1 National conditions of significance for greenhouse gas emissions and removals

1.1 Introduction

Emissions and removals of greenhouse gases are affected by prevailing environmental and social conditions in the country. National conditions also affect a country's ability to deal with problems by reducing emissions and increasing sinks. This chapter gives a background description of conditions having a bearing on emissions and removals of greenhouse gases, and conditions affecting the potential for remedial action. Important national conditions include the energy required by trade and industry, for transport, heating and electricity generation, with accompanying emissions of carbon dioxide, as well as the impact of agriculture and forestry on soils and their emissions of greenhouse gases such as carbon dioxide, methane and nitrous oxide. Other political considerations, such as the aims of regional and labour market policy, are also involved. For countries in the boreal coniferous belt, the forest is of great importance as a means of increasing the sink of carbon dioxide and for energy conservation.

Other important national conditions concern economically, socially and environmentally sustainable development and the scope for achieving the targets set by international commitments and national decisions. Since Sweden joined the EU in 1995, it is necessary in some cases to describe the conditions arising as a result of membership.

1.2 Swedish form of government, parliament and public authorities

Sweden is a democracy; 349 elected representatives sit in parliament, the Riksdag. General elections take place every four years. Citizens are allowed to vote from the age of 18. The speaker of the Riksdag proposes the prime minister, who will form a government, to be approved by parliament. The power of government thereby stems from the people.

The Swedish constitution comprises four parts: the form of government, the order of succession, the freedom of the press ordinance and the constitutional freedom of speech. These govern the relationship between the legislature and the judicature, as well as the freedoms and rights of the individual. Amendments to the constitution are subject to special provisions, one of which is that amendments have to be passed by two different parliaments. There are also detailed rules of parliamentary procedure. Under the constitution, the government makes decisions collectively and individual public authorities are independent under the government.

The government puts proposals (bills) before parliament for discussion and voting before they become law. Important matters of policy (such as energy and climate policy programmes) are also presented to parliament for its approval. Government bills are drafted by the Cabinet Office, which currently comprises ten departments, the Prime Minister's Office and an administrative department. Members of parliament are also entitled to put proposals before parliament in the form of motions. Parliamentary decisions are discussed by special committees, which consider all government proposals. These committees can also present their own proposals to parliament.

Sweden has a large number of central authorities, whose task is to serve as the government's expert body on specific issues and to implement the policy decided by parliament and the government. However, these agencies act independently in their role as public authorities. Sweden also has 21 county administrative boards and 289 municipalities, which decide on matters of a regional and local nature, respectively. Responsibility for climate is shared by several central agencies, including the Swedish Environmental Protection Agency, the National Energy Administration, the Swedish Institute for Transport and Communication Analysis (SIKA), the transport agencies (the National Rail Administration, the National Road Administration, the National Maritime Administration, the Civil Aviation Administration), the Swedish International Development Agency (Sida), Statistics Sweden (SCB), the National Board of Housing, Building and Planning, the National Board for Industrial and Technical Development (NUTEK) and the recently created agency for innovation systems (VINNOVA), the National Board of Agriculture (SJV), the National Board of Forestry (SKS) and the Swedish Meteorological and Hydrological Institute (SMHI). County administrative boards and municipalities also play an important part in formulating local plans for social planning, energy conservation, traffic and waste, and in implementing these plans.

The power of government is exercised centrally by the government itself, via the central administrative

authorities, via regional authorities, the 21 county administrative boards, and via Sweden's 289 municipalities.

Swedish membership of the EU means that some areas of national policy are, to a greater or lesser extent, governed by EC directives, which must be incorporated in national legislation or by EC regulations, which apply directly. Membership of the EU also enables Sweden to influence EU common policy in important areas that have a direct or indirect impact on climate.

1.3 Population

The population of Sweden rose from approximately seven million in 1950 to approximately 8.9 million in 2000.[1] The population grew by about 270,000 people between 1990 and 1999, which represents an increase of about 3 per cent per decade. The population grew by 21,366 in 2000, the largest rise since 1995. However, the rate of increase is expected to slow in the long term. Nativity has fallen in recent decades and the birth rate is now lower than the death rate. There were just over 2,000 fewer births than deaths in 2000, compared with just over 6,000 in 1999 and 4,000 in 1998. Population growth is instead due to the compensatory effect of immigration, which has been greater then emigration. The population is expected to peak at about 9.5 million around the year 2050.[2]

The population of Sweden is ageing and the base of the population pyramid is shrinking.

Nativity fell from approximately 2.0 children per female in 1990 to approximately 1.5 children per female in 1998. At the same time, life expectancy has risen over the last 30 years. In 1970 it was 72 years for men and 77 for women; by 1999 it had risen to 77 years for men and 82 for women.

Nearly 85 per cent of the Swedish population live in urban areas; 65 per cent live in urban areas with over 10,000 inhabitants. The three main conurbations (Stockholm, Gothenburg and Malmö) have a combined population of almost three million. The population is heavily concentrated in the south of the country; some 85 per cent live in the southern provinces of Götaland and Svealand. The mean population density is approx. 22 people per square kilometre. The population is densest in Stockholm county, which has 275 people per square kilometre. The most sparsely populated areas are in Jämtland and Norrbotten counties in the north, where the density is about 3 people per square kilometre. Rural depopulation is a widespread trend; the population is growing most rapidly in the conurbations of the south.

1.4 Geography and climate

The total area of Sweden, including lakes but excluding territorial waters, is 449,964 square kilometres of which the land area is 410,934 square kilometres. The country is long and narrow, extending 1,572 km from south to north (Smygehuk at 55° 20´´ N, Treriksröset at 69° 4´´ N). The northernmost part of the country lies beyond the arctic circle. Sweden borders Norway to the west and Finland to the east. The country has a very long Baltic coastline and some North Sea coast as well.

Most of the border with Norway runs along the mountain chain, where there are peaks just over 2,000 metres. The highest mountain in Sweden is Kebnekaise, at 2,111 metres above sea level.

The country has over 95,000 lakes of at least one hectare and a large number of large and small rivers and streams. The total area of lakes and watercourses is approx. 39,000 square kilometres. The total length of all running waters is about 300,000 km.

Most agriculture is in the south of the country, where the climate is more favourable and the soils more fertile. Forestry predominates in the north. The breakdown of land use in 1995 was as follows (approximately):

	%
agricultural land	8
forest	52
built-up areas	2.5
wetlands and mountain areas	29
water	9[3]

The total area of protected environments (in national parks, nature reserves, nature conservation areas, animal protection areas and provisionally protected areas) makes up just over 7 per cent of the total area.

Land elevation is occurring at present throughout large areas of Sweden. The land is rising having been depressed by ice during the last ice age, which ended just over 10,000 years ago. The mean rate of land elevation in the Stockholm area is about 40 cm every hundred years; the rate in the Gulf of Bothnia is as much as 90 cm per hundred years. In the southernmost part of the country the land level is falling slightly, at most by about 10 cm every 100 years.

The amount of daylight varies greatly in Sweden during the year. In mid-winter there are only a few hours of daylight in central Sweden. In the north it is dark round the clock (the sun never rises above the horizon). The shortage of daylight in winter thus requires extensive lighting and illumination of the

[1] Statistics Sweden 2001.

[2] Statistics Sweden 2001.

[3] Statistics Sweden 2001.

indoor and outdoor environments. The situation is the opposite in summer: short nights. In summer, above the arctic circle, the midnight sun shines in northernmost Sweden.

1.4.1 Climate

Sweden lies in the northerly west wind belt, an area where the prevailing winds come from the south and west. The Gulf Stream and the numerous areas of low pressure produce a climate with winters that are 20 – 30°C warmer than at the same latitudes in Siberia and Canada. The precipitation brought by the frequent lows gives us fairly plentiful rain and snow, although there is some rain shadow effect east of the Norwegian mountains.

According to the most frequently cited climate classification (Köppen), Sweden has a temperate, moist climate with year-round precipitation. Along the coasts of southern Sweden, the climate is warm temperate, with a natural cover of deciduous forest. The climate in the rest of the country is cool temperate, the predominate vegetation being coniferous forest. Tundra conditions prevail in the mountains.

The battle between areas of warm and cold air along the polar front and Sweden's location between the Atlantic to the west and the largest continent on earth to the east, results in dramatic changes in the weather, particularly in winter. Often, a change in wind direction will suffice for icy Siberian conditions to be replaced by mild air from the Atlantic.

Summer temperatures are largely governed by altitude, and to a lesser extent by latitude. Thus the mean temperature in July is 15 – 16°C along the entire coast. The mean temperature in summer drops by 0.6°C with every 100 metres of altitude. Even though there is little difference in temperature between southern and northern Sweden in high summer, summer itself (defined as the time of the year when the mean diurnal temperature is above 10°C) is much longer in the south than in the north. For example, in southernmost Sweden, summer lasts for five months, compared with three in the northernmost region. The turn of the seasons in spring and autumn, when the mean temperature is between 0 and 10°C, is also much shorter in the north. So in Lapland in northernmost Sweden, winter lasts for just over half the year, whereas the coast of Skåne in the far south, only has winter, with temperatures below zero, for a few weeks.

