REGERINGSKANSLIET

Ministry of the Environment
Sweden

Sweden's third national communication on Climate Change

Ds 2001:71

Ds 2001:71

Sweden's third national communication on Climate Change

Under the United Nations Framework Convention on Climate Change

REGERINGSKANSLIET

Ministry of the Environment
Sweden

This report is on sale in Stockholm at Fritzes Bookshop, which supplies Swedish official government reports (SOUs) and departmental series (Ds) and also on behalf of the Government Offices, Office for Administrative Affairs, arranges for them to be circulated to the competent parties for comments.

Address: Fritzes, Customer Service
SE-106 47 Stockholm
Sweden
Telefax: 08 690 91 91 (national)
+46 8 690 91 91 (international)
Telephone: 08 690 91 90 (national)
+46 8 690 91 90 (international)
E-mail: order.fritzes.@liber.se
Internet:www.fritzes.se

Further copies may be obtained from:
The Swedish Environmental Protection Agency
SE-106 48 Stockholm, Sweden

Translation: Maxwell Arding/Ardlang
Figures: Johan Wihlke/The Swedish Environmental Protection Agency
Layout: Svensk information AB
Printing: Graphium Västra Aros, Västerås, Sweden 2001

ISBN 91-38-21596-9
ISSN 0284-6012

Departementsserie 2001

Kronologisk förteckning

1. Distansavtalslagen och fritidsevenemang. Ju.
2. Priset för ett större EU – en ESO-rapport om EU:s utvidgning. Fi.
3. Romstadgan för Internationella brottmålsdomstolen. Ju.
4. Ett svenskt center i Istanbul. UD.
5. Förråande pornografiska filmer – en översyn av 4 § lagen (1990:886) om granskning och kontroll av filmer och videogram. Ku.
6. Genomförande av deltids- och visstidsdirektiven. N.
7. Svenska författningar i översättning till främmande språk. En förteckning. SB.
8. Två frågor om sekretess hos Säkerhetspolisen. Ju.
9. Yttrandefrihet för privatanställda. Ju.
10. Mänskliga rättigheter i Sverige – en kartläggning. Ju.
11. Riksrevisionen – ändringar i regeringsformen. Ju.
12. Konkurrens bildar skola – en ESO-rapport om friskolornas betydelse för de kommunala skolorna. Fi.
13. E-handelsdirektivet – genomförande av direktivet 2000/31/EG om vissa rättsliga aspekter på informationssamhällets tjänster. N.
14. Gränsöverskridande sårbarhet – gemensam säkerhet. Säkerhetspolitisk rapport från Försvarsberedningen. Fö.
15. Rapport om tillväxtavtalen. Första året. N.
16. En utvärdering av Folkbildningen om EMU. SB.
17. Konkurrens på lika villkor mellan offentlig och privat sektor. N.
18. Ändrade regler om annonser i TV-sändningar. Ku.
19. Elevens framgång – Skolans ansvar. U.
20. Benchmarking av näringspolitiken 2001. Indikatorer inom åtta områden som påverkar ekonomisk tillväxt. N.
21. Kreditsäkerhet i byggnader på annans mark. Ju.
22. Sammanställning av remissyttranden över betänkandet "Regionalt folkstyre och statlig länsförvaltning" (SOU 2000:85). Fi.
23. Förbränning av animaliskt avfall. Jo.
24. Betyg på skolan – en ESO-rapport om gymnasieskolorna. Fi.
25. Några frågor om myndigheternas service. Ju.
26. Politik för folkstyrelse på 2000-talet. Remissammanställning av Demokratiutredningens slutbetänkande "En uthållig demokrati" (SOU 2000:1). Ju.
27. EG-direktivet om personuppgifter – En offentlig utvärdering. Ju.
28. Långsiktig verksamhetsutveckling ur ett arbetsmiljöperspektiv. En handlingsplan för att förnya arbetsmiljöarbetet. N.
29. Nicefördraget. EU:s regeringskonferens 2000. + Bilagor. UD.
30. Finansieringen av kommunkontosystemet – en översyn. Fi.
31. Omhändertagande av berusade personer enligt LOB. Ju.
32. Myndigheternas skrivregler. SB.
33. Proceduren vid kommunala folkomröstningar. Ju.
34. Ökade möjligheter till brukarinflytande. Ju.
35. Skatteregler mot handel med skalbolag. Fi.
36. Hovrättsprocessen i framtiden. Ju.
37. Tillsynsansvar över jämställdhetslagen – en uppgift för länsstyrelserna? N.
38. Säkerställda obligationer. Fi.
39. Ändringar i lagen om arbetslöshetsförsäkring med anledning av aktivitetsgarantin. N.
40. Nya bud – en ESO-rapport om auktioner och upphandling. Fi.
41. Sweden's second national report under the Convention on Nuclear Safety. M.
42. Rättvisa och effektivitet – en idéanalys. Fi.
43. Åtgärder mot klotter. Ju.
44. Ny struktur för ökad säkerhet – nätverksförsvar och krishantering. Fö.
45. I rikets tjänst – en ESO-rapport om statliga kårer. Fi.
46. Vissa frågor om sjömäns vilotid. N.
47. Kommunernas ansvar i vissa barn- och ungdomsärenden. S.
48. Samverkande styrning. Om läroplanerna som styrinstrument. U.
49. Rättsligt skydd för biotekniska uppfinningar – genomförande av direktiv 98/44/EG. Ju.
50. Ändringar i arbetsmiljölagen. N.
51. Trafikskada utomlands – enklare att få ersättning. Ju.
52. Abonnentinflytande i kabel-TV-nät en analys av behovet av lagregler för att stärka abonnenternas inflytande över programutbudet i kabel-TV-nät. Ku.
53. Föräldrars samtycke till adoption, m.m. Ju.
54. Idrotten i Sverige och EU. En rapport från EU-idrottsarbetsgruppen. N.
55. Ändringar i konsumentköplagen – genomförande av EG:s konsumentköpsdirektiv. Ju.
56. Åtgärder mot sena betalningar – genomförande av EG-direktivet om bekämpande av sena betalningar vid handelstransaktioner. Ju.
57. Barnafödandet i fokus. Från befolkningspolitik till ett barnvänligt samhälle. S.
58. Straffrättslig sanktionering av EG:s punktskatteregler för alkohol, tobak och mineraloljor. Fi.
59. Mycket väsen för lite ull – en ESO-rapport om partnerskapen i de regionala tillväxtavtalen. Fi.
60. Effektivare energianvändning. Förslag till marknadsbaserade åtgärder. N.
61. Samverkan mellan kommuner – för ökad attraktivitet, tillväxt och sund ekonomi. Fi.
62. Etikprövning av forskning som avser människor. U.
63. Svensk basindustri. Konkurrenskraft och hållbar utveckling. + Bilagor. N.
64. Ändrad ordning. Strategisk utveckling för jämställdhet. N.
65. Förslag till program för långsiktiga avtal med energiintensiv industri. Energieffektivisering och andra åtgärder för att minska utsläppen av klimatpåverkande gaser. +Bilagor. N.
66. Några frågor om ordningslagen. Ju.
67. Behandling av personuppgifter i den arbetsmarknadspolitiska verksamheten. N.
68. Den nya produktionen – det nya uppdraget. Jordbrukets framtid i ett historiskt perspektiv. Jo.
69. Företagsbot. Ju.
70. Vägen tillbaka – stöd till verksamhet för att bistå personer som vill lämna rasistiska och andra liknande grupperingar. N.
71. Sveriges tredje nationalrapport om klimatförändringar. M. Swedens third national communication on Climate Change. Under the United Nations Framework Convention on Climate Change. M.

Departementsserie 2001

Systematisk förteckning

Statsrådsberedningen

Svenska författningar i översättning tillfrämmande språk. En förteckning. [7]
En utvärdering av Folkbildning om EMU. [16]
Myndigheternas skrivregler. [32]

Justitiedepartementet

Distansavtalslagen och fritidsevenemang. [1]
Romstadgan för Internationella brottmålsdomstolen. [3]
Två frågor om sekretess hos Säkerhetspolisen. [8]
Yttrandefrihet för privatanställda. [9]
Mänskliga rättigheter i Sverige – en kartläggning. [10]
Riksrevisionen – ändringar i regeringsformen. [11]
Kreditsäkerhet i byggnader på annans mark. [21]
Några frågor om myndigheternas service. [25]
Politik för folkstyrelse på 2000-talet. Remissammanställning av Demokratiutredningens slutbetänkande "En uthållig demokrati" (SOU 2000:1). [26]
EG-direktivet om personuppgifter – En offentlig utvärdering. [27]
Omhändertagande av berusade personer enligt LOB. [31]
Proceduren vid kommunala folkomröstningar. [33]
Ökade möjligheter till brukarinflytande. [34]
Hovrättsprocessen i framtiden. [36]
Åtgärder mot klotter. [43]
Rättsligt skydd för biotekniska uppfinningar – genomförande av direktiv 98/44/EG. [49]
Trafikskada utomlands – enklare att få ersättning [51]
Föräldrars samtycke till adoption, m.m. [53]
Ändringar i konsumentköplagen – genomförande av EG:s konsumentköpsdirektiv. [55]
Åtgärder mot sena betalningar – genomförande av EG- direktivet om bekämpande av sena betalningar vid handelstransaktioner. [56]
Några frågor om ordningslagen. [66]
Företagsbot. [69]

Utrikesdepartementet

Ett svenskt center i Istanbul. [4]
Nicefördraget. EU:s regeringskonferens 2000. + Bilagor. [29]

Försvarsdepartementet

Gränsöverskridande sårbarhet – gemensam säkerhet. Säkerhetspolitisk rapport från Försvarsberedningen. [14]
Ny struktur för ökad säkerhet – nätverksförsvar och krishantering. [44]

Socialdepartementet

Kommunernas ansvar i vissa barn- och ungdomsärenden. [47]
Barnafödandet i fokus. Från befolkningspolitik till ett barnvänligt samhälle. [57]

Finansdepartementet

Priset för ett större EU – en ESO-rapport om EU:s utvidgning. [2]
Konkurrens bildar skola – en ESO-rapport om friskolornas betydelse för de kommunala skolorna. [12]
Sammanställning av remissyttranden över betänkandet "Regionalt folkstyre och statlig länsförvaltning" (SOU 2000:85). [22]
Betyg på skolan – en ESO-rapport om gymnasieskolorna. [24]
Finansieringen av kommunkontosystemet – en översyn. [30]
Skatteregler mot handel och skalbolag. [35]
Säkerställda obligationer. [38]
Nya bud – en ESO-rapport om auktioner och upphandling. [40]
Rättvisa och effektivitet – en idéanalys. [42]
I rikets tjänst – en ESO-rapport om statliga kårer. [45]
Straffrättslig sanktionering av EG:s punktskatteregler för alkohol, tobak och mineraloljer. [58]
Mycket väsen för lite ull – en ESO-rapport om partnerskapen i de regionala tillväxtavtalen. [59]
Samverkan mellan kommuner – för ökad attraktivitet, tillväxt och sund ekonomi. [61]

Utbildningsdepartementet

Elevens framgång – Skolans ansvar. [19]
Samverkande styrning. Om läroplanerna som styrinstrument. [48]
Etikprövning av forskning som avser människor. [62]

Jordbruksdepartementet

Förbränning av animaliskt avfall. [23]
Den nya produktionen – det nya uppdraget. Jordbrukets framtid i ett historiskt perspektiv. [68]

Kulturdepartementet

Förråande pornografiska filmer – en översyn av 4 § lagen (1990:886) om granskning och kontroll av filmer och videogram. [5]
Ändrade regler om annonser i TV-sänd ningar. [18]
Abonnentinflytande i kabel-TV-nät – en analys av behovet av lagregler för att stärka abonnenternas inflytande över programutbudet i kabel-TV-nät. [52]

Näringsdepartementet

Genomförande av deltids- och visstidsdirektiven. [6]
E-handelsdirektivet – genomförande av direktivet 2000/31/EG om vissa rättsligaaspekter på informationssamhällets tjänster. [13]
Rapport om tillväxtavtalen. Första året. [15]
Konkurrens på lika villkor mellan offentlig och privat sektor. [17]
Benchmarking av näringspolitiken 2001. Indikatorer inom åtta områden som påverkar ekonomisk tillväxt. [20]
Långsiktig verksamhetsutveckling ur ett arbetsmiljöperspektiv. En handlingsplan för att förnya arbetsmiljöarbetet. [28]
Tillsynsansvar över jämställdhetslagen – en uppgift för länsstyrelserna? [37]
Ändringar i lagen om arbetslöshetsförsäkring med anledning av aktivitetsgarantin. [39]
Vissa frågor om sjömäns vilotid. [46]
Ändringar i arbetsmiljölagen. [50]
Idrotten i Sverige och EU. En rapport från EU-idrottsarbetsgruppen. [54]
Effektivare energianvändning. Förslag till marknadsbaserade åtgärder. [60]
Svensk basindustri. Konkurrenskraft och hållbar utveckling. + Bilagor. [63]
Ändrad ordning. Strategisk utveckling för jämställdhet. [64]
Förslag till program för långsiktiga avtal med energiintensiv industri. Energieffektivisering och andra åtgärder för att minska utsläppen av klimatpåverkande gaser. + Bilagor. [65]
Behandling av personuppgifter i den arbetsmarknadspolitiska verksamheten. [67]
Vägen tillbaka – stöd till verksamhet för att bistå personer som vill lämna rasistiska och andra liknande grupperingar. [70]

Miljödepartementet

Sweden's second national report under the Convention on the Nuclear Safety. [41]
Sveriges tredje nationalrapport om klimatförändringar.[71]
Swedens third national communication on Climate Change. Under the United Nations Framework Convention on Climate Change. [71]

Ds 2001:71

Sweden's third national communication on Climate Change

Under the United Nations Framework Convention on Climate Change

REGERINGSKANSLIET

Ministry of the Environment
Sweden

Sweden's Third National Communication under the Climate Convention

Foreword

Sweden has prepared the following National Communication in accordance with Article 12 of the Climate Convention. The material on which the communication is the result of an extensive project headed by the Swedish Environmental Protection Agency and involving a further ten Swedish public authorities.

