ban on landfilling organic waste, among other things.

Emissions of methane from landfill sites

These results must be treated with great caution because of the uncertainties in the model used and data on which the calculations are based. Several factors contribute to this uncertainty: doubts in the estimates of waste quantities, estimates of gas production (DOC_F), proportion of degradable carbon (DOC) in household waste, and the half-life of degradable carbon.

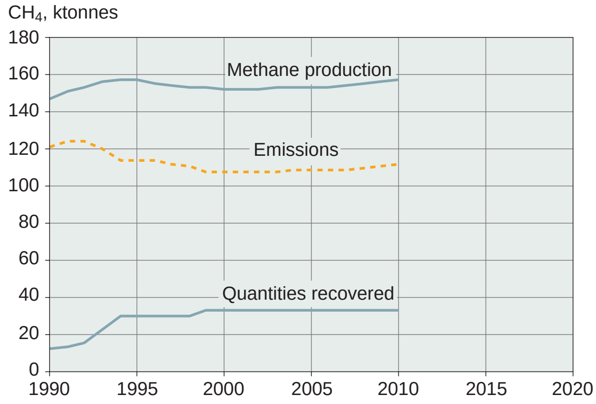
[29] Ongoing project at five landfill sites in Sweden; monitoring and evaluation is being performed by Tema vatten at Linköping University and Chalmers University of Technology.

Figure 4.8
Emissions of methane based on measures currently decided (1990 – 2020)



Source: Swedish Environmental Protection Agency, calculations performed by Statistics Sweden

Figure 4.9
Emissions of methane assuming no measures are taken after 1990 (1990 – 2010)



Source: Swedish Environmental Protection Agency, calculations performed by Statistics Sweden

The comparisons between model results and figures previously obtained in the field at Swedish landfill sites accord well with the results calculated using IPCC methodology.[29]

However, a recent comparison of readings taken in the field with the results presented in this report produce other results. The field results indicate substantially lower emissions.

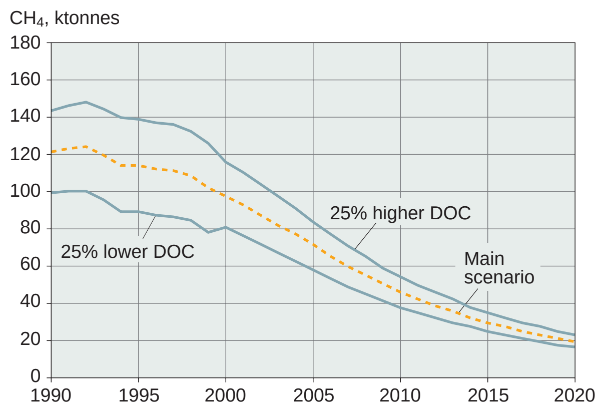
For the sake of comparison, emissions of methane from landfill sites without any measures being taken in the 1990s have been estimated. This provides a basis for estimating the combined effects of measures in the waste sector.

Sensitivity analysis of estimates of future emissions from the waste sector

Sensitivity analyses have been performed for some of the above parameters to gain an impression of the potential impact on results. The significance of historical assumptions was evaluated and, in summary, the result was that they had a fairly major impact on results for the early 1990s, but a much smaller one on results later that decade.

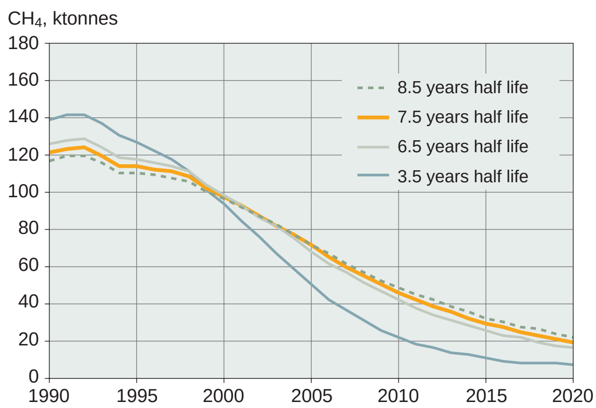
Since the scenarios mainly cover periods further in the future, the historical assumptions are even less important. The significance of the parameter measuring the proportion of degradable organic carbon that is turned into methane (DOC_F) was also analysed. This has a great impact on calculation results, with a margin of uncertainty of between 0 and 30 per cent. Household waste is the most important type here, and as well as knowing what quantities are landfilled, it is necessary to know how much of the waste comprises organic fractions. These figures are uncertain, and following evaluation of the analyses of household waste content, it is not uncommon for the results for various fractions to differ by around 25 per cent. Half-life is another parameter that is examined in greater depth.