The growing season, defined as the part of the year when the mean diurnal temperature is over 5°C, varies enormously over the country. It lasts for between 210 and 220 days in southernmost Sweden (western and southern Skåne and the coast of Halland), but is only half as long in the far north.

Local conditions such as topography and proximity to the sea or large lakes influence the climate locally. The temperature can be extremely low in valleys with open terrain in inland areas of northern Sweden (-15 to -17°C). Elsewhere in northern Sweden the January mean temperature is generally between -9 and -14°C, except along the coast in the south of the region where, as in much of the central inland region, the mean January temperature is -5 to -8°C. In the southern and eastern part of central Sweden, the mean temperature is -3 to -5°C in January, while it is -1 to -2°C in southern coastal areas owing to the ameliorating effect of the nearby open sea.

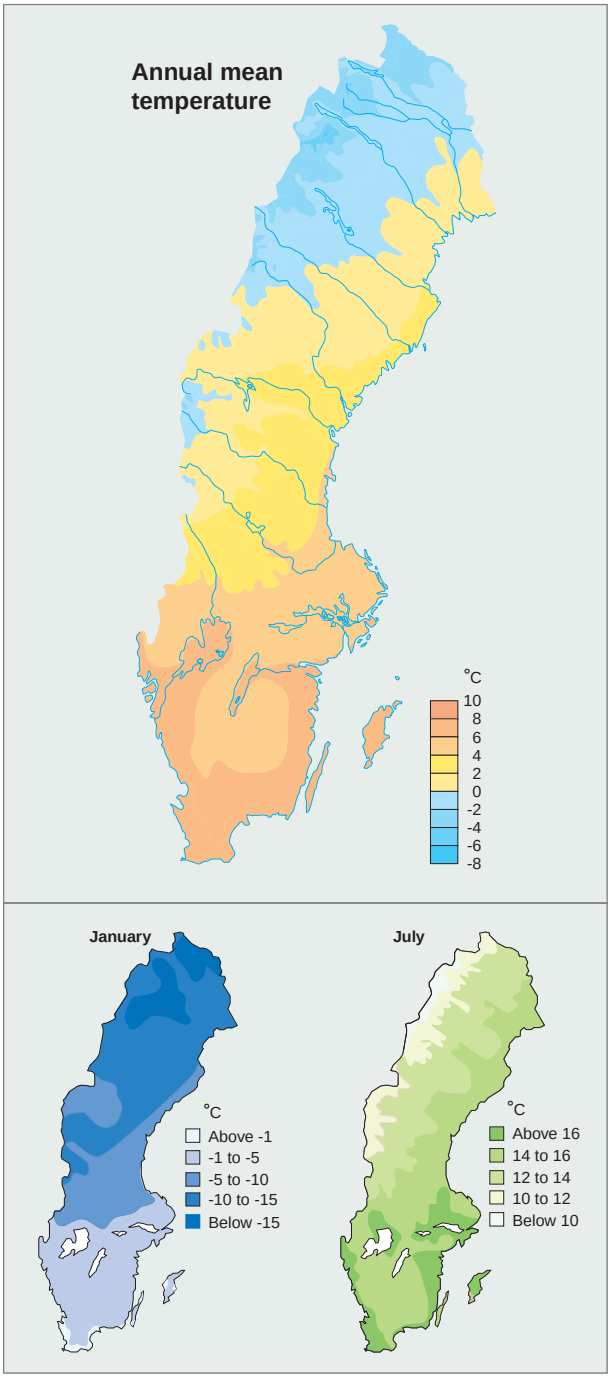
The temperature can vary a great deal, from approx. -50 to 38°C. The lowest recorded temperature is -53°C, recorded at two locations in northern Sweden. Elsewhere in Sweden the coldest recorded temperatures are -30 to -40°C, except along some parts of the southern coast, where it has never fallen below -25 to -30°C. The highest recorded temperatures display much less geographical variation than the lowest; in southern and central Sweden and along the northern coast, the records are between 34 and 36°C. Very occasionally, temperatures also rise above 30°C in other parts of the country.

Over much of Sweden annual precipitation is between 600 and 800 mm. Annual precipitation in the mountains most exposed to westerly winds in northern Sweden (western Lapland and Jämtland) is between 1,500 and 2,000 mm. On the western slopes of the southern uplands, maximum annual precipitation is 1,300 mm. The Abisko area in northernmost Sweden has least precipitation (approx. 450 mm per year). This area lies in the rain shadow of the mountains to the west. Precipitation is heaviest during July – November in more or less the entire country. Most falls along fronts as areas of low pressure move across the country.

Drought is rarely a problem in this sort of climate. But several weeks may sometimes go by in spring and early summer without a drop of rain. The most severe instance of this was in 1992, when parts of the far south had no rain for up to 60 days. The drought caused some problems for farmers and also made it very difficult to extinguish forest fires.

Most of Sweden usually has a snow cover in winter. In the mountains of Lapland, the ground has a snow cover for an average of 225 – 250 days a year. Most of the rest of northern Sweden is covered in snow for more than 150 days a year. In central Sweden and upland areas of the south, there is a snow cover on average between 100 and 150 days each winter. In

Figure 1.1 Annual mean temperatures, July isotherm and January isotherm, 1961 to 1990.

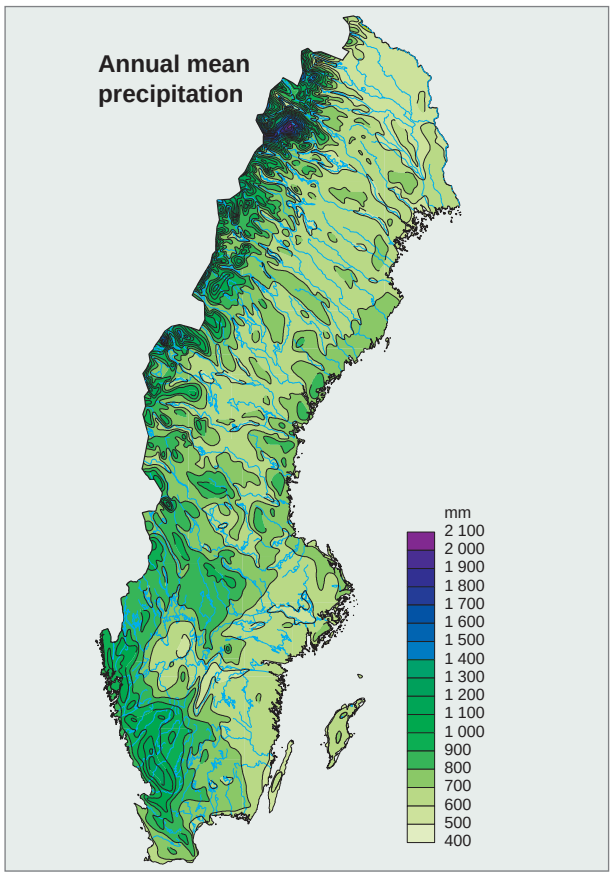


Source: Swedish Meteorological and Hydrological Institute

pressure arriving from the west, and the circulation of winds around them. Occasionally, lows reaching Sweden develop into storms so intense that winds reach hurricane force along the coast and above the tree line. The highest mean wind speed recorded during ten-minute period is 40 m/s at the southern tip of the island of Öland on 17 October 1967.

Throughout Sweden's almost 300-year-long history of weather observations, it has been possible to observe never-ceasing variations in the climate. Nonetheless, it must be emphasised that perhaps the most distinctive feature of our climate is its stability. Average conditions are based on observations over the most recent climatological "standard normal period" 1961 – 1990,

Figure 1.2 Annual mean precipitation, 1961 to 1990.



Source: Swedish Meteorological and Hydrological Institute

the rest of southern Sweden, there is a snow cover for between 50 and 100 days, except along the west coast and the far south, where snow lies for less than 50 days each winter. The maximum snow depth averages more than 60 cm throughout almost all of northern Sweden; the mountains generally have more than a metre of snow.

Air pressure distribution over the European continent causes winds from south and west to predominate somewhat. However, winds from other directions are fairly common because of the numerous areas of low

which in Sweden was somewhat colder and wetter than the preceding period (1931 – 1960). Changes in the mean monthly temperature were generally no more than half a degree, although there are local variations. Annually, precipitation was up to 10 per cent higher over the latter 30-year period; the figure for March increased by up to 80 per cent in some regions. The only month during which there was less precipitation in the latter period was February. Caution should be exercised in interpreting the differences between these two 30-year periods as actual trends.

We can now see that the clear fall in winter temperatures observed between the two most recent normal periods has been reversed. Instead, we have had a unique sequence of mild winters since 1988. However, some climate trend features over the last 100 years are so stable that we are in fact justified in treating them as trends. This applies particularly to the trend of higher spring temperatures, extending back more than 100 years, and the clear indications of increasing precipitation during this period.

It is very difficult to determine whether there has been any real change in the frequency of various kinds of extreme weather phenomena. However, some variations in the frequency of violent storms have occurred in recent decades; for example, they were fairly common along the Swedish coasts between 1967 and 1990.