The report was adopted by the government on 22 November 2001. Most of the work on the Third National Communication was carried out between autumn 2000 and summer 2001. The second part of the sixth meeting of the parties (CoP6 bis) was held while this communication was being prepared. An important political agreement was reached at that meeting and, as a result, the parties will be able to begin work on ratifying the Kyoto Protocol. Sweden is taking the steps necessary to ratify the Protocol in 2002.

Since most of the work on this communication was completed in the summer of 2001, events occurring after that time are not fully described here. For example, the forecasts of future Swedish emissions of carbon dioxide take no account of the economic slowdown in summer 2001. Nor has it been possible for these forecasts to take account of the growing uncertainty and the international tensions following the terrorist attacks in New York and Washington in September. However, the forecasts are already intrinsically uncertain because they deal with long or very long-term scenarios. The government does not consider that the relevance of the forecasts has been appreciably affected by near-term events of the kind described above.

Moreover, the Third National Communication does not take into account a number of political decisions that were taken after the summer of 2001 and have a bearing on Swedish climate policy.

In September 2001 the government decided to put a bill before parliament entitled Infrastruktur för ett långsiktigt hållbart transportsystem ("Infrastructure for a sustainable transport system") (Gov. Bill 2001/02:20). This bill represents the largest investment in Swedish infrastructure in modern times. The National Rail Administration and the National Road Administration will be instructed to plan investment in new roads and railways, to develop and modernise transport systems and to take the necessary steps to maintain and safeguard the existing road and rail network. SEK 364 billion will be allocated for this purpose between 2004 and 2015. Some of these resources will be made available earlier, so that work can begin during the period 2002 – 2004.

These major infrastructure investments are needed to promote growth, regional development and a change-over to ecological sustainability in Sweden. Investments of significance in terms of climate change include SEK 150 billion to maintain and safeguard the existing road and rail network, SEK 100 billion to be invested in the railways as part of a strategy to improve the competitiveness of rail as compared with passenger and goods transport by road. SEK 69 billion will be invested in road projects (most of them already planned), environmental improvements along roads and measures to improve road safety.

The "rush-hour charges" and "kilometre tax" issue will be further examined. SEK 30 billion will also be allocated for regional and local projects, including minor roads, public transport subsidies, municipal airports and harbour facilities. Efforts will also be made to develop new technology and a "transport system for sustainable travel". The government also proposes that a coherent programme for technical development, demonstration and implementation of new solutions be initiated.

The government also proposes a number of measures and projects of relevance to the climate issue in the Finance Bill for 2002 (Gov. Bill 2001/2002:1). A total of SEK 990 million will be used to fund climate investments and information on climate issues over a period of three years. Spending on "General environmental protection and nature conservation" will be substantially increased. The most important change in spending on the climate issue is a new appropriation for climate investment funding. The government proposes that the current funding for local investment programmes (LIPs) be replaced by funding for climate investment programmes as from 2002. This is because the climate issue is becoming more important and the government wants to reduce Swedish greenhouse gas emissions. Municipalities can apply for money for climate investment programmes involving measures to reduce emissions of greenhouse gases, for example, in the energy and transport sectors. The appropriation will be SEK 200 million in 2002, SEK 300 million in 2003 and SEK 400 million in 2004. It is also proposed that the landfill tax be raised by 15 per cent as from 2002. SEK 30 million a year will be allocated for information about climate issues during 2002 – 2004. The Swedish Environmental Protection Agency will be given responsibility for this information. Increased resources will also be devoted to research into biodiversity and sustainable development. Research at FORMAS ("the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning") will receive extra funding of SEK 80 million in 2002 and 2003 and SEK 90 million i n 2004. This is to be used for research into biodiversity and research in support of ecologically sustainable development. The spring budget also provided extra funding of SEK 50 million during 2002 – 2004 for Swedish Research Council research into biodiversity and ecologically sustainable development.

The government has also continued to develop a national climate strategy in 2001. The aim is to put a bill before parliament that will, among other things, define environmental quality objectives for "substances affecting climate", and present a strategy for achieving those objectives. The government intends to put this bill before parliament in autumn 2001.

Contents:

Summary –

National conditions having a bearing on emissions and removals of greenhouse gases

Greenhouse gas emissions and removals are influenced by prevailing environmental and social conditions in the country. National conditions also affect a country's ability to act.

Important national conditions include energy requirements for trade and industry, transport, heating and electricity production. Political objectives also play a part, in the form of regional policy and labour market policy objectives. Since Sweden joined the European Union (EU) in 1995, Swedish climate policy and re-lated policy areas have been influenced by the membership.

Climate policy and other political programmes are decided by parliament the Riksdagen on the basis of government proposals, which are generally based on documents produced by government agencies, review commissions and government committees. Sweden has a large number of central agencies, responsible to the government. Their role is to act as the government's expert body in relation to specific issues, and to implement government policy and decisions. These agencies act independently in their role as public authorities. There are also 21 county administrative boards and 289 municipalities in Sweden, dealing with matters of a regional and local nature. Responsibility for climate is shared between central agencies, county administrative boards and municipalities.

The population of Sweden was just under 8.9 million in 1999, having risen by approximately three per cent since 1990. The long-term rate of increase is expected to decline, however. The average age of the population is rising. Sweden has a low population density, with an average of 22 inhabitants per square kilometre. Nearly 85 per cent of the 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 total surface area of Sweden, including lakes but excluding territorial waters, is 449,964 square kilometres. The country lies at a northerly latitude (55°N to 69°N). Most agriculture is concentrated in the south of the country, owing to the favourable climate and fertile conditions there. Forestry predominates in the north and centre of the country. Sweden has a temperate climate, with a mean annual temperature of about 4°C and mean annual precipitation of approximately 650 mm. The montane region displays tundra conditions, however. Much of Sweden is usually snow-covered in winter.

The Swedish economy is open and the country is heavily dependent on foreign trade.

Exports account for approximately 44 per cent of GDP. The principal export products are iron and steel, engineering and forest products. The trend in Swedish industry is towards a greater proportion of processed products and increasingly sophisticated services. Capital-intensive and labour-intensive industry are declining in significance. However, basic industries still play an important part in Sweden, particularly in terms of the regional balance and as a source of employment around the country. The relatively rapid rise in the importance of sophisticated services is in part due to a rapid increase in demand for products in the telecommunications and pharmaceutical sectors, where the average annual increase has been approximately 20 per cent and 13 per cent, respectively.

Swedish per capita energy consumption is fairly high compared with other industrial nations, whereas per capita emissions of greenhouse gases are fairly low. Swedish carbon dioxide emissions peaked around 1970. Emissions fell by over 40 per cent between 1970 and 1990. This was largely due to a changeover from oil-based energy to electric power and other energy sources, as well as considerable improvements in energy efficiency. Factors making this possible included development of nuclear power. Biomass fuels have also increased at the expense of oil products, from nine per cent of the total supply in 1970 to 15 per cent in 1999.

Transport (goods and passenger) increased by approximately two per cent a year in the 1990s. The structure of society, the way communities are planned, the location of homes and shopping centres, and so on, affect transport requirements and the scope for taking effective action to reduce greenhouse gas emissions. Swedish municipalities have overall responsibility for local planning, although this is coordinated with regional and national plans. Building construction is subject to detailed regulations, which influence heating requirements. Building standards are high in Sweden, relative to other countries.

Over the last 50 years, Swedish agriculture has undergone far-reaching structural changes and rationalisation. The area of land under cultivation has decreased, while productivity has risen. Since 1995, the EU Common Agricultural Policy (CAP) has had a major impact on the area under cultivation and agricultural product quotas.

Forests are one of Sweden's most important natural resources and represent a basic supply of raw materials of the pulp and paper industry. This is of great importance to the national economy and as a source of renewable energy. Timber volume has increased by approximately 70 per cent since the 1920s.

Emissions and removals of greenhouse gases

Between 1990 and 1999 total emissions of greenhouse gases (not including the land-use and forestry sectors or international transport) rose by less than 0.1 per cent.

As classified in this report, transport and its emissions are included in the energy sector.

Emissions from transport rose somewhat between 1990 and 1999, whereas those from the housing and service sectors fell slightly. In other sectors, methane emissions from waste and transport fell, while emissions of halocarbons rose.

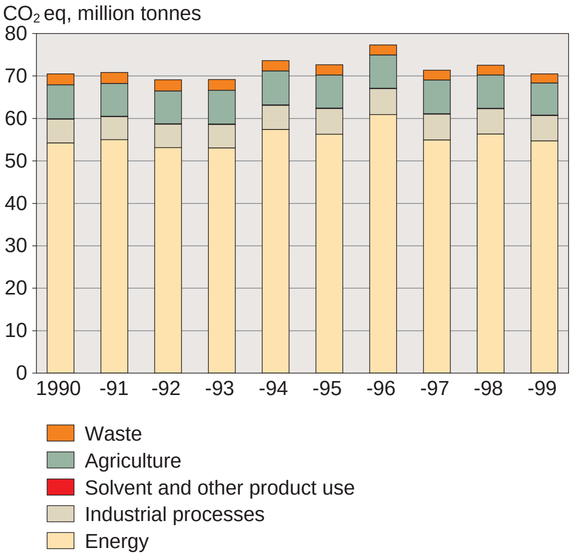
The inventory of emissions has been performed largely along the lines of the standard method formulated by the Intergovernmental Panel on Climate Change (IPCC), but has been refined using national methods in some areas. Emission statistics are largely based on official Swedish statistics. The total impact of various greenhouse gases has been estimated using the guideline weighting (Global Warming Potential) factors for the effect on climate the different gases have over 100 years. The total effect on climate of greenhouse gases is expressed in carbon dioxide equivalent emissions. Some minor revisions and corrections have been made in this national communication as compared with the report submitted under the Climate Convention in April 2001.

The energy sector accounted for 77.4 per cent of the total emissions of greenhouse gases in 1999, of which transport accounted for 29.5. Industrial processes produced 8.6 per cent, solvent use 0.1 per cent, the agricultural sector 10.7 per cent and the waste sector 3.0 per cent of all greenhouse gas emissions. There was some shift in the relative importance of emissions from sub-sectors of the energy sector, although total emissions did not change appreciably.

Less use of fossil fuels in district heating production and connection of homes and commercial premises to district heating networks have particularly reduced emissions in these housing and service sectors.