Figure 4.10
Differences in the DOC content of household waste (scenario involving measures currently decided)



Source: Swedish Environmental Protection Agency, calculations performed by Statistics Sweden

Figure 4.11
Some half-life figures for methane formation (scenario involving measures currently decided)



Source: Swedish Environmental Protection Agency, calculations performed by Statistics Sweden

Table 4.16
Total emissions to 2020 of greenhouse gases from waste, ktonnes carbon dioxide equivalent emissions per year.

Greenhouse gas	1990	1992	1994	1996	1998	1999	2010	2020
Waste, CH_4	2,554	2,607	2,406	2,367	2,284	2,147	966	407
Total, sector	2,554	2,607	2,406	2,367	2,284	2,147	966	407

Source: Swedish Environmental Protection Agency

The assumed half-life of 7.5 years is considered reliable under Swedish conditions. A margin of error of 1 – 2 years has little impact on the results.

Total greenhouse gas emissions from the sector
Emissions of methane from waste management are expected to have fallen from 102 ktonnes in 1999 to 46 ktonnes in 2010 and 19.4 ktonnes in 2020.

Comparison with the Second Swedish National Communication under the Climate Convention (NC2)
In NC2 it was estimated that methane emissions from waste would fall from 42 ktonnes in 2000 to 20 ktonnes in 2010. This may be compared with the new estimate, which is that methane emissions from waste will fall from 102 ktonnes in 1999 to 46 ktonnes in 2010.

A completely new method has been used in NC3. This takes account of the slow rate of decomposition of organic matter at landfill sites. Methane formation is therefore expected to continue long after organic matter has been landfilled. In addition, the new projections take into consideration the measures decided up to 2000, which have a major influence on the quantity of organic matter that will be landfilled in 2005 and subsequent years.

4.1.9 Projections and scenarios for Swedish emissions of "non-greenhouse gases"

The balance between incoming and outgoing radiation around the globe and in the atmosphere is affected by the true greenhouse gases carbon dioxide, methane, nitrous oxide, as well as the halocarbons. A number of other air pollutants also have an indirect effect. These include sulphur dioxide, which, once it has been oxidised into sulphate, produces small air-borne particles (aerosols). These aerosols affect the radiation balance, the main effect being a lowering of the average global temperature. Emissions of nitrogen oxides, carbon monoxide and VOCs cause the creation of tropospheric ozone, which is a greenhouse gas, and which therefore raises the average global temperature. These latter emissions also have an impact on particle formation in the atmosphere. Taken together, indirect greenhouse gases have a more than negligible effect on the global radiation balance.

Within the framework of the Convention on Long-Range Transboundary Air Pollution (CLRTAP), Sweden has signed the new protocol on reducing acidification, eutrophication and ground-level ozone ("the Gothenburg Protocol" 1999). This protocol is binding under public international law and will be implemented by the government bill entitled "Swedish Environmental Objectives".[30] Accordingly, Sweden has undertaken to reduce its emissions to below a given ceiling by 2010. A new EC directive on emission ceilings for air pollutants has been negotiated and implemented somewhat later than the Gothenburg Protocol. The two agreements have largely the same aim – to reduce pollution

[30] Gov. Bill 2000/01:130. Swedish environmental objectives
[31] ibid.
[32] According to a Council decision in October 2000

Table 4.17
Emission commitments in 2010 under CLRTAP as specified in the Gothenburg Protocol and the EC directive on national emission ceilings for certain air pollutants. Emissions in ktonnes, 2010.

Agreement/gas	SO_2	NO_X	VOCS	NH_3
CLRTAP-Gothenburg Protocol[31]	67	148	241	57
EC Directive[32]	67	148	241	57

Source: Swedish Environmental Protection Agency

in Europe. The emission targets for indirect greenhouse gases and the emission levels set in the above government bill should be regarded as planned measures.

4.2 Evaluation of the combined effect of policy and measures

The overall effect of targets and measures in the various sectors includes the effects of all instruments (economic and fiscal instruments, voluntary commitments, regulation and administrative instruments, information, education, training and research). In some instances it is possible to quantify the effect of individual instruments or packages of instruments using models or separate evaluations.

4.2.1 The energy sector (including transport) and its carbon dioxide emissions – an evaluation of instruments

In the scenario to 2010 it is estimated that carbon dioxide emissions from the energy sector[33] will remain largely the same as they were in 1997. The scenario calculations are based, inter alia, on forecasts of economic growth and fuel prices. It is further assumed that the instruments of current energy and environmental policy will apply throughout the scenario period.