1.5 Economy

The Swedish economy is based on free trade and the country is highly dependent on its exports. The current economic situation can be illustrated by some figures for 1999:

Exports rose sharply throughout the 1990s, from approximately 20 per cent of GDP at the beginning of the decade, to 43.7 per cent by 1999. This is largely because the krona has depreciated since 1992. Compared with other industrialised nations, heavy industry accounts for a fairly large share of exports.

Export of goods from Sweden accounted for 80.5 per cent of total export income in 1999: 56 per cent of goods went to the EU, representing a value of SEK 409 billion, 7.5 per cent were exported to Norway and 9.5 per cent to the US. The US has become an increasingly important trading partner.

The engineering industry, with key products such as motor vehicles and telecom products, is Sweden's largest sector. Engineering exports increased by 13 per cent in 2000, accounting for some 56 per cent of all Swedish exports by the end of that year. Basic industries remain important, particularly in terms of maintaining the regional balance, as well as for employment in some parts of the country.

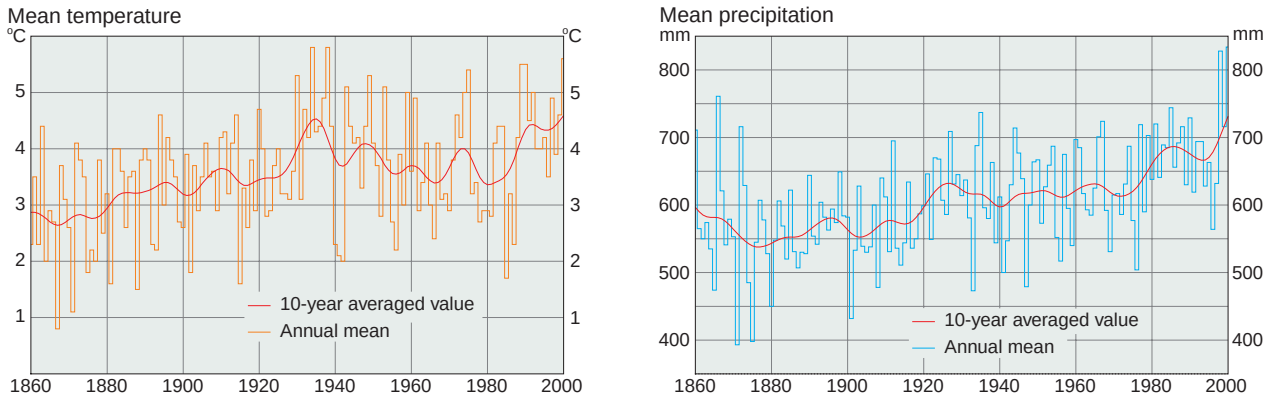
Car ownership was 0.44 per person in 1999, up on the mid-1990s, when the figure was 0.41. The number of cars on the roads rose by 2.8 per cent in 2000, totalling just under four million at the end of 2000. This means that car ownership rose to 0.45 per person in 2000.

GDP grew by an average of 1.8 per cent a year between 1975 and 1990. The Swedish economy went into recession in the early 1990s, and GDP fell by an average of 1.6 per cent a year between 1990 and 1993. Unemployment rose from 1.5 per cent to just over 15 per cent in just a few years.

The recession and increasing globalisation of the economy, trade and capital led to rationalisation in trade and industry, and many businesses and companies went under. Unemployment peaked in 1993 and is now much improved. Following the recession of the early 1990s, value added in the engineering industry rose dramatically. Energy consumption in relation to value added fell sharply between 1993 and 1995, which was partly because most growth in the engineering sector occurred in non-electricity-intensive industries such as the electronics and telecommunications industry.

GDP grew by an average of 3.1 per cent a year between 1993 and 1999. The economic trend was positive in the early 2000s: GDP rose, as did exports,

Figure 1.3 Annual mean and 10-year average temperature and precipitation in Sweden between 1860 and 2000



Note: The mean temperature is based on 10 monitoring stations and annual mean temperature (mm precipitation) in Sweden during the period 1860 – 2000 is based on records from 20 stations. With regard to recorded precipitation, it should be emphasised that the instruments used and the location of stations have both been improved over the years, particularly early last century. This may explain some of the increase in precipitation.

Source: Swedish Meteorological and Hydrological Institute

Table 1.1
Some Swedish economic statistics

Per capita GDP (current prices)	SEK 225,117
Per capita national debt	SEK 155,074
Exports as a % of GDP	43.7%
Manufacturing as a % of GDP (1998)	19.5%
Number of cars per capita	0.44

Source: Statistics Sweden and National Debt Office

Table 1.2
Various industrial sectors as a percentage of GDP (1998)

Sector	% of GDP
Chemicals	1.7
Iron and steel	1.0
Engineering	9.3
Pulp and paper	1.5
Construction	3.8

Source: Statistics Sweden National Accounts (2000)

new order and other key economic indicators. GDP grew by 3.6 per cent in 2000.

The rapid economic growth of recent years is slowing down. The global economy is faltering, which, according to the National Institute of Economic Research, will curb export demand and industrial production in Sweden. Domestic consumption is also rising more slowly, partly because of unusually low energy consumption as a result of warm weather in 2000. But consumption of durable goods, including cars, as well as recreational and leisure services was also lower than expected. The economic outlook has deteriorated, mainly as a result of the weakening US economy. However, the prospects for continuing stable growth in Sweden remain good. Inflation is low, although rising somewhat. The average inflation rate in 2000 was 1.3 per cent. It has since risen, however. State finances are healthy and Swedish industry is doing well in the face of international competition. GDP is expected to grow, albeit less than in 2000.

Unemployment fell in the latter half of the 1990s; the proportion of those in work rose to 77.2 per cent in spring 2000. This figure is expected to rise to 78.7 per cent in 2002, even though the economy is now growing more slowly. Per capita annual disposable income was SEK 111,700 in 1999, increasing by 2.5 per cent in 2000.

1.6 Energy

Emissions of greenhouse gases from the energy system may occur on the supply side in connection with the production of energy, district heating, and on the user side from the industrial sector, transport sector and housing and service sectors. Here, the energy sector comprises the sum of energy supply and energy consumption.

1.6.1 Energy supply 1970 – 1999

Swedish energy supply increased by almost 150 TWh between 1970 and 1999.[4] There was a marked shift between the various sources of energy during that period. In particular, oil accounts for a much smaller share, down from 77 per cent in 1970 to 33 per cent in 1999. One factor making this possible has been the expansion of nuclear power. Use of oil-based products has fallen as they have been replaced by substitutes, particularly biomass fuels. Use of biomass fuels and peat etc has increased from 9 per cent of total supply in 1970s to 15 per cent in 1999.

A parliamentary "energy policy decision" was enacted in 1997. It was decided that the two nuclear reactors at the Barsebäck power plant were to be shut down. A Nuclear Power Phase-Out Act was subsequently enacted.[5] Under the act, the government can make phase-out decisions on the basis that each nuclear reactor is to be shut down at the time that best serves the objective of transforming the energy system into a sustainable energy supply, based on renewable energy sources. Account must also be taken of the location of reactors.

Decisions on each reactor must take account of other factors such as age, design and importance to the energy system. The first nuclear reactor at Barsebäck was shut down in November 1999.

Under the 1997 energy policy decision, most recently confirmed in spring 2001, a condition for closure of the second Barsebäck reactor is that the electricity production shortfall can be compensated for by supply of new electricity production and reduced consumption. In addition, closure must not have a negative impact on electricity prices, the price paid by industry for electricity, the balance between output and demand or the environment and climate. It is parliament's task to decide whether these conditions have been met before a decision is taken to shut down the second Barsebäck reactor.[6] The government considers that these conditions may be met by the end of 2003.[7]

Shutdown of both nuclear reactors at Barsebäck will, in itself, cause a production shortfall of approximately 8 TWh of electric energy, half from November 1999 and the remainder when the second reactor is shut down. The impact of this shortfall depends on electricity demand, the development of renewable electricity generation, measures to reduce consumption and the scope for importing electricity. Model

calculations of the effect of shutting down the second reactor[8] indicate that the shortfall will be covered by increased export and development of renewable production. The latter will be influenced by the level of subsidies for wind power, small-scale hydropower, efficiency improvements at existing hydropower plants and biomass fuel-based combined power and heating plants. Accepting the assumptions used for the model calculations, closure of Barsebäck 2 will increase emissions in Sweden by about 100 ktonnes per year.

It is difficult to estimate emissions of carbon dioxide deriving from increased import of electricity. Import/export of electricity between countries in the north European electricity market varies considerably over the year. There is also significant variation from year to year, depending on the supply of hydropower on the Nordic grid. Elsewhere in this report, we have assumed that changes in electricity use in Sweden will be affected by emissions from electricity generated for marginal use. At present, electricity generated at coal-fired condensing power plants is at the margin on the north European grid. But in future it is expected that marginal electricity will be produced at natural gas combination plants. On the basis of these assumptions, the effect of shutting down the Barsebäck 2 reactor will be that emissions outside Sweden's borders will increase by about 700 – 1,600 ktonnes. If an average figure for the north European grid is taken instead, the emission increase will be about 800 ktonnes.[9] The effect on greenhouse gas emissions of shutting down the Barsebäck 1 reactor has not been evaluated.