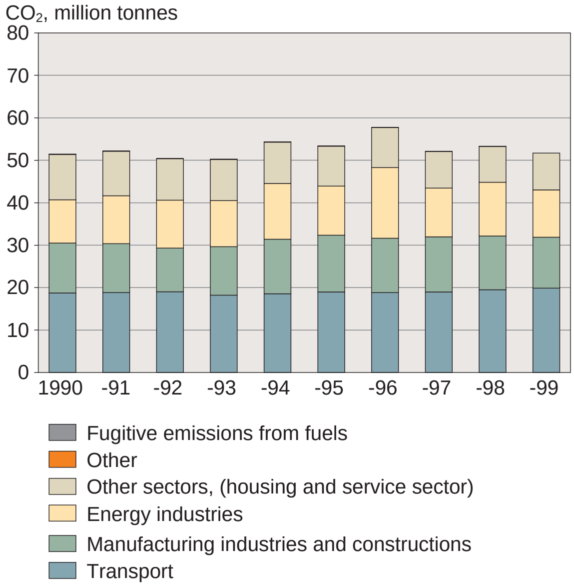
Removals by forest above ground (the change in stored forest biomass) varies over time depending on growth and removal of forest products. Forest above ground accounts for removal of about 23,000 ktonnes carbon dioxide a year, peaking at approx. 30,000 ktonnes carbon dioxide in 1991. Carbon dioxide sinks and emissions from forested land are influenced by a number of factors; it is not possible at present to

Figure 1
Greenhouse gas emissions by sector, not including the land-use and forestry sectors or international transport.



Source: Swedish Environmental Protection Agency

Figure 2
Emissions of carbon dioxide from the energy sector, broken down into sub-sectors.



Note: The sub-sector for combined heating and power plants, oil refineries etc includes emissions from district heating.

Source: Swedish Environmental Protection Agency

make a reliable estimate of the net effect on the carbon dioxide/carbon balance in forest soil. Overall, cultivation of agricultural land results in some loss of carbon dioxide: approx. 3,800 ktonnes a year.

Carbon dioxide is the main greenhouse gas emitted in Sweden, representing just over 80 per cent of all greenhouse gas emissions (expressed as carbon dioxide equivalent emissions) in 1999. Swedish emissions of this gas increased by just under one per cent between 1990 and 1999. Emissions derive mostly from the energy sector, ie, energy supply and use, which accounts for 87 per cent of all carbon dioxide emissions. Domestic transport accounts for some 35 per cent of total carbon dioxide emissions. Industrial processes and certain kinds of agricultural land use also result in carbon dioxide emissions.

Emissions of methane accounted for approximately eight per cent of total greenhouse gas emissions in 1999. The main sources of methane emissions are enteric fermentation (ie, ruminating cattle) and landfill sites. These sources are responsible for just under 90 per cent of all methane emissions. These emissions fell by about nine per cent between 1990 and 1999.

Emissions of nitrous oxide represented just over 10 per cent of all greenhouse gas emissions in 1999. Agricultural fertilisers are the main source, although combustion in the energy sector and industrial processes also contribute. Emissions have remained constant, falling slightly in agriculture and rising somewhat in the energy sector.

Perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6) accounted for just over one per cent of all greenhouse gas emissions in 1999. These halocarbons are used and emitted from a limited number of applications (eg, as refrigerants and in certain kinds of fire fighting) and are also released as a pollutant from aluminium production. They all score high in terms of their global warming potential (GWP), ie, greenhouse effect per kg expressed as carbon dioxide equivalent emissions.

Relatively speaking, these emissions increased sharply between 1990 and 1999, mainly owing to the phase-out of ozone depleting substances (including CFCs and HCFCs), governed by the Montreal Protocol.

"Normal-year" correction

Variations in temperature, wind and incoming radiation affect the fossil fuel requirement for heating. Precipitation also affects fossil fuel use because the availability of electric energy from hydropower is dependent on this. To make relevant comparisons between the years, a normal-year correction of carbon dioxide emissions in the energy sector is sometimes performed by calculating the effect of climate variations. The normal-year correction takes account of the annual variation in temperature, incoming radiation and wind, and also the availability of hydropower. However, variations in the economic cycle or temporary shutdowns at nuclear power plants are not included. The normal-year correction in this report differs slightly from that used in previous national reports.

Winters in the 1990s were fairly mild and wet. As a result, all years except 1996 have higher emissions after the normal-year correction. The largest correction was made for 1990, which was a warm and wet year.

Total emissions of greenhouse gases (not including the land-use and forestry sectors or international transport) rose by less than 0.1 per cent between 1990 and 1999. Corresponding normal-year-corrected total emissions of greenhouse gases during this period fell by about 1.6 per cent.

Objectives and measures affecting emissions and removals of greenhouse gases

In 1993 parliament decided that by 2000, emissions of carbon dioxide from fossil sources should have stabilised at 1990 levels and should then fall. This target was confirmed and supplemented in 1999 when parliament laid down the current environmental quality objective termed "Reduced Climate Impact":

> *"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."*

Government climate policy is intended to achieve this objective as part of the efforts to achieve an ecologically, economically and socially sustainable society.

Sweden is taking a number of steps and employing various instruments specifically designed to control greenhouse gas emissions, but most measures and instruments affect emissions as a side-effect. Inventories and analysis of the effects of these measures and instruments focus on those that

- are in use or were in use at some time in the 1990s but have now been discontinued or abolished;
- have been decided but will come into force later;
- have come a long way in the planning process, eg, by means of a parliamentary decision in principle or in the form of a government bill.

Measures that primarily have other aims may also help to reduce carbon dioxide.

Sweden is also spending large amounts of money on research and development of new technology, one of whose aims is to reduce environmental impact. Funding for research and development and ecological adjustment of the Swedish energy system totals approximately SEK 10 billion for the period 1998 – 2002.

The policy Sweden has pursued enabled it to keep greenhouse gas emissions in the late 1990s more or less at the same level as in 1990.

International comparison

Compared with other industrialised nations, per capita carbon dioxide emissions in Sweden are relatively low. Emissions of carbon dioxide total some 6 tonnes per person and year, which may be compared with the OECD average, which is approximately 11.5 tonnes per person and year. This is because the proportion of fossil fuels in the Swedish energy system is 40 per cent, compared with an average of 80 per cent in the rest of the OECD. The scope for reducing Swedish emissions therefore differs somewhat from many other countries. The differences are particularly pronounced in relation to electricity generation, where fossil fuels account for a mere 5 per cent or so of total production. Further emission reductions are therefore more costly in Sweden than in many other countries. Sweden's northerly latitude and cool climate and the predominance of energy-intensive basic industries make for relatively high per capital energy consumption compared with other industrialised countries.

Examples of the effectiveness of measures and instruments

Instruments within the tax system

Taxes and charges play a central part as a means of achieving the objectives of energy and climate policy. The tax burden on energy consumption has been raised while that on labour is being eased; there is also a shift in the tax emphasis between energy tax and carbon dioxide tax.

Energy and carbon dioxide taxation changed in the 1990s. Twenty-five per cent VAT on energy use was introduced in 1991. The carbon dioxide tax was introduced the same year.

This was subsequently raised on two occasions in the 1990s. Energy tax has been raised a number of times and the fuels and applications covered by the tax have also been extended. Energy tax was also levied on industrial use in 1990. A shift in the relative levels of energy tax and carbon dioxide tax was made in 2000. State revenues from energy and carbon dioxide taxes totalled about SEK 65 billion in 1999, almost double total revenues from energy taxes in 1990. Changes in Swedish energy and carbon dioxide taxation in the 1990s have had a great effect on carbon dioxide emissions. Estimates using the MARKAL model, which also includes the effect of subsidies for renewable electric energy generation, indicate that emissions of carbon dioxide in 2000 were at least 5,000 ktonnes less than they would have been if no changes had been made in energy and carbon dioxide taxation in the 1990s. This estimate includes the effects of changes in fuel use and some technological changes, but not the inhibitory effect of the taxation on consumption. The effect of these taxation changes on carbon dioxide emissions increases as time goes by. The carbon dioxide tax is one of the main reasons behind the dramatic increase in the use of biomass fuels in the district heating sector.

Other economic instruments such as trade in certificates and use of the flexible mechanisms offered by the Kyoto Protocol are now being prepared as a complement to taxes and charges to achieve clear management by objectives, with a high level of cost effectiveness.

Measures and instruments in the field of energy policy

When parliament laid down energy policy in 1997, new programmes were introduced to increase energy efficiency, reduce electricity consumption for heating and promote renewable electricity production. The programme for adjustment of the energy system is designed to establish a basis for an ecologically sustainable energy system. These measures are necessary to compensate for the loss of electricity generation from nuclear power at the Barsebäck nuclear power plant. The programme runs from 1998 to 2002 and involves funding of approximately SEK 3.5 billion.

To some extent, this was a continuation of the 1991 energy policy programme. Investment grants to increase the use of renewable energy sources such as small-scale hydropower, wind power and biomass power and heating complemented the changes in use brought about by energy taxation, since carbon dioxide tax is not levied on electricity generation.

A special operating grant for small-scale energy generation was introduced in 2000. A special "environmental bonus" for wind power generation was introduced as long ago as 1995.

Another part of the measures, known as "the long-term adjustment programme" is intended to develop new energy technologies and give financial support for the commercial launch of new technology. This support will total some SEK 5 billion between 1998 and 2004.

It is difficult to assess the effects of shutting down the two nuclear reactors at Barsebäck, since shutdown is being accompanied by wide-ranging measures to replace the electricity shortfall with renewable energy or to reduce energy requirements by greater efficiency.

One of the reactors was shut down in 1999, and, under the Nuclear Power Phase-Out Act, the government must decide when the other reactor is to be decommissioned. The government thinks it will be possible to shut down the second reactor by the end of 2003, at the latest. However, the decision to close down the second reactor involves a proviso that replacement electricity sources and lower consumption must compensate for the shortfall. Another condition is that a shut-down must not create negative effects with regard to electricity prices, electricity supply to industry, the balance between power supply and demand or the environment and climate.

The energy policy decision of 1997 also involved a strategy for Swedish climate policy in the energy field. It was decided that Sweden should adopt a pro-active approach to the use of effective measures and instruments in the energy field, and that it should press for the introduction of a minimum level of energy taxation in the EU. This strategy involves bilateral and multilateral cooperation on joint implementation within the framework of the Climate Convention and also involves efforts to develop new technology for ethanol production from forest biomass.

Measures and instruments in the field of transport policy

Increased traffic has resulted in an increase in total fuel consumption and hence emissions of greenhouse gases, particularly carbon dioxide. An official aim of transport policy since the 1970s has been for all forms of transport to bear their external costs. Among other things, there has been a desire to adjust the taxation of petrol and diesel to reflect the average marginal cost of cars in non-urban traffic. It is estimated that current fuel taxes generally exceed these marginal costs, however.

Sweden is investing to improve rail infrastructure, in particular by removing bottlenecks in our three main cities. Rail traffic largely runs on electric energy generated from renewable fuels.

Efforts to reduce emissions from road traffic include training courses in "Ecodriving" and procurement of ethanol/petrol-driven hybrid vehicles (as part of trade and industry policy).

The Swedish state and vehicle manufacturers are engaged in a joint project to reduce the environmental degradation caused by road traffic and create the potential for a competitive Swedish motor industry in the long term. Up to SEK 1.8 billion is being invested jointly during 2000 – 2005. The government is contributing a maximum of SEK 500 million. The programme covers areas such as advanced combustion technology, hybrid vehicles and fuel cell technology, weight reduction and ensuring that the right skills and know-how are available.

Measures and instruments in the field of housing policy

An express aim of housing policy is a sustainable housing sector and social planning. There are several examples of instruments to promote energy saving and conversion of energy carriers. In international terms, Swedish building standards do much to save energy or reduce energy requirements for heating. Urban and regional planning is a key tool in the long-term reduction of emissions, for example when it comes to siting residential areas and routing public transport systems.

A system of grants for ecological building is available for a three-year period ending 2003.

SEK 635 million has been made available for this.

Measures and instruments in the field of forestry policy

Current Swedish forest policy places commercial production values and environmental assets in forestry on an equal footing. There has been a very long tradition of forest management legislation requiring felled areas to be replanted and forests to be conserved as a natural resource. This has helped to promote removal of carbon dioxide in forest sinks over a long period. Hence, it is difficult to identify instruments introduced in the 1990s, which have, in themselves, had a major impact on climate. Biomass growth in Swedish forests is used for wood, paper and pulp products as well as fer energy. Biomass has increased substantially and carbon sinks have thus grown because the rate of felling was considerably lower than the rate of growth in the 1990s. This growth is expected to continue, albeit at a slower rate. The carbon dioxide tax makes forest fuels relatively cheaper than fossil fuels, particularly for district heating production. This tax is the single greatest reason why Sweden has an efficient, diversified market for biomass fuels, with low prices and a growth in turnover of around 50 per cent in the 1990s. There is considerable potential for further increase in biomass fuel abstraction from Swedish forests.