The instruments affecting emission trends changed in the 1990s. Overall, these changes took the form of more stringent measures to reduce emissions or limit emission increases.

The effects on (carbon dioxide) emissions from the energy system due to changes in economic instruments in the 1990s are presented below. The effects result from raised energy and environmental levies, and effects of investment and operating subsidies available for energy generation from renewable sources.

Model calculations have been performed using two sets of economic instruments: "1990 instruments" and "current instruments". The MARKAL model has been used (see method description in Appendix 4A). Two parallel scenario calculations have been made. The difference in emissions from the energy system resulting from changes in instruments can be identified because the other assumptions on which the calculations are based are the same in both scenarios.

Since it is difficult to assess the effects of the various instruments, it is important to stress that all figures involve a degree of uncertainty. The results should therefore be treated with great caution. The "current instruments" scenario (1 January 2001) assumes that energy and carbon dioxide taxes will be in place throughout the period studied. It is also assumed that current operating subsidies for wind power will apply until the end of 2002. As from 2003, it is assumed that electricity generated by wind power, biomass-fuel based combined power and heat and small-scale hydropower will fall under a certificate system encouraging the use of these forms of energy.[34] For modelling purposes, it is assumed that the subsidy is SEK 0.15/kWh and covers all forms of renewable energy. The current subsidies available are in the range SEK 0.06 – 0.30/kWh, depending on the kind of energy.

Current energy and carbon dioxide taxes are shown in the table below. Industry pays no energy tax and

[33] The energy sector includes emissions from combustion at power and district heating plants, as well as industry, combustion for domestic heating and transport.

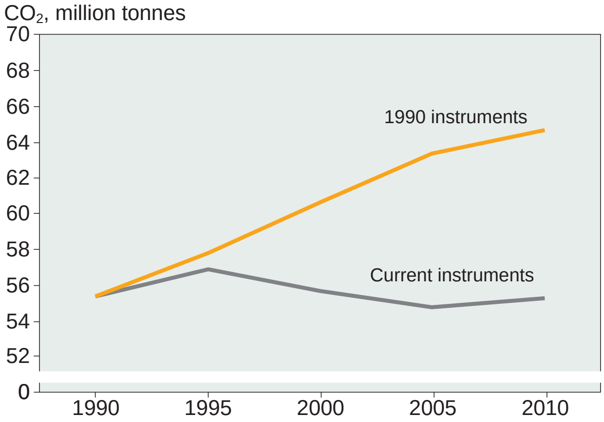
[34] The reason we include this certificate system in the "current instruments" scenario is that parliament has decided that a system of this kind is to be introduced as of 2003. The form the system should take is currently being studied (by "the ELCERTH Commission").

Table 4.18
Energy and carbon dioxide taxes in the "current instruments" scenario, SEK/MWh

	Energy tax	CO_2 tax	CO_2 tax industry
Oil, gasoil	70	154	54
Oil, HFO	64	141	49
Coal	40	181	63
Natural gas	21	106	37
LPG	10	126	44
Petrol	377	142	50
Diesel	206	154	54
Electricity	181		
Electricity, heating plants etc	158		

Source: National Energy Administration

Figure 4.12
Total carbon dioxide emissions in the two scenarios, carbon dioxide, Mtonnes



Source: National Energy Administration

reduced-rate carbon dioxide tax. Current instruments also include a sulphur tax of SEK 30/kg emitted sulphur. There is also a NO_X levy on large combustion plants. This is not included in the description, however.

The "1990 instruments" scenario assumes that taxes in 1990 (in force from 1 January 1990) are in place throughout the period studied (see table below). There was no carbon dioxide tax in 1990; it was introduced on 1 January 1991. Energy tax at that time was also levied on industrial energy consumption. There was no VAT on energy use and the sulphur tax and NO_X charge had not yet been introduced. VAT was imposed on energy on 1 March 1990. There were no operating subsidies for wind power or investment subsidies for specific energy technologies.

Electricity generation in both scenarios is exempt from energy and carbon dioxide tax. Fuel used for the heat component of combined power and heat

Table 4.19
Energy taxes in the "1990 instruments" scenario, SEK/MWh

	Energy tax
Oil, Eo1	109
Oil, Eo5	100
Coal	62
Natural gas	32
LPG	16
Petrol	303
Diesel	109
Electricity	92
Electricity, industry	70
Electricity, heating plants etc	92

Source: National Energy Administration

production is subject to energy tax in the 1990 instruments scenario. Heat production is subject to full carbon dioxide tax and 50 per cent energy tax in the current instruments scenario.