An extensive process of structural change is under way in the field of energy supply. The power companies are becoming larger, more integrated energy suppliers, operating in several countries. Swedish companies are looking for new markets and increasing their stake in neighbouring countries. At the same time, foreign companies are increasing their stake in Sweden.

Greater use of biomass fuels

Biomass fuels and peat accounted for some 95 TWh in 1999, which represents about 15 per cent of total energy supply. Most of this (about 85 TWh) was produced by biomass fuels, of which recycled liquors from the pulp and paper industry accounted for some 34 TWh. The remainder (just under 3 TWh) came from peat and (mainly household) waste (just over 5 TWh). Biomass fuels, peat etc are used in three main areas: district heating plants, pulp and paper industry and the housing sector. The greatest increase has taken place in the district heating sector, where use rose from 2 TWh in 1980 to just over 26 TWh in 1999. Use in industry, (mainly pulp and paper) has also increased. The pulp and paper industry uses its by-products (ie, that which is "left over" during the manufacturing processes and from spent liquor) for process heating and electricity generation. This increased use by the pulp and paper industry has occurred partly because oil, which is an alternative source of energy, has become relatively more expensive. The process chemicals in the various liquors are recycled so that their energy content can be used. Industry has also increased its production somewhat. Industrial use of biomass fuels totalled just over 54 TWh in 1999, which represents almost 60 per cent of total use of these fuels. 3.6 TWh of biomass fuels were used for electricity generation in 1999, which represents just over 2 per cent of total production. Most electricity generated using biomass fuels is produced in industry.

Use of biomass fuels in the housing sector has remained at a fairly constant level between 10 and 12 TWh since 1980. Most of this is log burning, mainly by households with access to their own firewood. The use of refined biomass fuels (pellets and briquettes) in the housing sector remains fairly limited, totalling 0.5 TWh in 1999.

Lower carbon dioxide emissions

Emissions of carbon dioxide from the energy sector, not including industrial processes and international transport, fell by nearly 15 per cent between 1970 and 1979 and by almost 30 per cent between 1980 and 1999.[10] This reduction is largely due to a change-over from oil to electric energy and other energy forms on both the consumer and the supply side, as well as greater energy efficiency. During the same period (1970 – 1999), emissions from domestic transport rose by approximately 40 per cent.

Emissions of carbon dioxide from the energy sector rose from 51.3 to 51.7 million tonnes between 1990 and 1999, ie, by just under 1 per cent.[11] Most of this increase is attributable to electricity generation. Emissions from the transport sector and the industrial

[4] According to the international method of measuring nuclear power production, where statistics are based on the stated quantity of thermal energy. This is almost three times the electric energy generated.

[5] Swedish Code of Statutes 1997:1320, Gov. Bill 1996/97:176, Report 1997/98:NU5, rskr. 1997/98:132.

[6] Parliamentary Standing Committee on Industry and Trade Report NU 2000/01:NU3.

[7] Government communication 2000/01:15: Continuing adjustment of the energy system.

[8] National Energy Administration Report ER 8:2001. Electricity Market Report 2001:1: Scenarios for electricity supply with and without Barsebäck 2.

[9] ibid.

[10] According to Statistics Sweden/Swedish EPA emission calculations. Emissions of carbon dioxide from the energy sector represent just over 90 per cent of all Swedish carbon dioxide emissions.

[11] According to Statistics Sweden/Swedish EPA emission calculations. Report under the Climate Convention in April 2001. Combustion for energy purposes is included in the energy sector.

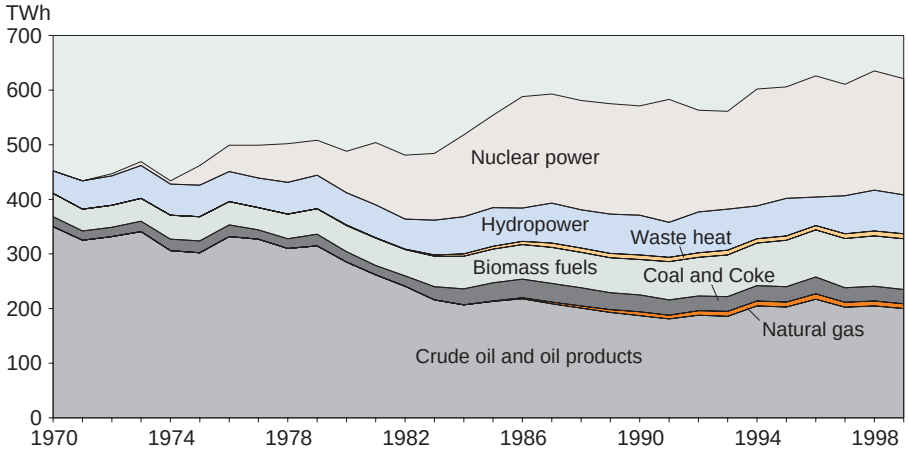


Figure 1.4
Swedish energy supply 1970 – 1999, TWh

During the period, trade in electric energy varied between a net import of 6 TWh and a net export of 11 TWh.

Source: Energiläget 2000, National Energy Administration

sector also rose, whereas those from the housing and service sector fell between 1990 and 1999.

1.6.2 Energy use 1970 – 1999

Energy consumption in the industrial and housing sectors fell somewhat between 1970 and 1999. But energy consumption in the transport sector rose dramatically, by over 40 per cent. The use of oil, in particular, has declined in the industrial and housing sectors, but has increased in the transport sector. Industrial electricity consumption has risen substantially in industry and the housing sector.

Industrial energy use

Industrial energy use accounts for approximately 40 per cent of the national total. 26 per cent of this is based on fossil fuels and 35 per cent on biomass fuels, peat etc. The remainder is electric energy and district heating.

A limited number of industries account for the majority of industrial energy use. The pulp and paper industry uses almost 45 per cent, iron and steelworks 14 per cent, and the chemicals industry 7 per cent. Energy-intensive industries thus account for two thirds of total energy use. However, the engineering industry, which is not considered to be energy-intensive, accounts for almost 8 per cent of total industrial energy use because it represents such a large proportion of total industrial production in Sweden.

Over the longer term, there has been a clear shift between various kinds of energy, and, in particular, a shift away from oil in favour of electricity. In spite of rising industrial production, oil consumption has fallen sharply since 1970. This has been possible because of increased use of electricity and greater energy efficiency. The decline in oil use began at the time of the oil crises of the early 1970s. Industry and society at large began to make concerted efforts to reduce our dependence on oil. Electricity use accounted for 20 per cent of total energy use in the sector in 1970s, compared with the current figure of 36 per cent. Oil consumption fell from 48 per cent to 14 per cent of total industrial energy consumption between 1970 and 1999. During the same period, the proportion of biomass fuels, peat etc rose from just over 21 per cent to 35 per cent of total energy use in the industrial sector.

The changeover from oil to electric energy has been accompanied by a reduction in energy use by the sector. This is because electric energy often has greater conversion efficiency than oil at the user stage, and also because conversion losses from energy production are ascribed to the electricity generation sector. These were previously attributed to the industrial sector.

Energy use in the transport sector

Energy use by the transport sector is virtually confined to various oil products such as petrol, diesel and aviation fuel. Energy use in this sector has been rising since 1970 as a consequence of the overall growth in transport. Passenger traffic and goods transport both increased by over 50 per cent between 1970 and 1999. Energy consumption in the transport sector (not including bunkering oils used in international shipping) increased by 60 per cent between 1970 and 1999. Petrol consumption rose by approximately 45 per cent and diesel use doubled during this period. Consumption of aviation fuel also rose during the period.

Energy use in the housing and service sector

Energy use in this sector represents some 40 per cent of total end use in Sweden. Just over 60 per cent of energy consumed in the sector goes on heating and hot water. This is influenced by outdoor temperatures, which means that there are sizeable variations in energy demand from year to year. Energy consumption is often adjusted by way of "normal year correction" to take account of these fluctuations and give a more accurate

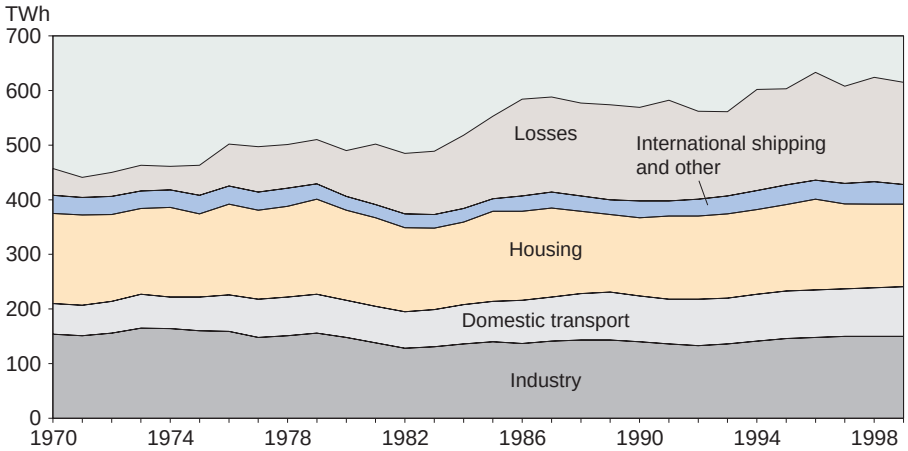


Figure 1.5
Swedish energy use 1970 – 1999, TWh

Note: Losses in 1999 from nuclear power generation were 140 TWh out of the total conversion and distribution losses of 187 TWh.