Measures and instruments in the field of environment policy, including waste policy and local initiatives

The Local Investment Programme (LIP) for sustainable development in Swedish municipalities is the largest single programme and is expected to reduce carbon dioxide emissions in certain sectors, such as district heating production. Half of the SEK 5.3 billion that has so far been allocated under the programme is considered to have been invested to reduce greenhouse gas emissions. According to the information given in the applications submitted to Swedish municipalities, the overall effect of projects approved under the LIPs may reduce national emissions of carbon dioxide by 1,700 ktonnes a year. The programme has not yet been concluded and further effects may be expected. This estimate is based on advance estimates of the effect by municipalities. In 1999 Swedish environmental legislation was gathered under a unified "umbrella" known as the Environmental Code. The new general appraisal of systems as part of the permit procedure under the Environmental Code offers great scope for reducing greenhouse gas emissions.

Sweden has adopted a rigorous policy on waste over the last few years. This has resulted in a tax on landfill and a ban on landfill of burnable waste from 2002 and organic waste from 2005. The policy is expected to have a major net impact on greenhouse gas emissions.

The potential quantity of methane-generating waste is expected to fall by about 80 per cent by 2010, which is expected to yield an emission reduction of 780 ktonnes carbon dioxide equivalent emissions by 2010, compared with the instruments in place in 1990. Most organic waste is expected to be recycled for energy by incineration in the district heating sector. Municipal Agenda 21 projects and the municipal waste plans required by the Environmental Code should ultimately reduce the amount of waste landfilled.

Measures and instruments in trade and industry policy

Trade and industry policy is focusing on environmental technology as a growth industry of the future. Some support is being given in the form of market analyses of technologies capable of reducing carbon

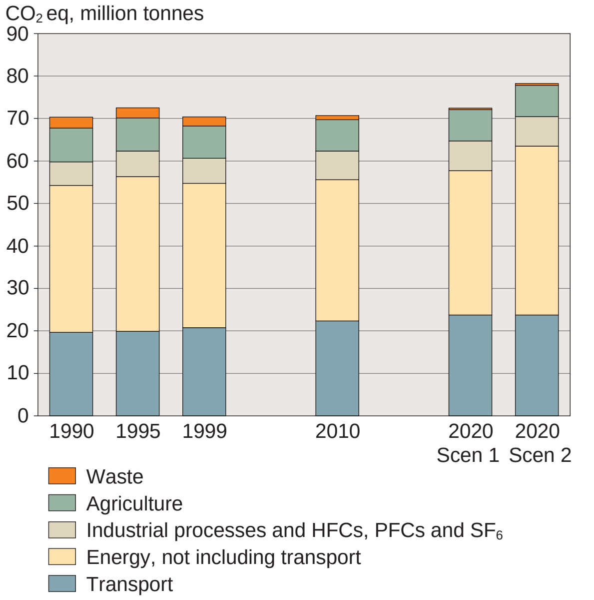
Table 1
Examples of some important measures and instruments and their impact on greenhouse gas emissions and removals.

Name of measure/instrument	Type of instrument[1]	Status of measure[2]	Assessment of effect measured in ktonnes carbon dioxide equivalent equivalent emissions per year[3 4] 1995	2000	2005
Energy and carbon dioxide taxes (inc. VAT) on energy	T	O (57-)	1,000	5,000	10,000
Investment subsidy for biomass fuel-based combined power and heating	E	O (98-02)	N.I.U.	490-820	490-820
Investment subsidy for wind power	E	O (98-02)	N.I.U.		
Operating subsidy for small-scale electricity generation	E	O (00-)	N.I.U.	170-414	170-414
Environmental bonus for wind power	T	O (95-)			
Conversion from electric heating to district heating	E	O (98-02)	N.I.U.	88-236	88-236
Conversion of electric heating to other individual heating system	E	O (98-02)	N.I.U.	34-81	34-81
Information, education etc	I	O (98-02)	N.I.U.		
Procurement of new energy technology	E	O (98-02)	N.I.U.	200-400	200-400
Testing, labelling and certification	E	O (98-02)	N.I.U.		
Local Investment programmes for ecological adjustment (LIP)	E	O (98-03)	N.I.U.	1,600	N.C.
Waste policy measures	R, T	O (91-)	N.C.	193	781
64 projects under the climate convention pilot programme for joint implementation (AIJ)	E	O (93-)	N.C.	c. 220	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) and miscellaneous (M).
2 The following symbol is used to describe the status of instruments: O = ongoing (with the year of introduction and, where applicable, conclusion).
3 N.C. means not calculated and N.I.U. means not in use at the time.
4 The calculations assume that the electricity that is substituted comes from coal-fired condensing or natural gas combination power plants. 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).
5 The impact of LIP projects is based solely on applications received by Swedish municipalities.

Note: The figures in the table also include emission reductions in other countries due to reduced import of electricity.

Figure 3
Emissions of greenhouse gases in 1990, 1995 and 1999, and projected emissions of these gases in 2010 and 2020. By sector. (Not including the land-use and forestry sectors or international transport)



Scenario 1 2020 includes the possibility of reinvestment in nuclear power;
Scenario 2 2020 assumes a working life of only 40 years for existing reactors.

Source: Projected emissions of carbon dioxide by the energy sector: National Energy Administration; otherwise Swedish Environmental Protection Agency.

dioxide emissions. Industry has invested in new technology and has thereby been able to make more efficient use of resources in relation to value added.

"Regional Growth Agreements" were drawn up throughout the country in 1998 – 1999.

Various actors in every county came together to analyse industrial potential and development requirements. This resulted in joint proposals for specific measures and their funding. Many of these measures are closely related to development of environmental technology. However, regional administrations also have a number of instruments at their disposal, which, while serving other important purposes, may be assumed to have the opposite effect on emissions of greenhouse gases. Transport subsidies are one example.

Measures and instruments in the field of agricultural policy

Swedish agricultural policy is closely related to the CAP, which, at present, provides no instruments designed to reduce greenhouse gas emissions. Certain forms of agricultural support that have other primary aims may have some positive effects on greenhouse gas emissions.

Examples include various forms of support to reduce nitrogen leaching. There has also been an environmental tax on artificial fertilisers since 1984, which may also have reduced greenhouse gas emissions.

The pilot phase of joint implementation

Sweden is involved in a series of joint projects with actors in the Baltic States to develop systems for sustainable energy supply and more efficient energy use. These projects, which include loans, credits and competence transfer, are being conducted under the Climate Convention pilot programme for activities implemented jointly (AIJ). Seventy projects have so far been initiated by Sweden, of which 64 have been reported to the UN Climate Convention Secretariat.

The total cost of the 64 projects is estimated at SEK 271 million, of which SEK 197 million is being met by the recipient countries and SEK 74 million by Sweden (the donor). The total reduction in carbon dioxide emissions to date is estimated at about 4,000 ktonnes (approx. 220 ktonnes a year).

Most of these projects have been implemented in the district heating sector in the Baltic States and in the St Petersburg and Kaliningrad areas of Russia. A biogas project has been started in Poland. The programme has been continually evaluated by local experts and independent consultants and has attracted attention internationally. The programme has been praised not only for lowering emissions of greenhouse gases, but also for its other positive effects, both in Sweden and in the recipient countries. Table 1 presents a selection of the measures and instruments that have been identified and are considered to impact greenhouse gas emissions or sinks. There is some doubt as to the accuracy of the figures given.

Projections and the combined effects of policy and measures

Projections

A combination of models has been used to estimate future emissions. It must be pointed out that all estimates are unreliable, and the results should therefore be treated with great caution.

Between 1990 and 1999 total emissions of greenhouse gases (not including the land-use and forestry sectors or international transport) rose by less than 0.1 per cent. Total emissions of these gases are expected to rise slightly from their present levels and be about 0.5 per cent higher by 2010 than they were in 1990.

After 2010 greenhouse gas emissions are expected to increase more rapidly. The decisive factor for the size of the increase between 2010 and 2020 is the rate at which nuclear power may be phased out after the two Barsebäck reactors are shut down. If 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 projections assume that the various sectors will change in different ways. The relative emissions of the various greenhouse gases will also change.

- Total emissions of greenhouse gases from the energy sector will increase by approx. 2.4 per cent per year between 1990 and 2010. If reinvestment in nuclear power is allowed (Scenario 1), emissions will rise by about 6.5 per cent between 1990 and 2020, whereas 40 years further operation of every reactor (Scenario 2) will increase emissions by approximately 17 per cent between those years.
- Emissions of carbon dioxide are the most significant emissions from the energy sector. Carbon dioxide emissions are expected to increase by about 20 per cent from the transport sector (not including international transport) and the industrial sector beween 1990 and 2020. Carbon dioxide emissions are expected to decrease in the housing sector (housing and services) by about 15 per cent (scenario 2) and 20 per cent (scenario 1) between 1990 and 2020. Carbon dioxide emissions from district heating production will fall by about 30 per cent, despite an increase of about 20 per cent in energy use in the sector. This is because much greater use of biomass fuels is expected in these sectors.
- Carbon dioxide emissions from electricity generation is expected to fall somewhat by 2010. The same applies up to 2020 in scenario 1. In scenario 2, in which the reactors are shut down after 40 years' operation, emissions of carbon dioxide from electricity generation are expected to double between 1997 (the base year) and 2020. These higher emissions in scenario 2 will arise because a larger proportion of the shortfall of electrical energy from nuclear power will be covered by electricity generation based on natural gas.
- Emissions of greenhouse gases from industrial processes and emissions of halocarbons rose by around
  6 per cent between 1990 and 1999. This trend is expected to continue, in particular because of greater emissions from the iron and steel industry and increased emissions of HFCs. Towards the end of the period, the rate of increase of fluorocarbon emissions will level off somewhat. Emissions are expected to increase by some 25 per cent between 1990 and 2010, and by around 30 per cent between 1990 and 2020.
- Emissions of greenhouse gases from agriculture fell by around 5 per cent between 1990 and 1999. This trend will continue until 2010, mainly because there are expected to be fewer animals producing methane, and because new systems for managing manure are expected, which will reduce nitrous oxide emissions. The trend after 2010 is much less certain, and the figure for 2010 has been used for 2020. Emissions from agriculture are expected to fall by 7 – 8 per cent between 1990 and 2010/2020.
- Emissions of greenhouse gases from waste fell by around 16 per cent between 1990 and 1999. The rapid decrease is expected to continue as a result of existing political decisions, including a ban on landfilling of organic and burnable waste, and the requirement that gas recovery systems be fitted at landfill sites. Emissions are expected to fall by 62 per cent between 1990 and 2010, and by about 84 per cent between 1990 and 2020.
- It is assumed that felling rates will remain largely unchanged over the coming decade, as compared with 1998 – 2000. The rate of sink growth in forest biomass will not have changed by 2010 under this scenario. There is much doubt as to the longer-term trend, and no removal figures have therefore been given for 2020.
- Emissions from international transport rose by approximately 70 per cent between 1990 and 1999. This trend is expected to continue, albeit at a slower rate after 2010. Emissions are expected to increase by 115 per cent between 1990 and 2010, and by 155 per cent between 1990 and 2020.

Evaluation of the combined effects of policy and measures

Economic instruments and effects on the energy system
To analyse the effects of economic instruments on the energy system, model calculations

(MARKAL) have been performed using two sets of economic instruments: "1990 instruments" and "current instruments" (1 January 2001). The calculation based on 1990 instruments assumes that taxes that year will remain constant throughout the period studied. There was no carbon dioxide tax in 1990. Energy tax was also levied on industrial use. Neither VAT on energy use nor the sulphur tax had been introduced, nor was there any operating subsidy for wind power or small-scale power generation. The investment grant for special technologies had not yet been introduced either.

Since the other premises on which the calculations are based are identical in the two scenarios, the differing effects on the energy system resulting from the differences in the instruments can be identified. One difference between the scenarios concerns the use of fossil fuels, the result being different carbon dioxide emissions. Our analysis assumes that the system of subsidies for renewable energy production will continue. For modelling purposes, it is assumed that the subsidy is SEK 0.15/kWh and covers all types of renewable energy. The current subsidy system is in the range SEK 0.06 - 0.30/kWh, depending on the type of energy. All calculations are uncertain and the results should therefore be treated with great caution.