Results

Estimates of emissions from the energy system in relation to different instruments result in differing use of fossil fuels and hence variations in carbon dioxide emissions. The current instruments scenario leads to much lower emissions than does the 1990 instruments scenario. Estimated emissions of carbon dioxide will eventually be 15 – 20 per cent lower on the basis of current instruments as compared with retention of 1990 instruments. It is estimated that total carbon dioxide emissions in 2010 will be 55 Mtonnes with current instruments and 65 Mtonnes with 1990 instruments, a difference of 10 Mtonnes. The current instruments scenario indicates that carbon dioxide emissions in 2010 will be about the same as they were in 1990 (55.4 Mtonnes). However, it must be borne in mind that both the 2010 scenarios assume net electricity imports of just over 4 TWh. The emissions this may entail are not included in the calculations. Sweden exported 3 TWh in 1990.

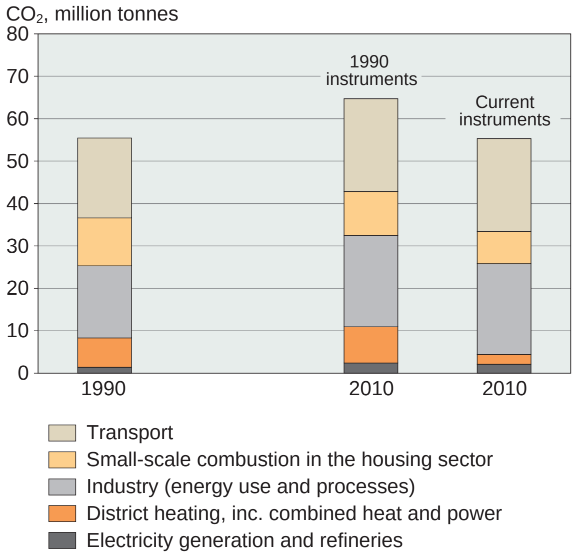
In all likelihood, the estimated difference in emissions is an underestimate of the actual effect, since calculation using the MARKAL method does not include the impact on energy use of differences in energy prices. In most cases, taxes are lower in the 1990 instruments scenario and a greater demand for energy can therefore be expected there, the size of the difference depending on the price difference and the end-user sector involved.

In the 1990 instruments scenario, carbon dioxide emissions would mainly be greater from district heating production and individual heating of private homes and commercial/industrial premises. It is important to remember that the current tax system is not being compared with a case with no instruments at all. As long ago as 1990, Sweden had imposed certain taxes on fossil fuels, which effectively discouraged their use, in favour of renewable energy production. A scenario entirely without taxes on fossil fuels would result in even higher carbon dioxide emissions.

District heating production

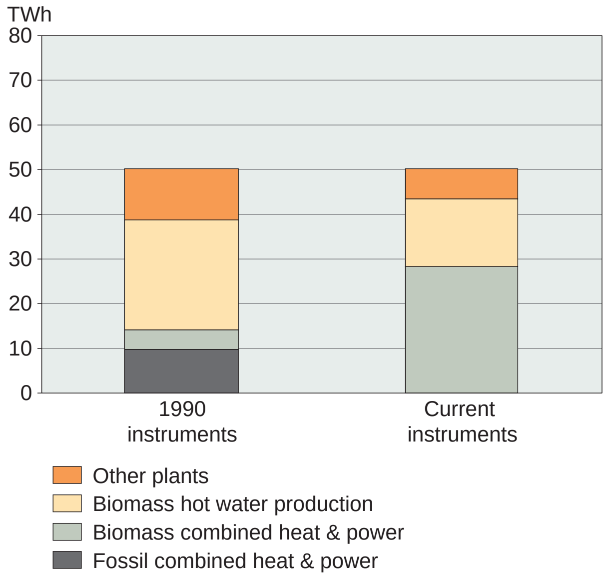
District heating is the sector where the effects of changes in instruments are greatest. The increase in carbon dioxide emissions in the 1990 instruments scenario can be explained by greater use of fossil fuel-based combined power and heat production. The reason the increase is not greater is that biomass fuel-based hot water production will remain competitive

Figure 4.13
Effects of economic instruments during 1990 – 1999, broken down into various sectors, carbon dioxide, Mtonnes



Note 1: The model calculation only produces marginal differences in emissions from the industrial sector, and no differences in emissions from transport (see comments further on).