Source: Energiläget 2000, National Energy Administration

picture of energy consumption trends.

Normal-year-corrected energy consumption in the housing and service sector remained relatively steady between 1970 and 1999, although there were changes in the relative proportions of energy types used. Oil crises, rising energy prices, changes in energy taxation and investment programmes have influenced the changeover from oil to other sources of energy. Total oil consumption by the housing and service sectors was 30 TWh in 1999, compared with 113 TWh in 1970. On the other hand, use of electric energy increased continually from 1970 to the mid-1990s. Electricity consumption has remained steady at around 70 TWh in recent years. The fall in oil consumption is largely due to a changeover from oil to electric energy and district heating for heating of homes, commercial and industrial premises etc. As a result, electric heating is now used in most houses and district heating in most apartment buildings and commercial premises.

The changeover from oil to electric energy and district heating and more widespread use of heat pumps in the 1990s has reduced total energy use in the sector as a result, among other things, of lower conversion losses at the end-user stage. Other factors countering increased use of heating and hot water in homes and commercial premises are energy-saving measures, such as the installation of regulation systems, additional insulation and replacement of windows in old buildings.

National statistics from Statistics Sweden and the National Board of Housing, Building and Planning show a constant and significant reduction in carbon dioxide emissions from heating of homes and commercial premises in the 1990s. Emissions of carbon dioxide from the housing and service sectors in 1999 were approximately 81 per cent of those in 1990. Reasons for this include increased use of district heating for heating homes and commercial/industrial premises, which has led to greater energy efficiency than is achieved using other forms of heating, and more use of biomass fuels.

Household electricity use more than doubled between 1970 and 1999, from 9 to 19 TWh. The main reason was a growing number of households and an increasing number of household appliances.

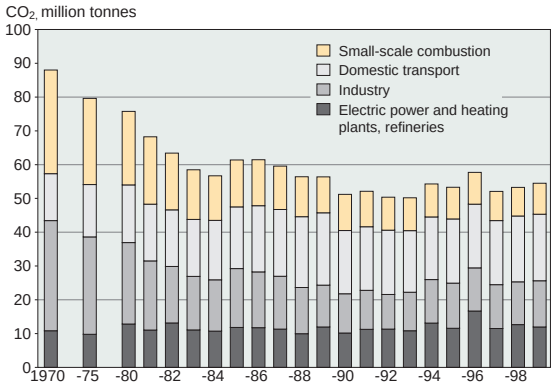
The use of electricity for household appliances, as well as for lighting and ventilation in offices, commercial and public premises, has also risen sharply since the 1970s, from 8 TWh in 1970 to 22 TWh in 1999. One reason for this has been the rapid growth of service industries and increasing use of office machines.

1.6.3 International comparison

Per capita energy consumption in Sweden is high compared with that in other OECD countries. This is because of the ready availability of natural resources such as forests and hydropower, which led to early and rapid expansion of energy-intensive industries.

Sweden's geographical position, with low mean annual temperatures and low population density also explains the high heating demand and long distances. However, carbon dioxide emissions per inhabitant are relatively low in Sweden compared with other industrialised nations. This is because the proportion of fossil fuels in the energy system is 40 per cent, compared with an average figure of 80 per cent in the OECD. Per capita carbon dioxide emissions in Sweden in 1998 were 6.0 tonnes, compared with the 15 EU member states, where average per capita emissions were 8.6 tonnes, and the OECD, where per capita emissions were 11.1 tonnes.

Figure 1.6 Carbon dioxide emission trends between 1970, 1975 and the period 1980 – 1999



Note 1: Bunkering oils used in international aviation and shipping are not included. Emissions from international transport varied during the period between 3 and 5 Mtonnes. Emissions from international transport have risen to between 6 and 7 Mtonnes over the last few years.

Note 2: Small-scale combustion represents housing and service.

Source: National Energy Administration

1.7 Transport

The Swedish road network, comprising around 137,000 km of public highways, reaches all areas of the country. There are an additional 75,000 km or so of private roads in receipt of government subsidies, and a very large number of private roads receiving no such support, most of them forestry vehicle roads. Some 98,000 km of the 137,000 km of public highways are state owned and run; the rest are municipal streets and roads.

The Swedish rail network covers approximately 17,000 km. Some 14,000 km of this are state railways. The remainder comprises the "Inland Railway" in the north of Sweden and historical railways.

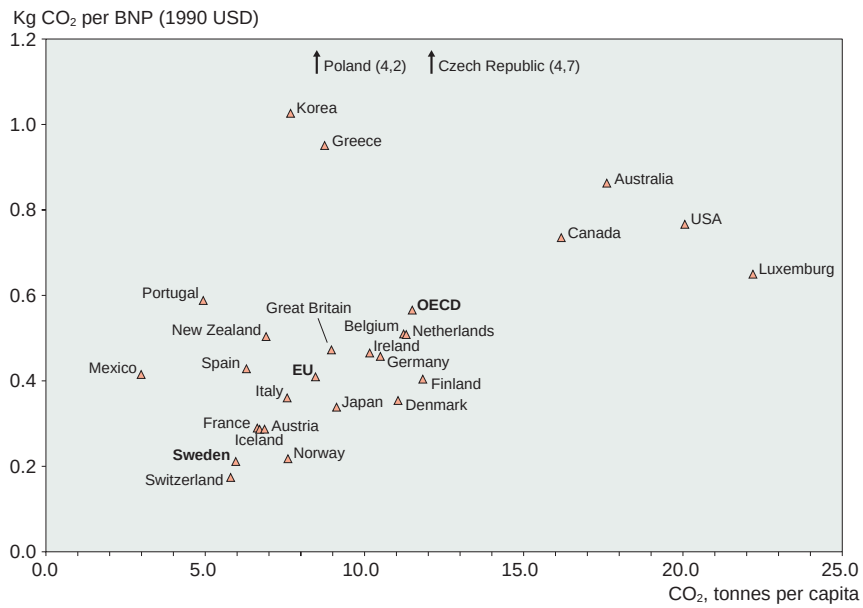
1.7.1 Passenger transport

The motor car is the most common mode of transport in Sweden, regardless of purpose, and is used for almost 60 per cent of all journeys. Journeys on foot or bicycle account for about 30 per cent of journeys. Most journeys on public transport are made by bus. Almost 40 per cent of all journeys are made for pleasure, making them the largest single category. Journeys to and from work and school make up 25 per cent of all journeys, as do shopping trips and journeys to use services. Approximately 40 per cent of journeys are shorter than 2.5 kilometres. The majority of trips abroad are made by air as the principal mode of travel. After air travel, the motor car is the most used form of transport for foreign travel, followed by journeys by ship (mostly by ferry to Denmark and Finland).

On average, Swedes travel 44 km per individual and day by various modes of transport. The motor car is also the main form of transport in terms of distance: 86.9 billion vehicle kilometres. In other words, about 75 per cent of all kilometres travelled are by car. Other forms of transport account for almost a quarter of passenger transport, including those used for longer journeys, such as rail, air and long-distance coach. Only for really long journeys, exceeding 600 km each way, does air travel rival the motor car. The train is mostly used for journeys longer than 400 km, whereas the bus is used most for journeys of 200 – 400 km.

In early 2000 there were almost 3.9 million cars on the roads of Sweden. This is the highest number ever recorded, an increase of just under 100,000 (3 per

Figur 1.7 Emissions of carbon dioxide per inhabitant and in relation to GDP in various industrialised countries[12]



[12] Turkey is not included in the figure for the OECD. There are no emission figures for some countries for 1998. The emission figures most recently reported to UNFCCC have been used. (Iceland: 1995, Japan: 1997, Luxembourg: 1995, Korea: 1994, Mexico: 1990). "Energy Balances of OECD Countries" presents two methods of enabling comparisons between the GDP of different countries. The first is to convert figures to US dollars using the relevant exchange rates; the second is to adjust the figures in line with purchasing power parity (PPP). The first method has been chosen in Figure 1.7. Sources: UNFCCC and Energy Balances of OECD Countries, 1997 – 1998, Edition 2000.