The combined effect of "current instruments" is that carbon dioxide emissions in 2010 are expected to be about 10,000 ktonnes lower than they would be using "1990 instruments". Even "1990 instruments" clearly act as a curb on the use of fossil fuels.

The conclusion from the evaluation of the effects of economic instruments on the energy system is that

- The use of biomass fuels is being greatly encouraged by "current instruments". Most of the increase is occurring in the district heating sector.
- The use of biomass fuels also increases in the "1990 instruments" scenario, but at a much slower rate. The differences between the scenarios are most evident in district heating production. More than half of district heating production in 2010 will derive from biomass fuel-fired combined heating and power plants under the "current instruments" scenario. Most of the rest will come from biomass fuel-based hot water production.
- Electricity generation from biomass fuel-fired combined heating and power plants, wind power and small-scale hydropower will be greater and will be introduced sooner using current instruments, thanks to the subsidy of SEK 0.15/kWh. Wind power would not be competitive on the basis of 1990 instruments.
- Electric energy for heating and heat pumps will be used more as a result of current instruments.

The "current instruments" scenario improves the scope for use of alternative fuels owing to the increase in the tax on petrol and diesel fuels. However, the instruments are not sufficient to achieve a changeover to alternative fuels.

Measures concerning waste

The evaluation of measures relating to waste has been performed using the spreadsheet model used for the projections. Two scenarios have been produced. One describes developments resulting from instruments decided up to and including 1990, the other developments on the basis of instruments decided to the end of 1999. Some of these measures, such as the ban on landfilling burnable and organic waste, enter into force after this year, but have been decided and have the force of statute. The total effect of decided measures from 1990 and on is arrived at by comparing the two scenarios.

The measures decided in the 1990s did not begin to take effect until 1995. Under the scenario with 1990 instruments, methane emissions would remain approximately at 1995 levels until 2010, ie, around 115 ktonnes a year. Under the scenario based on measures currently decided, emissions will fall more slowly than the quantity of waste landfilled, owing to the time lag before methane is formed. By 2010, methane emissions are expected to be about 50 per cent lower than in 2000, ie, around 46 ktonnes a year. The decrease will then continue, and by 2020 emissions of methane are expected to be about 80 per cent lower than in 2000, ie around 20 ktonnes a year.

Vulnerability analysis, impact on climate and adjustment to climate change

Swedish nature and the various parts of Swedish society, including its infrastructure, are vulnerable under current variability in climatic conditions. Particular pressure and damage occur during violent storms – often in a complex of various effects. Climate change will mean changes in vulnerability and the creation of new threats. In some cases new risks and new forms of vulnerability will arise. Efforts to reduce vulnerability and risks must take account of changes occurring by virtue of changes in society and those expected as a result of climate change.

The global warming trend observed in the twentieth century has also been evident in Sweden. It has become warmer and wetter here over the last 140 years. The temperature rise is most marked in spring. Precipitation has increased at all times of year except summer, which does not display any clear trend. With regard to extremes of weather (cold, heat, heavy precipitation during a single day, storms), there might be said to be a tendency towards more heat records and fewer cold records in recent decades, although it is difficult to see any other lasting changes.

The vulnerability analysis is based on the SWECLIM research programme climate scenarios, which describe what the climate may be like in a hundred years' time. On average, the Nordic climate is expected to change more than the global climate. It is estimated that a global temperature increase of 2.6°C will raise the annual mean temperature in Sweden by approximately 4°C, with a greater increase in winter than summer.

The relative lengths of the seasons will then change, the result being much shorter winters. The surface temperature of the Baltic Sea is expected to rise by 2 – 3°C. Temperature extremes will also be affected. Extremely high temperatures are expected to rise as much as the mean summer temperature; extremely low temperatures are expected to rise much more than the rise in the mean winter temperature. The hydrological cycle is expected to become more intensive. Precipitation and water supply are expected to increase in many parts of the country: 10 – 20 per cent as an annual mean figure, more in the autumn. The rise in the mean temperature will cause greater evaporation from soil and water. Some parts of southern Sweden will suffer from water shortages, particularly in summer. However, there is much doubt in the climate change scenarios and also about the effects that may arise. In some areas there is a lack of basic knowledge about the significance of climate in terms of effects and risks.

Effects and vulnerability in the natural environment, and in agriculture and forestry:

- There will be marked effects on hydrological cycles. Climate change resulting in higher precipitation and temperatures as shown in the SWECLIM scenarios will increase water flow in the north of the country, but will result in more variable conditions in the south. There will also be a general effect on seasonal distribution, with more water flow in winter and an earlier but less dramatic spring flood than at present. Water flow may be more extreme in autumn than it is today. Control of flow and water levels may mitigate the adverse effects of high flow rates and high water levels.
- Winter snow cover is expected to be less extensive and last for a shorter period. On average, southern Sweden will not have a lasting snow cover. Ice in the Baltic will be less extensive and, on average, will only occur in the Bothnian Bay and parts of the Bothnian Sea.
- It is estimated that climate change according to the SWECLIM scenario will increase forest growth and hence conditions for forestry and agriculture (new crops as well as increased growth). But sensitivity and vulnerability will increase somewhat because many pests and diseases are currently kept in check by our climate.
- The Baltic Sea may be greatly affected, but for much of the region we lack knowledge of the fundamental effects of climatic conditions. Changes in temperature have a direct effect on various species, as well as on ice conditions. Increased precipitation in the Baltic drainage basin is expected to increase the influx of fresh water, which may cause the Baltic to become appreciably less saline. However, the key to the future salinity trend is the magnitude of salt water intrusion from the North Sea. An increase in drainage into the Baltic is also expected to bring with it more nutrients, particularly in connection with autumn rain. These changes might cause freshwater species of fish (perch, pike, pike-perch and carp) to thrive at the expense of marine species such as cod. There is a risk of non-native species spreading into the Baltic. The dynamics governing algal blooms in the Baltic may also be affected.
- Lake fauna is expected to change in favour of species tolerant of higher temperatures (perch, pike, carpinids). Other species typical of colder water (cisco and other salmonids) will suffer and may disappear from shallow lakes and watercourses in southern Sweden.
- It is thought that a change in temperature will allow a number of southern species to become established in terrestrial ecosystems, but there are also a number of obstacles to migration (the Baltic Sea and the agricultural region of southern Sweden). Some resident species of southern origin currently under threat may do better in a warmer climate. Other, more northern species and ecotypes may suffer greatly owing to a combination of warmer climate, increased nitrogen leaching and the current high levels of nitrogen deposition. There is a very great risk in montane regions that arctic-alpine species will lose out to species favoured by warmer, more nitrogenous conditions. Valuable shore biotopes and wetlands are also at risk.
- Endangered, vulnerable and care-demanding terrestrial species are threatened by climate change if the geographical continuity of their habitat (corridors – microenvironments) cannot be maintained because these species have a relict distribution confined to small, sporadically occurring habitats.
- Wetlands play an important part in the global carbon cycle and make up a large proportion of the surface area of Sweden. Their future role in the global ecocycle is ultimately a question of the hydrological status of these wetlands. However, the tools currently available are not accurate enough to be able to quantify this status with precision. Wetlands over much of Sweden can continue to absorb carbon dioxide from the atmosphere. The effects of climate change on the biodiversity of wetland areas are little known.
- Sudden changes and surprises cannot be ruled out.

Effects and vulnerability in relation to society, infrastructure and health:

- The risk of erosion, land slip and collapse increases with the amount of water in circulation and threatens infrastructure such as roads, embankments, bridges, buildings, dams, sewers and water supply systems.
- Society needs a good capability to take action in emergencies to mitigate the consequences of future extreme weather phenomena. Strong winds, storms and hurricanes, heavy rain, snow, icing and salt coating are the factors causing most damage to infrastructure. Weather of this kind often strikes across large regions, causing a number of effects at the same time. Particularly serious consequences arise when electricity supply is cut off, since society relies on a constant supply of electric power. To some extent, sensitivity and vulnerability can be reduced by strategic development of secure electricity supply and reserve capacity in the event of power cuts.
- Rising lake temperature may have serious effects on drinking water quality in terms of flavour, odour and colour. There will be a greater risk of infectious diseases and toxins spreading if flooding upstream flushes pollutants into lakes and watercourses used for drinking water supply. Water supply infrastructure has a very long life and is sensitive to climate change. The south and south-east of the country are particularly vulnerable.
- Climate change resulting in milder winters and longer spring and autumn seasons may assist the spread of infectious diseases. Carriers of infection such as rats, certain insects and tics are favoured by a milder climate, which will increase the risk of diseases such as TBE (tic-borne encephalitis), borrelia, certain forms of diarrhoea and diseases carried by mosquitoes being spread. A rise in temperature may also lead to an increased risk of infections caught from drinking water. There is expected to be a shift in the seasonal occurrence of pollen allergies and asthma. The severity of attacks may also increase. The lower frequency of periods of extreme cold will result in fewer cold-related illnesses and injuries.

The effects of climate change in the world around us may change conditions and thereby make it more difficult to achieve sustainable use of natural resources, such as agriculture and forestry in other countries. This may also put pressure on Sweden.

Financial support and technology transfer

Swedish development assistance is intended to create the right conditions for sustainable development in recipient countries. This will alleviate poverty in developing countries and help to achieve peace, democracy and sustainable use of natural resources. Compared with other OECD countries, Sweden gives a high
proportion of its gross national income (GNI) in foreign aid. Foreign aid during the period 1997 – 2000 was 0.7 per cent of GNI, a sum totalling almost SEK 52 billion.

Sweden's new and future contributions to aid development in developing countries under the Climate Convention are mainly made via the Global Environment Facility (GEF). The amount committed for the period 1998 to 2001 is SEK 448 million. Additional funding (the Special Environmental Appropriation) totalling approximately SEK 750 million (1997 – 2000) has been earmarked for the promotion of the environmental dimension in foreign aid.

The main aim of Swedish development assistance is to help fight poverty, and the vast majority of "programme countries" are those with low or very low per capita GDP. Many are among the least developed countries in the world and many are particularly vulnerable to climate change. Swedish aid given to the least developed nations in 1998 and 1999 comprised just over 25 per cent of total Swedish aid given for development assistance. Around one third of Swedish foreign aid goes via multilateral organisations. Total payments to multilateral institutions, including the Global Environment Facility, were SEK 13,184 million during the period 1997 – 1999. Important multilateral organisations are the World Bank, the regional development banks and funds and the UN environment programme. Sweden also makes contributions to a number of other organisations, including the World Conservation Union (IUCN), the World Resources Institute (WRI) and the International Institute for Environment and Development (IIED).

Swedish bilateral development work is largely conducted by the Swedish International Development Agency (Sida). Some 120 countries are involved, including cooperation with central and eastern Europe. Most resources are deployed to help the twenty countries with which Sweden is engaged in far-reaching long-term cooperation. Programmes and projects are based on the changes the recipients themselves wish to bring about and are prepared to devote resources to. Development assistance is also carried out by Swedish NGOs.

Environmental issues are an integral component of Swedish foreign aid. Among other things, environmental impact assessments are to be made of all joint projects. Priority areas for foreign aid are sustainable agriculture and forestry and land management, the marine environment, the urban environment, sustainable energy and water resources. Methods given particular emphasis are skills development and cooperation with NGOs.

All Swedish aid programmes and projects have been classified according to their environmental relevance using the OECD Development Assistance Committee (DAC) system. Programmes and projects in which the environment has been a main or secondary objective account for approximately 50 per cent of total aid.

Sweden funds development assistance in various sectors of significance for the reduction of emissions of greenhouse gases and to increase carbon dioxide sinks. Areas given particular priority are energy, transport, trade and industry, waste management, air pollution, forestry and agriculture. Most of these efforts are not primarily intended to reduce emissions of greenhouse gases, but they do have direct or indirect relevance to the climate issue. Additionally, a portion of foreign aid is allocated to developing skills and administrative competence in recipient countries, often integrated with projects funding "hard technology".

Total bilateral development assistance with some bearing on the Climate Convention was SEK 3.59 billion during 1997 - 2000, including credits of SEK 166 million. Just over 50 per cent is development assistance linked to measures to reduce emissions or increase sinks of greenhouse gases. The other 50 per cent goes on projects involving adjustment, particularly financial support for skills and capacity development.