Figure 4.14
District heating production in 2010 with "1990 instruments" and "current instruments"



Source: National Energy Administration

even at the tax rates involved using 1990 instruments.

The current system of instruments has a different effect on the growth in district heating production. The grants paid to biomass fuel-fired combined power and heating plants, combined with the high tax on the use of fossil fuels, will result in a substantial expansion of biomass fuel-based combined power and heating production even by 2010. More than half of district heating will then be generated from this source. The portion that is not biomass fuel-based combined power and heating will mostly comprise biomass fuel-based hot water production. Hence, biomass fuels will be by far the most used fuels for district heating production in the current instruments scenario.

Electricity consumption and production

Electricity consumption will be greater in the current instruments scenario than in the 1990 instruments scenario. One reason for this is that the system of subsidies for wind power and biomass fuel-based combined power and heat production will reduce production costs.

In addition, electricity will become more competitive as much higher taxes are imposed on energy consumption based on fossil fuels. The difference in electricity consumption between the two scenarios can largely be explained by differences in consumption for heating homes and commercial/industrial premises. Both water-borne electric heating and heat pumps will be more widely used in the current instruments scenario. By 2010, the difference in electricity consumption for heating would be approximately 5 TWh.

Electricity production differs in the two scenarios, mainly because it is assumed there will be a certificate system, here represented by a subsidy of SEK 0.15/kWh for electricity generated by wind power, biomass fuel-based combined power and heat and small-scale hydropower.[35] Moreover, taxes on fossil fuels will be considerably higher in current instruments the scenario. Most electricity generation, large-scale wind power and nuclear power is essentially the same in the two scenarios.

On the basis of current instruments, wind power will have been developed fairly substantially by as early as 2005. The entire assumed terrestrial production potential (4.5 TWh per year) will be in use by 2010. Combined power and heat production will also increase between 2005 and 2010.

Individual home heating

The relative popularity of various heating systems for homes and commercial/industrial premises will be appreciably affected by the two systems of instruments. Expressed simply, current instruments make electricity more competitive, whereas oil has become less so because the taxes on oil have risen more than those on electricity. In addition, the price of electricity[36] around 2010 will be somewhat lower in the current

[35] Solar cells and biomass fuel condensing power plants are also included in the certificate subsidy, although these alternatives are not being used.

[36] "Electricity prices" means the "shadow price" of electricity production (which is roughly the same as the marginal cost of electricity production). The shadow price of electric energy is one of the calculation results in the model.

instruments scenario owing to the subsidies for wind power, biomass fuel-based combined power and heating, and small-scale hydropower. Biomass fuels and district heating will also be more competitive. Total energy consumption will rise in both scenarios.

Industry

Industrial energy consumption differs only marginally in the two scenarios. As discussed earlier, the model calculations performed do not include any adjustment of the demand for energy as a result of energy price changes.

Many of the taxes on electricity and fuels for use in industry are lower in the current instruments scenario than in the 1990 scenario. This applies particularly to electricity. Current instruments may therefore increase energy demand somewhat. This has not been separately calculated, however.

Transport

The calculations show the same trend for the transport sector in both instrument scenarios.

Alternative fuels become more competitive in the current instruments scenario because tax on petrol and diesel rises. However, this is not enough for the model to indicate any changeover from one fuel to another due to these tax differences. Since the model does not reflect adjustment in demand (less transport or less fuel consumption) resulting from the raised taxes in the current instruments scenario, the MARKAL model has been supplemented with a separate calculation of the effect of taxes on petrol and diesel consumption.

Petrol and diesel are used almost exclusively for road transport, and represent just over 80 per cent of total energy consumption in the transport sector (not including bunker fuels for international shipping). The calculations of the effects of raised taxes on petrol and diesel have made use of price elasticity. Price elasticity is assumed to be -0.7 for petrol and -0.2 for diesel.[37] The model indicates that petrol consumption would have been just over two per cent higher in 2010 in the 1990 instruments scenario than in its current instruments counterpart. This represents just over 1 TWh, ie, emission of 0.3 million tonnes of carbon dioxide. Consequently, petrol demand is relatively inelastic, ie, it is not much affected by price rises. However, prices are now so high than they may arguably be having some effect, ie, demand is becoming more elastic. Diesel price elasticity is lower than that for petrol, which automatically means that there is less impact on diesel consumption. Diesel consumption would only be marginally affected.

Conclusions in summary

Use of biomass fuels is being greatly stimulated by current instruments. Much of the increase is occurring in district heating production. Use of biomass fuels also increases in the 1990 instruments scenario, albeit at a considerably slower rate.