Source: National Energy Administration

Table 1.3
Number of journeys broken down into purpose and mode of transport. Millions, 1999

Mode of transport	Work/school	Business/studies	Shopping	Services	Leisure	Other
Car	1,083	322	804	312	1,494	707
On foot/bicycle	618	55	450	130	890	138
Local public transport	334	18	63	26	163	42
Other	44	57	11	4	74	16
All	2,096	458	1,353	479	2,657	913

Source: SIKA

cent) compared with 1998. On average, there were 439 cars per 1,000 inhabitants. The county of Dalarna (central Sweden) and the Baltic island of Gotland had the highest number of cars per thousand inhabitants: 502 and 498, respectively. Stockholm county had the lowest: 377. A total of 335,600 new motor cars were registered in 1999, up almost 49,000 (17 per cent) on 1998. This was the highest figure for a single year in the entire 1990s. The number of buses on the roads has risen since 1993, although the figure has fallen over the last year. There were slightly fewer than 14,900 buses on the roads in early 2000. Half the Swedish population, ie, 4.45 million people, held a driving licence and had access to a car in the family in 1999.

There were just under 50 airports with scheduled flights in Sweden, of which 14 were state-owned. The single most-used ferry route in 1999 was that between Helsingborg and Helsingör in Denmark, with 7.2 million passengers, followed by Stockholm – Turku in Finland, with 1.9 million. Ferries between Visby on the island of Gotland and Nynäshamn/Oskarshamn on the mainland carried a total of 1.2 million passengers in 1999.

1.7.2 Goods transport

Goods transport increased rapidly in Sweden in the 1950s and 1960s to keep pace with the growth in trade and industry. The rate of expansion has been lower in recent decades. Just over 538 million tonnes of goods (domestic loads) were transported within Sweden's borders in 1999. Just over 61 per cent of those goods were carried by truck. Road transport predominates, particularly over shorter distances, where it accounts for more than 90 per cent of all transport.[13] The further goods are transported, the more even the choice between the various forms of transport. Shipping is the main mode of goods transport for journeys exceeding 300 km. A total of 329 million tonnes of goods were transported by Swedish trucks on Swedish roads in 1999. Swedish trucks transported just over 4.2 million tonnes of goods to and from other countries in 1999. The five largest

[13] These figures include goods of domestic as well as foreign origin/destination.

Table 1.4
Transport distances according to mode of transport. Vehicle kilometres, billions, 1999

Mode of transport	Transport distance
Car	86.9
Bus	12.4
Rail	6.5
Air (domestic)	5.2
On foot/bicycle	5.0
All	116

Source: SIKA

Table 1.5
Goods transport – quantity and distance in Sweden in 1999, broken down into mode of transport

	Tonnes, millions	%	Tonne km, millions	%
Road	329	61	32,761	40
Rail	53	10	18,905	23
Sea	156	29	30,155	37
Total, of which international shipping comprised	538	100	81,821	100
	103	19	22,455	27

Source: SIKA/Statistics Sweden (Figures for foreign trucks are not included here, nor is a minor proportion of transport of foreign goods by sea, including ferry traffic.)

countries of destination and origin were, in descending order, Norway, Germany, Denmark, Finland and the Netherlands. Transport to these five countries accounted for almost 90 per cent of international goods traffic involving Swedish trucks.

Domestic goods traffic totalled 81.8 billion tonne kilometres in 1999. Goods traffic in Sweden has increased by 12 per cent since 1990. A growing proportion of goods in Sweden are carried by truck, which has been the most important form of domestic goods transport since the 1970s. The percentage of goods by weight and the amount of goods transported (tonne kilometres) by truck both increased during the five-year period 1993 – 1998. Rail transport and domestic shipping remain largely unchanged, whereas carriage of foreign goods by sea along Swedish coasts has risen by 10 per cent. Road freight accounted for about 32.8 billion tonne kilometres in 1997, ie, just over 40 per cent of transport measured in tonne kilometres. Shipping accounted for approximately 35 per cent and rail for the remaining 20 per cent or so. Air freight, measured in tonne kilometres, is negligible, but is more significant in terms of the value of goods carried. Some 74 per cent of goods carried by sea in Swedish waters are of foreign origin.

Freight on rail fluctuated between 18.6 and 19.4 billion tonne kilometres throughout the 1990s. Rail freight peaked in 1995 and was at its lowest in 1993. Total carriage of goods in Swedish waters was just under 30.2 billion tonne kilometres in 1999, which is four billion tonne kilometres (just over 15 per cent) more than in 1991, the low point in the 1990s. Air freight accounts for a very small proportion of goods transport, but increased by 90 per cent in the 1990s. Emissions from air freight remain small, however.

Like passenger traffic, road freight peaked in 1999. There were just under 354,300 trucks on the roads at the end of 1999, an increase of almost 16,000 (approx. 5 per cent) on 1998.

1.8 Trade and industry

Swedish trade and industry is the engine of national economic growth. Structural changes are constantly taking place. In order to describe the structural changes and changes in the use of various resources within and between sectors, trade and industry can be broken down into knowledge-intensive, capital-intensive and labour-intensive production. Account is also taken of whether it is industrial production, ie, goods, or the production of services. Other sectors not fitting easily categorised in this way can be grouped together under "Other".

Production in knowledge-intensive sectors increased during the period 1980 – 1996. The percentage of production from capital-intensive sectors fell somewhat and labour-intensive sectors have experienced the greatest decline. The three service sectors accounted for 63 per cent of total production in the Swedish economy in 1996; industry and other production accounted for the remaining 37 per cent. This shows the trend towards more knowledge-intensive production, which accelerated in the 1990s. The growth in knowledge- intensive production means that the percentage of production of goods and services based on human know-how and various technologies has increased.

One of the reasons for the relatively rapid production increase in knowledge-intensive industry is that demand for telecom and pharmaceutical products has risen sharply, ie, by an annual average of approx. 20 per cent and 13 per cent, respectively. These industries did not experience the depths of the recession between 1990 and 1993. Production in the financial services and corporate services sector has risen by an average of 3 per cent a year.

One structural change in the capital-intensive sectors, which are often also energy-intensive, is that the Swedish pulp and paper industry and iron and steel industry have moved towards more refined products, with fewer but larger production units. Most pulp, paper, iron and steel produced is exported. Sweden's total exports in 1998 were worth SEK 670 billion, of which these sectors accounted for SEK 180 billion.

1.9 Waste

73 millions tonnes of waste are generated each year, of which some 62 million tonnes comprise industrial and mining waste. Approximately 75 per cent all waste is landfilled, of which mining waste is the major part (approx. 40 million tonnes per year).[14] Only 25 per cent of household waste (which is of greater relevance in terms of greenhouse gas emissions) was landfilled. 29 per cent was recycled, 38 per cent was incinerated and 8.5 per cent underwent biological treatment.[15]

Emissions of greenhouse gases from waste mainly occur during treatment and final disposal of waste, ie, incineration and landfill. However, indirect emissions of these gases also occur during collection at various stages of the waste chain.

The objective for the management of waste, including by-products and residual products from agriculture and forestry etc, is to establish toxin-free, resource-efficient ecocycles. Recycling of many materials greatly reduces consum-ption of resources and the burden placed on the environment. Good examples of this are aluminium and copper, the recycling of which

consumes far less energy and other resources than production from raw materials. Recycled paper also saves considerable amounts of energy. This also means that these materials have an economic value when they are sorted by the recycling industry. Sorting of waste at source and recycling of products of this kind based on producer responsibility has been successfully established in a number of instances. Other types of "waste", such as straw, bark and other biological waste must be seen as a resource, often a renewable source of energy. The growing market for biomass fuels is largely based on materials of this kind. There are also waste streams where energy extraction can be combined with recycling of valuable substances.

Producer responsibility for certain types of waste has been introduced to encourage recycling and reuse and to reduce the quantity of waste generated. This means that producers are responsible for collecting and disposing of end-of-life products. This form of responsibility has so far been introduced for recyclable

Table 1.6 Trade and industry broken down into industrial sectors, service sectors and other sectors, depending on their use of capital, labour and human resources

Sector	Sub-sectors according to Swedish sectoral breakdown 1992
Industry	
Knowledge-intensive	Electrical, electronic and telecom products, machinery, means of transport, publishing products, pharmaceutical products, instruments and office machinery
Capital-intensive	Pulp and paper, steel and other metal production facilities, chemicals, petrochemicals industry, earth and rock, mining and mineral abstraction
Labour-intensive	Food, engineering, wood, rubber and plastics, textiles and clothing, other manufacturing
Services	
Knowledge-intensive	Corporate services, finance, culture and sport, education, training, health and medical care, other care services
Capital-intensive	Property management and property companies, transport and communications (haulage, post and telecom)
Labour-intensive	Retail, repairs, construction, hotel and restaurant
Other	Electricity, gas, heating and power plants, agriculture, forestry and fisheries

Source: Appendix 3, LU99

Table 1.7
Production structure in trade and industry. Value added, percentage breakdown and absolute figures, selected years 1980 – 1996

Sector	1980	1990	1993	1996
Knowledge-intensive				
Industry	12.6	12.2	11.9	15.7
Services	13.4	16.5	16.8	17.9
Capital-intensive				
Industry	6.5	6.5	6.7	6.4
Services	25.1	23.3	25.0	22.6
Labour-intensive				
Industry	10.0	8.9	8.0	8.1
Services	25.6	25.3	24.4	22.6
Other	6.8	7.3	7.3	6.6
Total percentage Industry	29.2	27.6	26.5	30.2
Total percentage Services	64.1	65.0	66.2	63.2
Value added, SEK millions	796,628	1,008,447	962,786	1,106,542

Statistics Sweden, National accounts

paper, motor cars, tyres, electric and electronic products, and also for packaging materials made of glass, plastic, wood or metal. Recycling targets have been set for each of these waste categories and, generally speaking, these are currently being met. For example, 99 per cent of recyclable glass is recycled.