The Swedish Trade Council, whose task is to promote Swedish exports, has received government funding (SEK 12 million in 1999) to design a special programme for the export of goods and services involving the use of environmental technology of importance to work on the climate change issue in other countries. The Swedish Export Credits Guarantee Board promotes Swedish exports by providing guarantees protecting against the risk of losses on transactions in other countries. Its sphere of operation spans the globe, including many developing countries (non-Annex I-countries). The Board has recently adopted an environmental policy that includes guidelines to ensure that the environmental dimension is taken into account when credits are issued. One requirement, for example, is that an EIA should be performed for major projects.

Research and systematic observation

Sweden accounts for approximately one per cent of global research and development. Almost four per cent of GDP went to fund research in 1999, ie, SEK 75,800 million. Most of this takes place in the private sector, which accounts for about 68 per cent of funding.

Public sector funding amounts to about 26 per cent. The aim of government research policy is for Sweden to be a leading research nation. Substantial efforts and further investment by government and industry alike are needed to achieve this objective.

Research on climate is being carried out in the fields of basic research as well as applied and measures-related research. Swedish research was reorganised 1 January 2001. The purpose was to gather forces in important areas of research, promote cooperation between various fields of research and improve the dissemination of information on research and research findings. The new Swedish way of organising research and development, resulting from the amalgamation of a number of research funding agencies, will help to achieve efficient coordination in the design of research programmes and the allocation of research funding. The newly created research council FORMAS has coordinating responsibility for research on climate. The National Energy Administration is responsible for coordinating measures-related research and development in the energy field.

Government-funded research is mainly conducted at universities and colleges. Some research is conducted by public authorities and independent research institutes, wholly or partially in receipt of government funding.

Distinguishing between climate research and other research is no easy matter. The inventory presented here is based on assessments made by funding bodies as well as scientists. Total government funding of climate-related research in Sweden during the period 1998 – 2001 was approximately SEK 2 billion, of which approx. SEK 1.5 billion was investment in the long-term adjustment programme.

The emphasis and scope of climate-related research during 1998 - 2001 is:

- Climate processes and climate systems, including paleo-climatological studies: SEK 102 million
- Modelling and projections, including general circulation models: SEK 74 million
- Research into the environmental impact of climate change: SEK 209 million
- Socio-economic analyses, including analyses both of effects of climate change and of possible measures: SEK 11 million
- Research and development to reduce emissions and increase sinks of greenhouse gases, and for adjustment (in addition to funds allocated under the long-term adjustment programme for energy): SEK 210 million.

In addition, trade and industry spend a great deal of money on development of technology, eg, treatment technology for burning and use of new fuels.

Responsibility for systematic monitoring and observation is shared by a number of agencies in Sweden. The Swedish Environmental Protection Agency has overall responsibility for environmental monitoring. The main responsibility of the Swedish Meteorological and Hydrological Institute (SMHI) is to supply background material for planning and decision making by those dependent on weather and water. A number of other authorities also have some responsibility for systematic observation of other environmental parameters relating to climate. The Swedish National Space Board is charged with developing satellite systems for systematic observation and research using remote analysis. The National Land Survey is responsible for systematic observation of the land mass.

The Swedish Environmental Protection Agency has overall coordinating responsibility for environmental monitoring in Sweden. This covers national and regional sub-programmes.

Large quantities of data are also generated by municipalities, non-profit-making organisations and other activities at the county administrative level. Only a small proportion of all the environmental monitoring taking place is directly related to climate.

SMHI is charged with the task of supplying the national and international community with meteorological, hydrological and oceanographic data and related products. SMHI also has long-term responsibility for the establishment and operation of the national databases for meteorological, hydrological and oceanographic data, and is the national expert body on climate issues. It produces a great deal of data, products and services, including the gathering and storage of climatic observations at ground level and from satellites. SMHI's climate operations follow the guidelines developed by the World Meteorological Organisation (WMO).

Sweden participates in the Global Climate Observing System (GCOS) and has a long tradition of recording weather, climate and other atmospheric observations, such as visibility and the occurrence of substances affecting climate. Six terrestrial stations have been appointed to record atmospheric observations within GCOS (GSN), and Sweden report metadata and other information from them in accordance with WMO guidelines.

An important part of the WMO World Weather Watch programme is the operational meteorological satellite system. Sweden is one of several European parties involved in the development and operation of meteorological satellites (EUMETSAT).

As well as making meteorological and aerological observations, Sweden takes part in systematic observations of climate-related parameters in the fields of hydrology, oceanography, ground characteristics and land mass. The joint programme for gathering oceanographic data for the Baltic Sea and North Sea operates within the framework of the HELCOM and OSPAR marine conventions.

Sweden only gives limited support for the express purpose of establishing and maintaining monitoring systems for reporting under the Climate Convention. Via Sida, Sweden provides fairly extensive assistance for the development of institutions and administration in the environmental field. This is indirectly relevant to the environment.

Education and public information

Environmental issues have been fairly well to the fore in public debate in Sweden and among Swedes in general since the late 1960s. Since then, Swedish people have learnt more about the environment and become more aware of environmental issues. So nowadays most people are aware of the link between a rise in temperature and climate change. They also think it is necessary to use less fossil fuels than oil and petrol. Public awareness and knowledge about the climate issue have increased as a result of the attention these topics have attracted by way of information campaigns run by various organisations and public authorities and via the press, TV and radio.

Responsibility for raising public awareness and providing information on the climate issue is shared by a large number of agencies such as the Swedish Environmental Protection Agency, SMHI, the National Energy Administration, the National Road Administration, the Swedish Consumer Agency and the National Institute for Ecological Sustainability.

NGOs such as the Swedish Society for Nature Conservation, the World Wildlife Fund (WWF) and Ekocentrum also play an important part in raising public awareness.

The government pursues an active consumer policy in the environmental field with a view to reducing household emissions, energy consumption and waste. Goods, transport, housing and social planning are all involved. Important aims of this work are to improve public awareness of the relationship between consumption and the environment, to give information about the environmental impact and energy consumption of products, and to encourage a change in patterns of behaviour among consumers.

On the government's instructions, the Swedish EPA has drawn up a draft national strategy for the dissemination of information and know-how about Agenda 21 and sustainable development. The aim has been to develop a strategy capable of raising people's awareness about their own lifestyles and thereby to help meet the aims of Agenda 21. Agenda 21 has met with a very positive response in Sweden. Most municipalities have been, or are, engaged in the process of formulating local Agenda 21 programmes. A study in 1999 revealed that almost all municipalities (97 per cent) had taken concrete action to involve the local inhabitants. Common methods used to get the message across to the public were dissemination of information materials, exhibitions, marketing events and advertising or articles in the local press.

In the field of education, the government decides the national curriculum for schools using clearly defined management by objectives. The environmental dimension is a constantly growing feature of the Swedish compulsory school system. The entire environmental field is covered, the explicit aim being to ensure that everyone understands the environmental perspective and to affect lifestyles. The climate issue is part of this process. Trade and industry also play a part in communicating information about the environment to schools.

The curricula for universities and colleges do not contain the same requirements in relation to general environmental knowledge as do the curricula for compulsory schools. But colleges and universities are included in the extensive efforts being made by government agencies to introduce environmental management systems. These focus on important environmental aspects, such as resource utilisation and energy use. At present, 25 universities and colleges run courses focusing on the environment. The climate issue is a natural feature of these courses, whatever their environmental angle.

Several climate campaigns have been conducted in recent years. The "Klimat.nu" campaign was intended to show that carbon dioxide emissions can be quickly reduced if firm action is taken. The objective is to cut Swedish emissions by two per cent in two years. In autumn 1997 the government appointed the Delegation for Energy Supply in Southern Sweden (DESS), whose task is to develop energy supply in that region. SparKraft Effektivare energianvändning ("Save Power - More Efficient Energy Use") – a DESS initiative, was started in 1999. It is a four-year information project aimed at the industrial, real property and household sectors. Its aim is to spread information and know-how about energy in general, and substitutes for electricity in particular. The idea is to support energy conservation and limit the use of fossil fuels by changing over to renewable energy sources. This is to be achieved by way of various pilot projects, public education and energy information.

Following the climate negotiations in Kyoto, the Federation of Swedish Industry has been running a number of information campaigns aimed at member companies as well as politicians, decision makers, journalists and schools. The Climate Book, published in 1999, describes industry's basic view of the climate issue.

The Swedish Society for Nature Conservation ran a project involving five "challenger" municipalities during 1998 - 2000. Participating municipalities set targets and programmes so that use of fossil fuels will eventually fall to a minimum. Each municipality has adopted reduction targets for carbon dioxide emissions of 50 per cent by 2020 or 25 per cent by 2010, subject to some local variations. The inhabitants of these municipalities have been informed of these commitments in various ways.

Government support for local investment programmes has two aims: (i) to markedly increase the rate at which Sweden is converting to an ecologically sustainable society; and (ii) to help create jobs. Some of this support also takes the form of "supportive measures", including information campaigns on climate.

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.

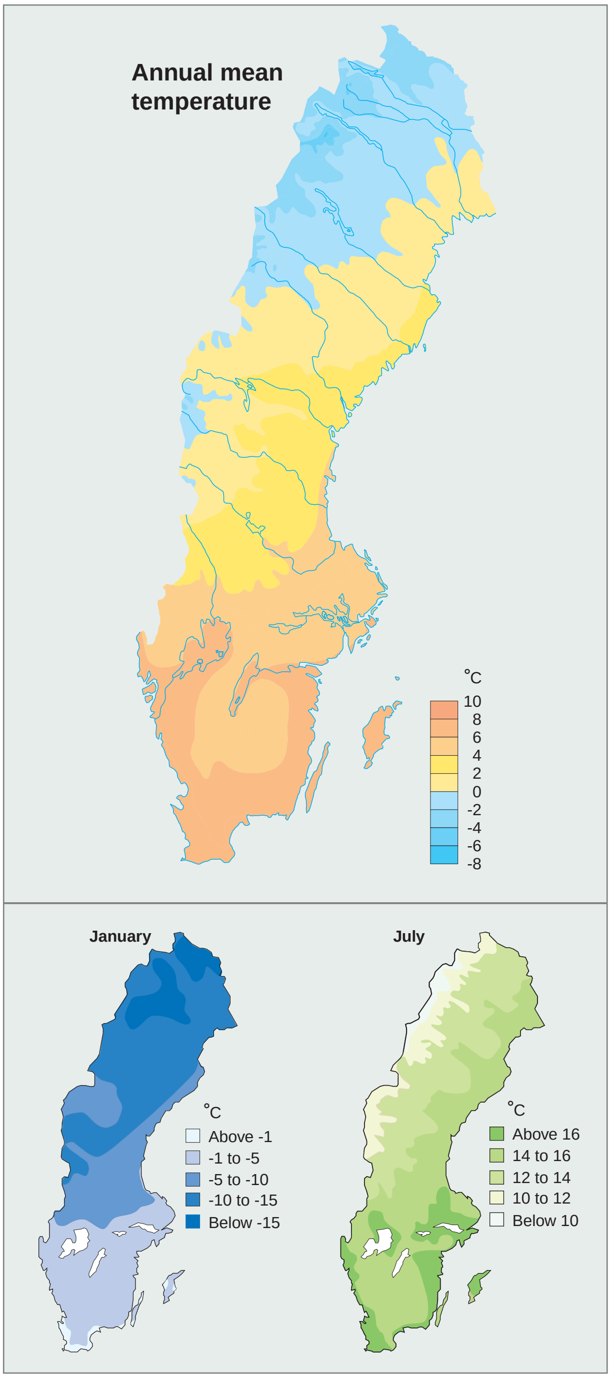
The temperature can vary a great deal, from approx. -50 to 38°C. The lowest recorded temperature is -53°C, recorded at two locations in northern Sweden. Elsewhere in Sweden the coldest recorded temperatures are -30 to -40°C, except along some parts of the southern coast, where it has never fallen below -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.