The differences between the instrument scenarios are most obvious when it comes to district heating production. According to the current instruments scenario, more than half of district heating production will be biomass fuel-based combined power and heat production in 2010. The portion that is not biomass fuel-based combined power and heating mostly comprises biomass fuel-based hot water production.

Electricity consumption will increase using current instruments as a result of cheaper electricity generation (because of the SEK 0.15/kWh subsidy) and more costly alternatives (the tax on fossil fuels has risen more than the tax on electricity).

Electricity generation using biomass fuel-based combined power and heat production, wind power and small-scale hydropower will increase and will be introduced earlier because of current instruments, thanks to the subsidy of SEK 0.15/kWh. Wind power would not be competitive on the basis of 1990 instruments.

Electricity for heating and heat pumps will be used more in the current instruments scenario. Use of biomass fuels in industry falls somewhat in both scenarios. The current instruments scenario improves the scope for using alternative fuels because of the higher tax on petrol and diesel. However, this is not enough to bring about any changeover in fuel use.

When interpreting these results, it is important to remember that the certificate system has been simulated with a notional subsidy of SEK 0.15/kWh for certain alternative forms of electricity generation. This is an estimate, taken as an average over the whole period.

Bearing in mind the other uncertainties, the level selected should be regarded as a good approximation. At present, no-one can predict with any degree of certainty the level at which the certificate price will be set or how it will vary over time.

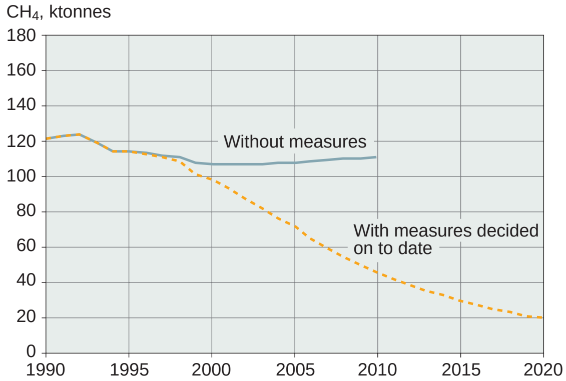
4.2.2 Waste

The estimated combined effect of measures taken since 1990 to limit methane emissions into the atmosphere is presented below.

The total effect of measures decided since 1990 is obtained by comparing the two scenarios. The effect of measures taken in the 1990s could not be discerned until 1995. The scenario without any decided measures indicates that emissions would remain at their 1995 levels (ie, about 115 ktonnes per year) until 2010. In

[37] "Bensinskatteförändringars effekter" (Effects of Changes in Petrol Taxation"). Expert Group for Studies in Public Sector Economics, government report Ds 1994:55

Figure 4.15
Methane emissions (tonnes per year) in two scenarios, one involving current instruments, and the other assuming the instruments decided on in 1990



Source: Swedish Environmental Protection Agency, calculations performed by Statistics Sweden

the scenario based on current measures, emissions fall so that they will be approximately 50 per cent lower in 2010 than they were in 2000, ie, about 46 ktonnes a year. This decrease continues and by 2020, emissions will be approximately 80 per cent lower than in 2000, ie, around 20 ktonnes a year.

The scenario without measures indicates a certain increase in methane emissions because the quantity of household waste is expected to increase in proportion to consumption.

Other types of waste are expected to remain virtually at the same level as they were in 1995. The current instruments scenario indicates a sharp fall in the quantity of landfill by 2020. The most important measures are:[38]

- Ban on landfilling burnable waste from 2002
- Ban on landfilling organic waste from 2005
- Landfill tax introduced in 2000
- EC Landfill Directive 1999

4.3 Projection methods

Three main model types have been used for projections and scenarios in the Third National Communication.

- Economic-technical models for energy use (National Energy Administration) and energy supply (MARKAL) combined with analytical models for future transport demand (SIKA's passenger and goods transport model).
- Spreadsheet models in which expert assessments are made of future changes in premises (activity data and emission factors). Emissions are quantified using IPCC/UNFCCC methodology.
- Statistical analyses and supplementary expert assessments.