Treatment and final disposal of waste in Sweden mainly occurs in the form of incineration, landfill and biological treatment such as composting and digestion.

There are about 600 operational landfill sites in Sweden at present, of which some 270 receive consumer waste. Other receive industrial production waste. Most of the sites receiving consumer waste are owned and run by municipalities. Only 10 per cent of consumer waste goes to privately owned landfill sites. In addition, there are about 120 landfill sites solely receiving sludge, and a large number of waste tips for excavated material.[16]

We have a fairly good idea of what is landfilled at Swedish sites. The 25 largest sites receive about half the waste sent to municipal landfill, whereas the 170 smallest receive no more than about 10 per cent. 4.9 million tonnes were landfilled at municipal sites in 1999. Household waste makes up about 20 per cent of waste sent to municipal landfill.

In addition to landfill, most sites for disposal of consumer waste run a number of other operations, such as sorting for reuse and recycling, composting or digestion, as well as gas extraction for energy purposes.

Landfilled biological waste generates gas under anaerobic conditions. This gas mainly consists of methane and carbon dioxide. Collection and extraction of landfill gas at sites receiving biological waste is therefore environmentally important. Gas equivalent to 435 GWh was extracted at 74 sites in Sweden in 1999. Most of this was used for heat production, although a small proportion was used to generate electric energy.[17]

1.10 Planning, building and infrastructure

Planning includes everything affecting built-up areas, land and water in a municipality. All Swedish municipalities must have a current general plan. The conservation provisions set forth in the Environmental Code must be given tangible form in the general plan. One example of this are areas for production and distribution of energy, transport and communications. A detailed plan is made for areas of a municipality that are to be changed or conserved in a certain way. Regional planning in Sweden is uncommon and non-binding.

The way communities are planned, the siting of homes and shopping centres in relation to other activities and the extent to which an area is developed all have a great impact on the scope for organising public transport and reasonable cycleways to various workplaces and facilities, the development of district heating, the scope for building local heat distribution stations, transport distances for oil and biomass fuels, and for many other factors that have an impact on carbon dioxide emissions.

Buildings in urban and rural areas comprise business

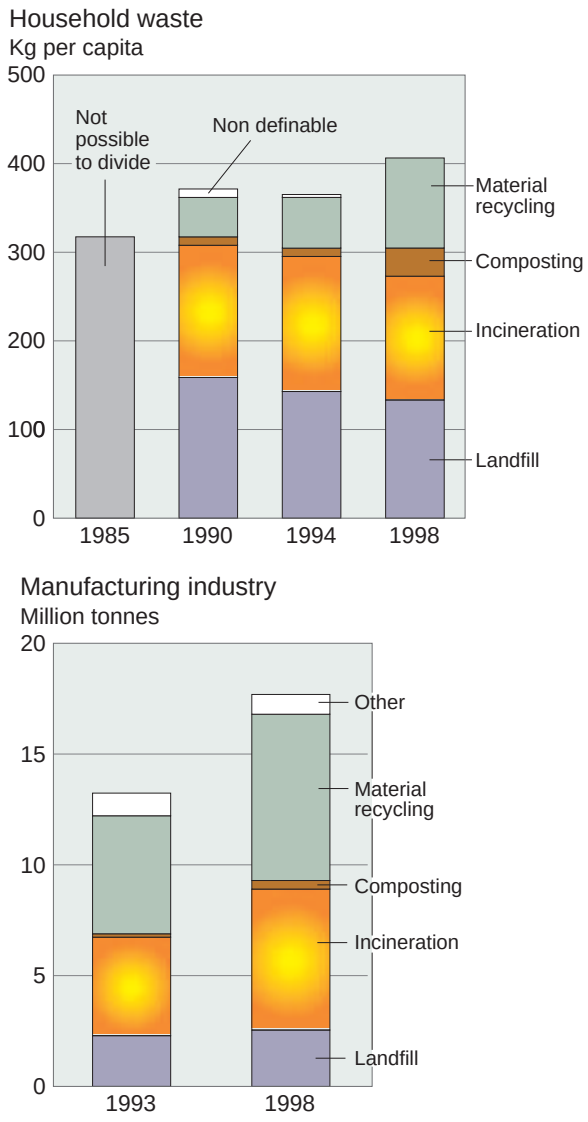
[14] Deponering av avfall ("Landfilling waste"), draft General Guidelines, Swedish EPA Report 4610

[15] Svensk avfallshantering 2000 ("Swedish Waste Management Yearbook 2000"), Swedish Association of Refuse Collection Departments and Contractors

[16] Government communication 1998/99:63, p 27

[17] Svensk avfallshantering 2000 ("Swedish waste management 2000"), Swedish Association of Refuse Collection Departments and Contractors Yearbook

Figure 1.8 Waste, generated and landfilled quantities (household waste and manufacturing industry



Source: Statistics Sweden and Swedish Environmental Protection Agency

premises, residential buildings, workshops, industrial and agricultural buildings, office buildings, hospitals and schools, as well as facilities for other services. These buildings need energy for heating and operation, some of which comes from fossil fuels. Swedish buildings currently comprise 256 million square metres of houses, 166 million square metres of apartment buildings and 156 million square metres of other premises. There is about 47 square metres of residential floor space and a further 35 square metres of heated floor space per inhabitant.

Swedish buildings are relatively well insulated. Almost all heated buildings are at least double-glazed. Nowadays all new buildings are fitted with triple glazing or special windows with a low heat transmission coefficient.

At present, 107 TWh of electric energy is used each year to heat buildings and produce hot water. Energy for heating supplied by district heating plants and electric energy produced centrally is added to the supply side of the Swedish energy system. Energy for heating and hot water supplied by the user's own boiler and from local generation of electric energy is included in the housing and service sector on the consumption side of the energy system.

A further 53 TWh of electric energy is used for domestic and building supply in houses and apartment buildings. This comes primarily from central sources such as hydropower plants and nuclear reactors. Some production takes place at municipal plants for combined power and heating production.

A limited quantity of methane is used in gas boilers and gas ovens. Other greenhouse gases (mainly HFCs) are used as refrigerants in refrigerators, freezers and heat pump units in various types of building.

The term "infrastructure" usually means constructions required for the supply of various functions for living, as well as for trade and industry and services in urban and rural society. Infrastructure comprises parks, streets, roads and bridges, railways, airports, canals and ports, sewers, water supply, waste disposal and district heating systems, as well as electronic communications, such as the telephone and data communication. The effects of energy use on traffic, district heating systems and waste are dealt with in the sections on transport, energy and waste. Considerable quantities of heat and bio-energy are now recovered from sewage and waste water.

1.11 Swedish agriculture

Swedish agriculture has undergone radical structural changes and rationalisation over the past 50 years. One fifth (about 700,000 hectares) of the Swedish arable land cultivated in the 1950s is no longer farmed. The greatest decline has been in the most densely forested areas of central and northern Sweden.

The number of people temporarily and permanently employed in agriculture and associated industries has fallen steadily. The figure in 1999 was 177,000, which is about 2 per cent of the population. Most of those working in agriculture are self-employed people or their relatives. Agricultural productivity has increased. Sweden is a net exporter of grain crops and dairy products. Overall, the country is largely self-sufficient in meat. Most imports are of products not produced in Sweden, such as coffee, fruit, vegetables, rice, as well as meat and cheese. Exports of food and agricultural products (not including intra-community exports) totalled SEK 15.5 billion in 1999. Imports (not including intra-community imports) totalled SEK 34.9 billion.

The number of farms and the area under cultivation both continued to decrease in the 1990s. In 1999 there were about 80,000 agricultural holdings each having at least 2.1 hectares of arable land and making up a total of 2.7 million hectares of arable land and just under 500,000 hectares of grazing land. The number of agricultural holdings fell by about 10,000 between 1994 and 1999 and the area under cultivation decreased by about 35,000 hectares. Most of the closures were small holdings; those remaining are becoming ever larger. In 1999 some 31,000 agricultural holdings were livestock farms, 14,000 were purely arable farms, and a mere 5,000 were a combination of the two. The other holdings were smallholders.

Livestock farmers predominantly engage in milk production. There were about 450,000 dairy cows in Sweden in 1999, 160,000 suckling and nursing cows for rearing calves, and about 1.1 million calves and replacement heifers. There were also approximately 400,000 sheep and goats, 2.1 million pigs, 13 million hens and chickens, 200,000 domesticated reindeer and 300,000 horses.