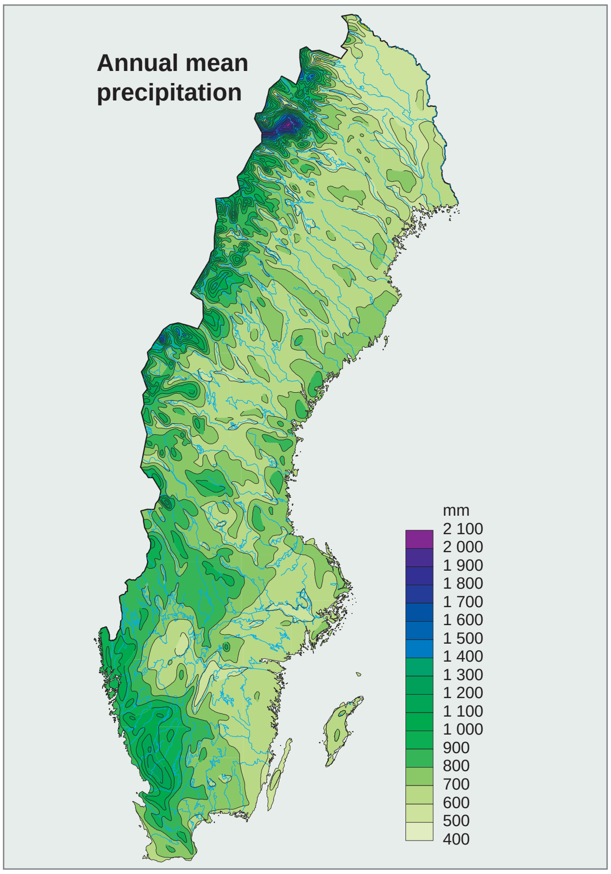
Source: Swedish Meteorological and Hydrological Institute

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 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, 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.

Figure 1.2 Annual mean precipitation, 1961 to 1990.



Source: Swedish Meteorological and Hydrological Institute

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.

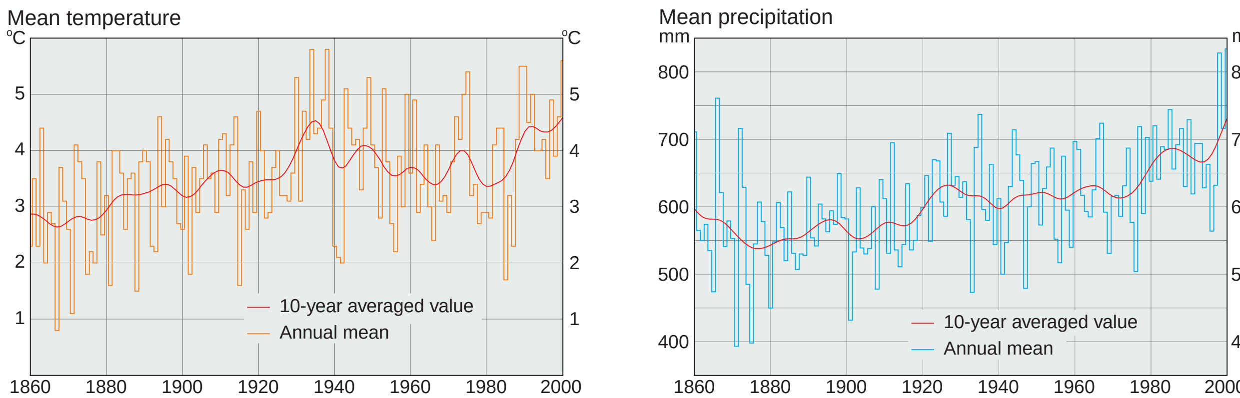
Car ownership was 0.44 per person in 1999, up on the mid-1990s, when the figure was 0.41. The number of cars on the roads rose by 2.8 per cent in 2000, totalling just under four million at the end of 2000. This means that car ownership rose to 0.45 per person in 2000.

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 changeover 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.

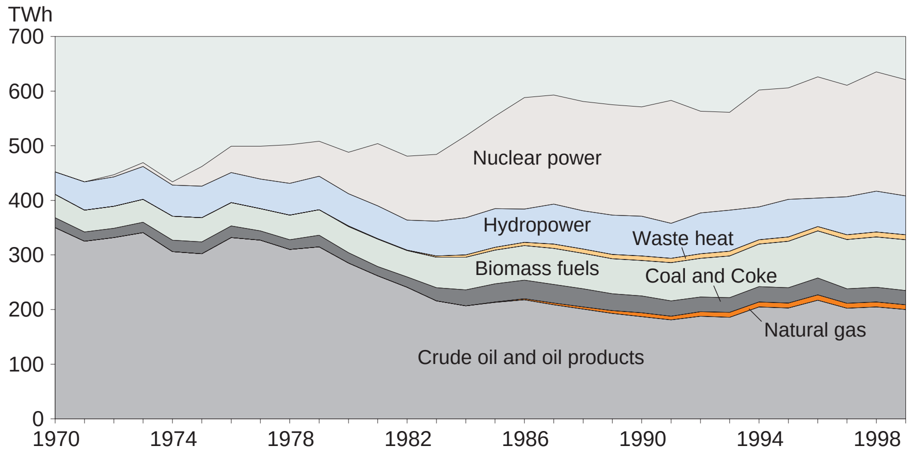


Figure 1.4
Swedish energy supply 1970 – 1999, TWh

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

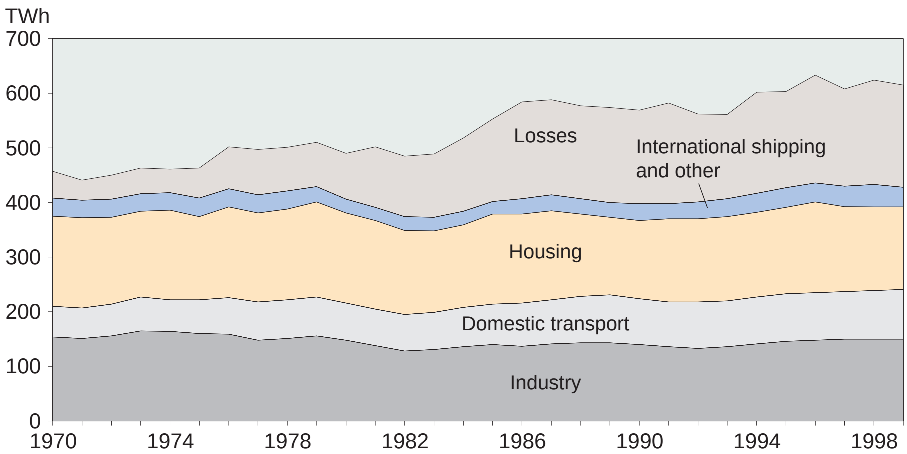


Figure 1.5
Swedish energy use 1970 – 1999, TWh

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.

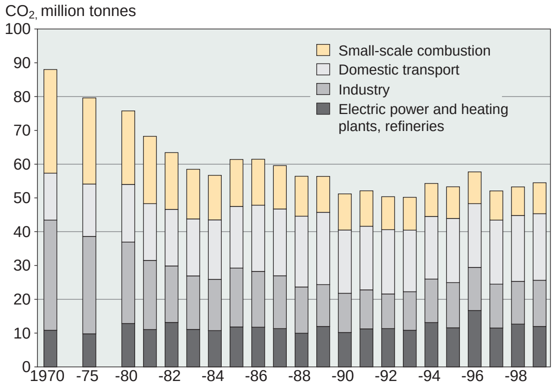
The use of electricity for household appliances, as well as for lighting and ventilation in offices, commercial and public premises, has also risen sharply since the 1970s, from 8 TWh in 1970 to 22 TWh in 1999. One reason for this has been the rapid growth of service industries and increasing use of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

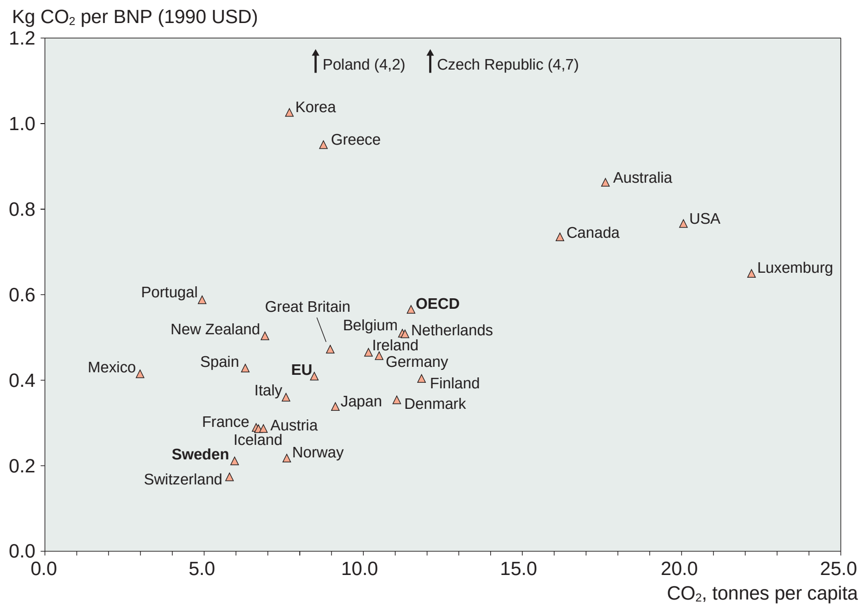
1.7.1 Passenger transport

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,	538	100	81,821	100
of which international				
shipping comprised	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

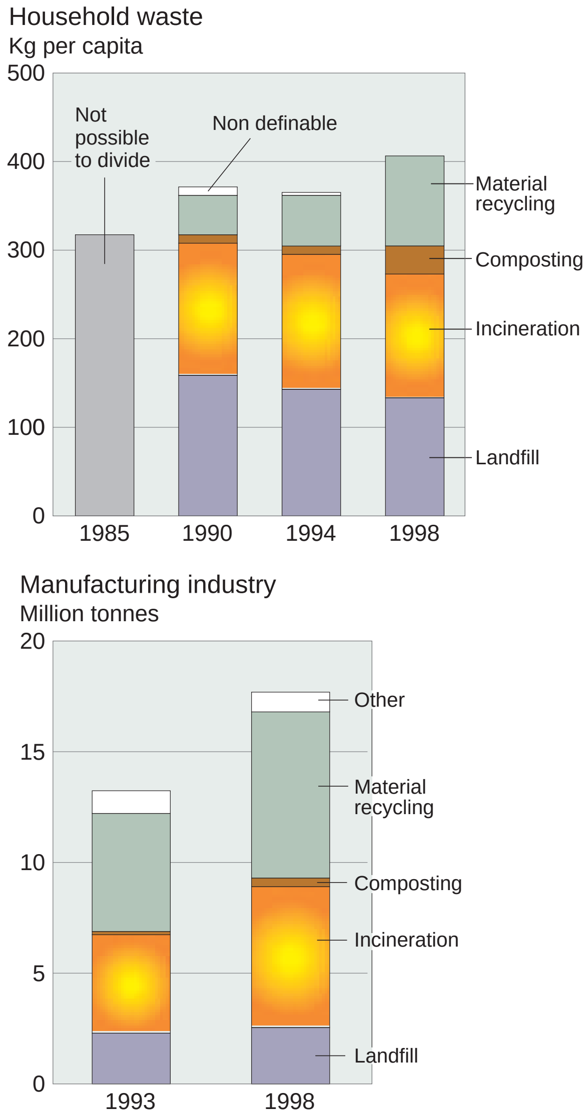
[14] Deponering av avfall ("Landfilling waste"), draft General Guidelines, Swedish EPA Report 4610

[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.

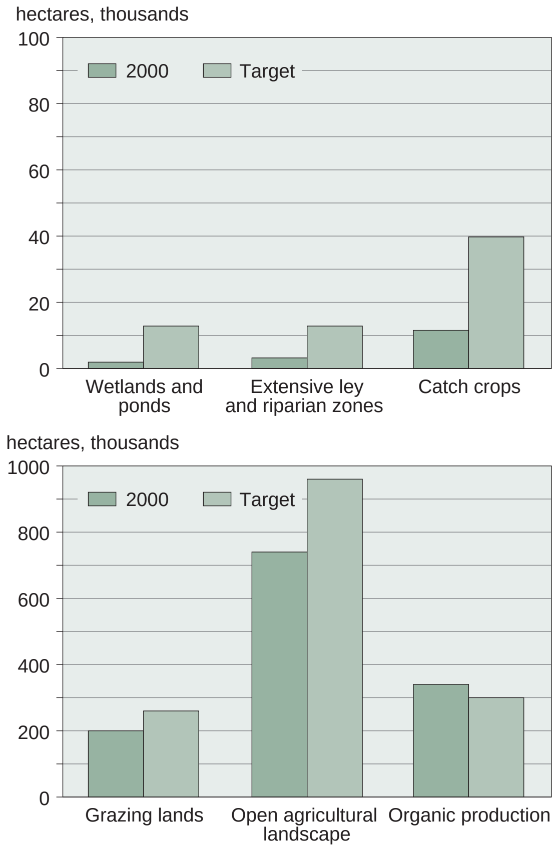
Nonetheless, it is estimated that these emissions fell by about 5 per cent between 1990 and 1999.