Table 4.20 Method/model for quantifying projects and scenarios for greenhouse gases in each sector

Sector/greenhouse gas	Energy	Transport	Industry	Agriculture	Forestry	Waste
CO_2	MARKAL Ec. model	MARKAL SAMPERS SAMGODS Ec. model	Trend analysis Expert assess.	Expert assess. Spreadsheet model	Expert assess. Spreadsheet model	NA
CH_4	Trend analysis Expert assess.	Trend analysis Expert assess.	Trend analysis Expert assess.	Expert assess. Spreadsheet model	NA	Expert assess. Spreadsheet model
N_2O	Trend analysis Expert assess.	Trend analysis Expert assess.	Trend analysis Expert assess.			
HFCs	NA	NA	Expert assess. Spreadsheet model	NA	NA	NA
PFCs	NA	NA	Expert assess. Spreadsheet model	NA	NA	NA
SF_6	NA	NA	Expert assess. Spreadsheet model	NA	NA	NA

Source: Swedish Environmental Protection Agency

Method for carbon dioxide emissions from the energy sector, including transport

The scenarios for carbon dioxide emissions from the energy sector are based on calculations and assessments of developments in the energy system. The energy system comprises energy use as well as supply. Scenarios have been produced for various energy sub-sectors. These are then combined to form an "energy balance". Energy consumption is balanced by energy supply. In addition to end use in industry, housing and services, and transport, the user side also includes conversion and distribution losses, as well as international shipping. The supply side comprises total supply of fuel and hydropower generation, nuclear power generation, wind power and net import of electricity. The methods and analyses used are based on a socio-economic perspective. One fundamental assumption is that total energy use and the relative use of various types of energy will adjust in line with anticipated energy prices, the economic climate and technical developments. International developments are also placed in relation to the Swedish system. A more detailed description is given in Appendix 4A.

Method for expert assessments and use of spreadsheet models

The basic approach is the methodology used to determine emissions of greenhouse gases developed by the IPCC and used in the common reporting format under the Climate Convention. In some cases, UN methodology has been supplemented with national emission factors or has been expanded to better describe national conditions. These calculations principally require input data in the form of activity data, emission factors, correction factors and their changes over time. Assessments have been made of the way this input data changes over time as a consequence of the objectives and measures decided up to 1999. This has been done in consultation with experts at various agencies and trade organisations. The advantage of these models is that the same type of input data is used for historical emissions and the time series is thus congruent. The drawback is that input data for the calculations must be determined independently – often in the form of output data from another model or with the help of experts.

Spreadsheet models of this kind are used for projections for halocarbons, methane and nitrous oxide from agriculture, forest sinks of carbon dioxide and methane from waste (landfill).

Calculation methods for emissions of fluorinated greenhouse gases[39]

Projected emissions of fluorinated greenhouse gases (HFCs, PFCs and SF_6) are based on the same methodology as that used to quantify historical emissions. Changes over time in the parameters and variables involved have been assessed by experts at the Swedish Environmental Protection Agency in consultation with other experts at trade organisations, universities and elsewhere.

Estimates of future emissions have been made in the light of available information on, and indications of, future use of HFCs/PFCs/SF_6 from each industry, and also based on discussions with experts on specific industries at the Swedish EPA and industry representatives. Much of the information supplied by industry representatives has been fairly imprecise. This information has then been reinterpreted for use as input data for activity and emission factors.

The factors that may be included as assumptions in the calculations are itemised below.

This is a "gross" list not all factors are relevant to all applications.

- Increase in the number of units (eg, that more cars are expected to be sold and that the proportion of them fitted with air conditioning will increase).
- Changes in the quantity installed (product development often improves efficiency, so that less refrigerant is required).
- Changes in leakage/emission factors (design and handling is improved).
- Changes in the proportion of units using HFCs (hydrocarbons are increasingly being used in refrigerators).
- Emissions when products are manufactured.
- Emissions when products are destroyed.

Calculation methods for emissions of methane and nitrous oxide from agriculture

Projected emissions of methane and nitrous oxide are based on the methods used to quantify historical emissions. Changes over time in the parameters and variables included, such as number of animals, use of manure and artificial fertiliser, and area under cultivation, have been included in the calculations. Doubts attach to the assessment of developments in agricultu-

[38] See the section entitled "Measures and instruments in the field of waste policy" for more detailed information.

[39] Environmental Research Institute Report: "Scenarier för emissioner av fluorerade växthusgaser" ("Scenarios for emissions of fluorinated greenhouse gases") – preliminary June 2001

[40] National Board of Forestry 2000. Skogliga Konsekvensanalyser 1999. Skogens på 2001-talet ("Forest Impact Analyses 1999. Forest potential in the 21st century"). National Board of Forestry, Jönköping. ISSN 110-0295

[41] Swedish EPA Report 5169

[42] Statistics Sweden: Environmental Accounts Report 2000:3

re, both for 2010 and for 2020, mainly because the CAP only extends to 2006.