The main crops grown in Sweden are grain (mainly barley, wheat and oats) and fodder crops. Grain is most important in flat country, whereas fodder crops are mainly grown in forested areas and areas with mixed agriculture and forestry. Oil-plant cultivation is concentrated in southern and central Sweden. Potatoes are grown throughout the country, sugar beet only in the far south. Crops for energy production (energy crops) are only grown to a limited extent; total production represents 0.5 TWh of energy.

Energy crops are only grown to a limited extent; in the late 1990s energy forest covered 14,000 – 17,000 hectares, whereas energy grass was only being grown on a few thousand hectares. Energy forest, energy grass and a small quantity of straw are used mainly as

(energy crops) are only grown to a limited extent; total production represents 0.5 TWh of energy.

Energy crops are only grown to a limited extent; in the late 1990s energy forest covered 14,000 – 17,000 hectares, whereas energy grass was only being grown on a few thousand hectares. Energy forest, energy grass and a small quantity of straw are used mainly as a source of solid fuel at district heating plants. Residual agricultural products are used at 10 or so large biogas plants: Sweden's first facility for the production of ethanol from grain was opened in 2001. Little biogas is produced at individual farms in Sweden.

The most important factors governing greenhouse gas emissions from agriculture are:

- the extent of livestock farming, including farmyard manure management methods
- use of artificial fertilisers, and
- cultivation of organic soils (soils rich in organic matter).

Other factors, such as type of animal feed, soil cultivation methods, choice of crops, timing and method of spreading fertiliser, fallowing methods, timing of grassland ploughing, catch crops, length of grazing period etc, may also play a part in greenhouse gas emissions. However, so little is usually known about these matters that the effects of various measures cannot be evaluated.

Figure 1.9 shows the area of land receiving certain form of environmental support in 2000. A new environment and rural area programme (for environmental and rural development), with new and different objectives and support levels was introduced on 1 January 2001. Various forms of support for grazing land and open cultivated landscapes help to maintain an open landscape, which is important if the traditional Swedish rural landscape is to be maintained. To some extent, the support for organic cultivation has the same purpose, but their main aim is to encourage cultivation without the use of artificial fertilisers and pesticides. The objectives set for the previous programme have largely been achieved.

However, the different forms of support for wetlands and small water bodies, for extensive ley and riparian zones, and for catch crops, have not achieved their aims. One of the main purposes of these forms of support was to reduce the leaching of nitrogen from agricultural land into ground and surface waters.

The purpose of the forms of environmental support has not been to limit emissions of greenhouse gases from agriculture, but they do encourage measures that may have that effect. One effect has probably been to limit the use of artificial fertilisers, which helps to reduce emissions of nitrous oxide. On the other hand, general agricultural support is available for grain and other cultivation, and there is other support based on the number of animals. Without these subsidies, and all things being equal, the area under grain cultivation would probably be less than it was in the 1990s. Hence, the system of agricultural support is not primarily designed to limit greenhouse gas emissions.

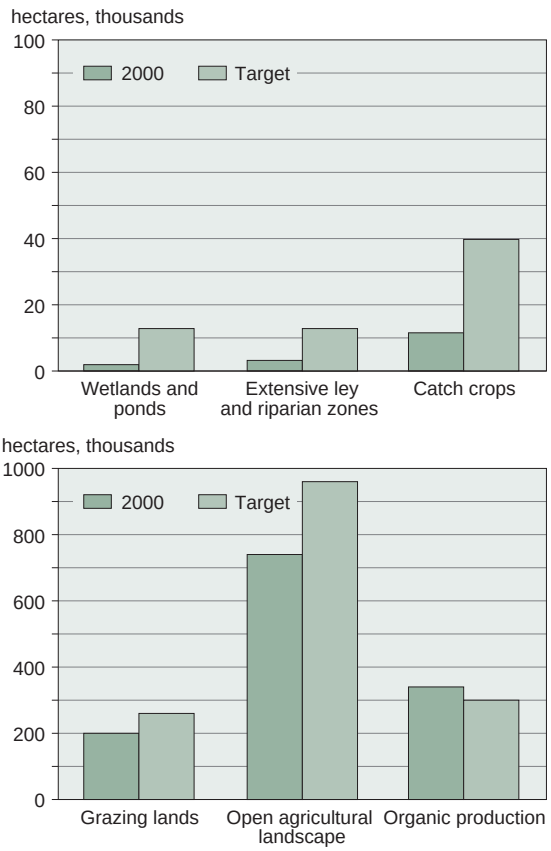
Nonetheless, it is estimated that these emissions fell by about 5 per cent between 1990 and 1999.

Cultivation of organic soils is a significant source of carbon dioxide and nitrous oxide.

These soils occupy an area of between 200,000 and 250,000 hectares, ie, just under 10 per cent of Swedish arable land. The other major source of greenhouse gas emissions from agriculture are methane emissions from livestock farming. Other emissions of greenhouse gases from agriculture are of secondary importance. The following may be said about the fundamental conditions for greenhouse gas emissions from agriculture in the 1990s:

- the area of arable land decreased by 30,000 hectares (1 per cent) since 1990

Figure 1.9 Area of land qualifying for certain environmental subsidies; nitrogen leaching subsidy (upper panel) and grazing land subsidy (lower panel)



Source: Swedish Board of Agriculture

- grain cultivation has increased, whereas the area under fodder crops remained
- unchanged and cultivation of oil plants declined
- the number of dairy cattle fell by about 2 per cent a year, while milk production remained more or less the same
- other cattle and sheep increased slightly in number, particularly during 1993 – 1996
- the number of pigs remained constant, apart from in 1999, when production of fattening pigs fell
- it has become increasingly common to deal with farmyard manure in slurry systems, particularly manure produced by pigs and dairy cattle
- use of nitrogenous artificial fertilisers did not change appreciably during the period.

Grain cultivation fell following the food policy decision of 1990, whereas the area under fodder crops and extensive livestock farming increased markedly. When Sweden joined the EU in 1995 and became subject to the CAP, the trend for both livestock and arable farming stabilised, although the area under fodder crops declined and in 1999 was close to the area in use around 1990.

1.12 Swedish forests

Sweden has just over 27 million hectares of forested land, of which just under 23 million hectares are classified as productive forest and are available for forestry. Timber reserves total 3 billion cubic metres total volume over bark. Annual growth is currently about 100 million cubic metres, whereas felling is 70 – 75 million cubic metres.

Just over half the area of Swedish forests is owned by about 350,000 private landowners.

Limited companies own just under 40 per cent of forested land; the state and other public owners own the remainder. More forest is privately owned in the south than in the north.

Approximately 85 per cent of the total timber volume comprises coniferous trees. Spruce accounts for 45 per cent of timber volume and pine 39 per cent. Birch is the predominant broadleaf tree, accounting for 10 per cent of total timber volume. Other broadleaf trees such as aspen, beech and oak make up the remainder.

Forests are one of Sweden's most important natural resources and represent a raw material base for the forest products industry of great importance to the country's economy. Timber volume has increased by about 70 per cent since the 1920s. There has been a parallel increase in annual growth and the area of forested land has also increased.[18] There are several reasons for this. In previous centuries the forests surrounding cultivated land were in many ways exploited more ruthlessly than they are nowadays. Among other things, this took the form of felling, gathering of firewood, slash-and-burn and forest grazing. Demand for charcoal and timber grew in the 18th and 19th centuries, in parallel with development of transport systems. For a long time, this allowed a level of exploitation entailing a steady decline in forest resources. Even sparsely populated forests often had a low timber content, since dry and moderately dry forests usually suffered forest fires about once a century.

Reforestation of former agricultural land and sparsely forested land, in combination with improved forest management, resulted in a dramatic increase in timber volume in Sweden in the 20th century. This has allowed a continuous increase in the rate of felling.

Swedish forest assets constitute the base for the Swedish forest products industry. This industry provides jobs for about 93,000 people, of whom some 17,000 work in forestry itself and 76,000 in processing industries. In addition, forestry provides almost as many jobs again indirectly in other industries such as transport, chemicals and IT.

Swedish pulp production was 11.5 million tonnes in 2000. Most of this is used internally to make paper. A small proportion is exported or sold to other companies.

Paper production totalled 10.8 million tonnes and timber production 14.8 million cubic metres. 80 per cent of forest products are exported. The total value of these exports was SEK 106 billion in 2000

The low rate of forest growth in Sweden means a relatively low rate of return on investment in regeneration in the form of planting and soil preparation. Bearing in mind the importance of forest resources to the Swedish economy, a general statutory duty to replace felled trees with a stand making good use of the growth potential of the soil was introduced as long ago as 1903. A tradition also developed throughout the 20th century whereby good forest management made it possible to maintain or increase overall forest production over time. Hence, forests have not been seen merely as a capital investment like any other. The laws, regulations and guidelines that have been introduced have followed in this tradition. The general trend towards increased timber removal in the 20th century has been more than counterbalanced by increased growth. The direct and indirect supply of various types of forest fuel has increased in recent decades. However, the practice remains only to make use of a small proportion of the branches and tops removed during felling for timber.

[18] "Forest growth" means usable stemwood production

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