Calculations methods for removals of carbon dioxide in forestry

Projected removals of carbon dioxide in forest bio-mass are based on National Board of Forestry impact analyses, which are mainly intended to quantify forest growth to meet the needs of forestry. The model takes into account felling, forest growth dynamics and the impact of use of nitrogenous fertilisers, but not climate change.[40]

Calculation methods for emissions of methane from waste[41]

Projected methane emissions from waste are based on the methods used to quantify historical emissions. Changes over time in the parameters and variables included have been assessed by experts at the Swedish Environmental Protection Agency in consultation with other experts at trade organisations, universities and elsewhere.

Standard Climate Convention methodology has been used to estimate future methane emissions from landfill sites. However, following evaluation, the method has been modified to suit Swedish conditions better.[42]

The method is "top-down", ie, quantities of landfilled waste are first multiplied by gas potential and emission factors. Because of the time lag in methane formation, gaseous emissions from a given quantity of landfill are distributed over the years according to a declining exponential function.

Emissions a given year are estimated by adding together the emission contribution from the previous years, deducting gas recovered and reducing the result by a factor representing the reduction in emissions due to methane oxidation in the surface layer of landfill.

The quantity of methane generated depends on the gas potential of the waste landfilled and the point at which it is considered the potential is realised in the form of emissions. Gas potential depends on the total quantity landfilled and the fraction of the waste that is degradable, eg, organic waste. The quantity of methane generated is calculated as the sum of gas contributions from landfill over all years.

Method for statistical analysis and expert assessment of emissions

In addition to the specific studies made using the above models, projections have been made for the other emissions from the respective sectors. This is based on emissions between 1990 and 1999, which have been analysed in terms of linear trend, and some cases with supplementary information on sector-specific parameters (such as the production value in a given industry) to provide a higher degree of explanation of the variability in the data series. Standard errors (squared mean deviation) have also been calculated.

All series have first been analysed for the linear trend using regression analysis. Emissions of methane from transport are falling rapidly; the emission series was made logarithmic prior to statistical linear analysis in order to better describe the process.

In many cases, results become substantially less certain if an additional explanatory parameter is added. This may be because the two parameters "year" and "sector-specific" are not mutually independent. In other cases, there may be too little correlation between the sector-specific parameter and emissions in the sector and, as a result, it has not been included in the model. Only the linear time-dependent trend has been used where the degree of explanation has declined dramatically in relation to several explanatory variables.

The statistical analysis has then been supplemented with expert assessments by the Swedish EPA of potential future emission trends in the light of technical and economic developments.

Strengths and weaknesses. The strength of this type of expert assessment is that there is a time series that can be analysed and that the uncertainty in the model can be quantified.

The drawback of the simple analysis is that the models do not specifically take into account any overlaps or synergies between sectors or policy areas. The estimates of future emissions must therefore be supplemented with expert assessments of the potential impact of current political objectives, measures and instruments on emissions.

References

Energimyndighetens Klimatrapport (”National Energy Administration Climate Report 2001”.) Report ER 13:2001, National Energy Administration, 2001.

Energi och Klimat i Sverige – Scenarier 2010, ("Energy and Climate in Sweden – Scenarios 2010"), National Energy Administration, 4:2000 SOU 2000:23 Förslag till svensk klimatstrategi (SOU 2000:23 "A Proposed Swedish Climate Strategy")

Framtida utsläpp av fluorerade växthusgaser ”Future emissions of fluorinated gases”) Report 5168.
Swedish EPA, 2001

Economic Evaluation of Emission Reductions of Nitrous Oxides and Methane in Agriculture in the EU. Contribution to a Study for DG Environment, European Commission by Ecofys Energy and Environment, AEA Technology Environment and National Technical University of Athens. Final Report November 2000.

Skogsstatistisk årsbok 2000 ("Yearbook of Forestry Statistics 2000"), National Board of Forestry, Jönköping, ISSN 0491-7847

Skogsstyrelsen 2000. Skogliga Konsekvensanalyser 1999 – Skogens möjligheter på 2000-talet. (" Forestry Impact Analyses 1999 - Forest Potential in the 21st Century"), National Board of Forestry 2000, Jönköping. ISSN 1100-0295.

Anonymous 2000. Skogsdata 99. Inst för resurshushållning och geomatik, Swedish University of Agricultural Sciences, Umeå. ISSN 0240-0543.

Proposition 2000/01:130 Svenska miljömål (Gov. Bill 2000/01:130 "Swedish Environmental Objectives")

Framtida metanemissioner från deponier (“Future methan emissions from landfills”). Report 5169, Swedish EPA, 2001.