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

References

National Energy Administration: Energimyndighetens klimatrapport (“National Energy Administration Climate Report 2001”) Report ER13:2001 National Energy Administration, Eskilstuna, 2001.

Swedish Environmental Protection Agency: Aktionsplan avfall, ("Action Plan on Waste")1996. Swedish EPA Report 4601. Naturvårdsverket förlag, Stockholm, 1996.

Swedish Environmental Protection Agency: Deponering av avfall ("Landfilling Waste"), 1996. Swedish EPA Report 4610. Naturvårdsverket förlag, Stockholm, 1996.

Swedish Environmental Protection Agency: Kartläggning av hur kommunerna planerar att omhänderta sitt avfall ("Survey of waste management methods planned by municipalities"), Swedish EPA Report on a government assignment. Naturvårdsverket, Stockholm, 2000.

Swedish Government Communication 1998/99:63: En nationell strategi för avfallshanteringen ("A national waste management strategy"). Ministry of the Environment, Stockholm, 1999.

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

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

	Sectors						
	Energy use (inc. transport)	Industrial processes	Solvents	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	$C_2 HF_5$	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

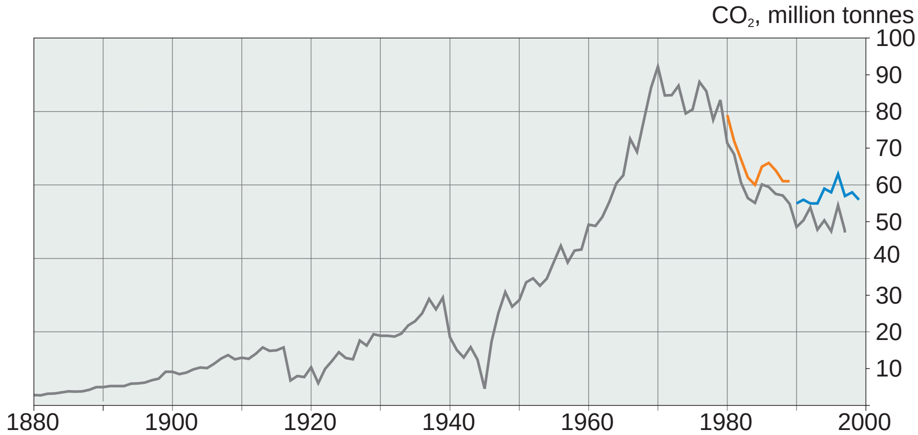


Figure 2.1
Carbon dioxide emissions in Sweden 1880 – 1900

— Total emissions of CO_2 1990-1999 according to Sweden's report under UNFCCC, April 2001

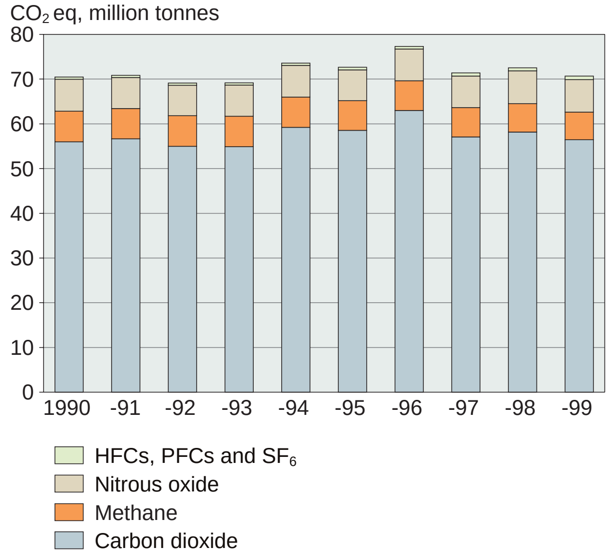
— Total emissions of CO_2 1980-1989 according to Statistics Sweden

— Emissions from burning of fossil fuels, cement manufacture and gas flaring in Sweden 1840-1997 according to Boden and Marland*

*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.

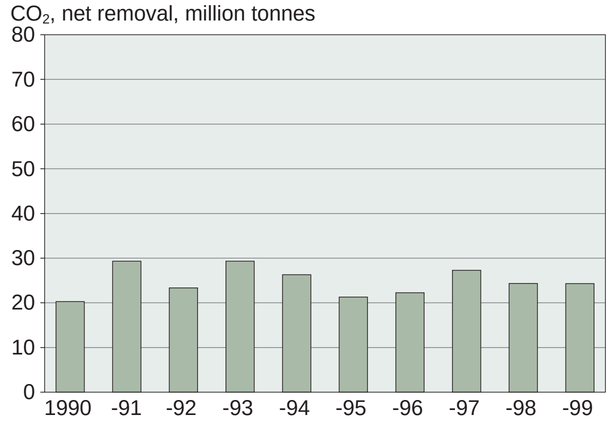
Source: Swedish Environmental Protection Agency

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.

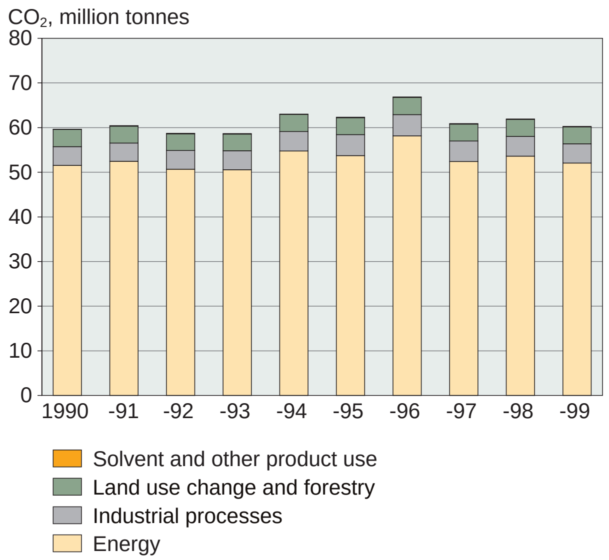
2.3.1 Carbon dioxide

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.

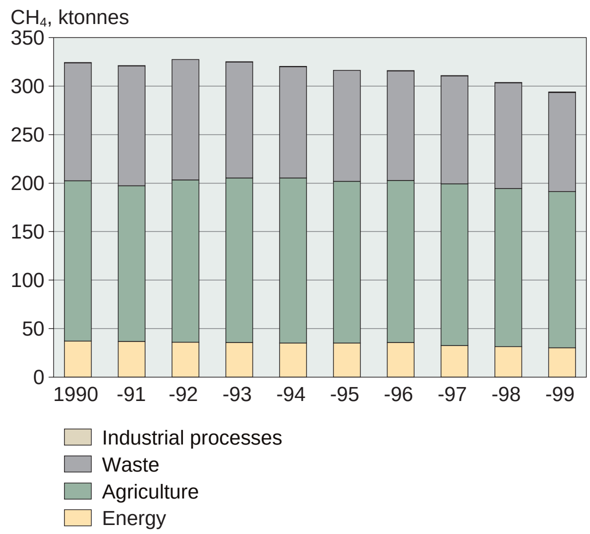
Carbon dioxide emissions come primarily from the energy sector, ie, the burning of fossil fuels for trans

Figure 2.4
Carbon dioxide emissions by sector



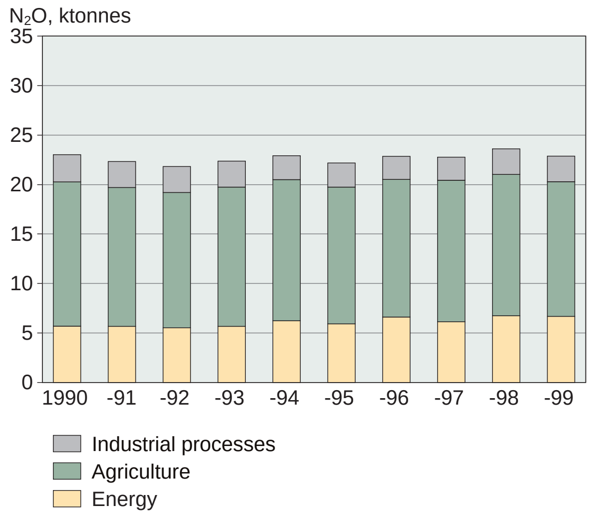
Source: Swedish Environmental Protection Agency

Figure 2.5
Methane emissions by sector



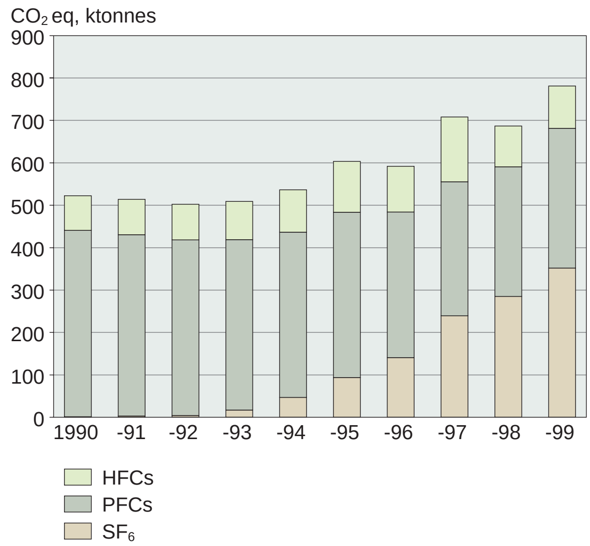
Source: Swedish Environmental Protection Agency

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

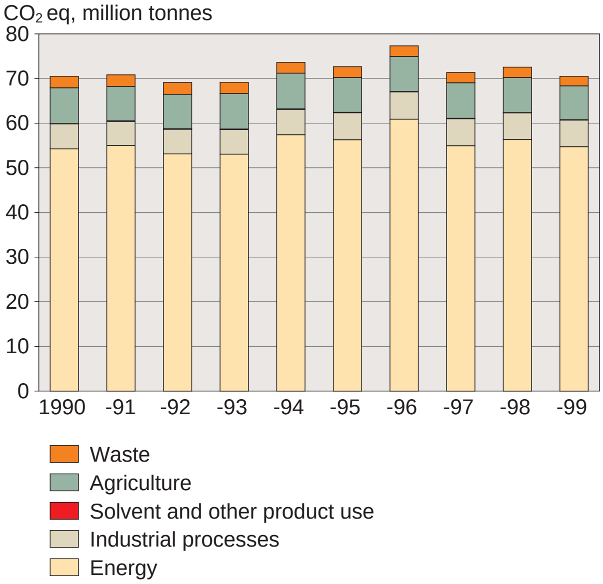
Greenhouse gas emissions by sector are presented below, together with a brief explanation of the changes in the 1990s. The table below shows emissions in the 1990s expressed as carbon dioxide equivalent emissions.

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.

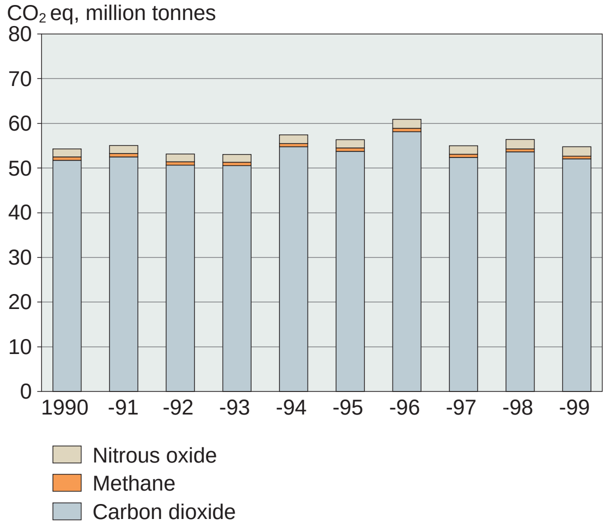
Domestic transport is responsible for approximately one third of Swedish carbon dioxide emissions. Figure 2.9 shows greenhouse gas emission trends in the energy sector in the 1990s. Emissions of nitrous oxide (see tables appendix) have increased from electricity and heat producers, "Other sectors" including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

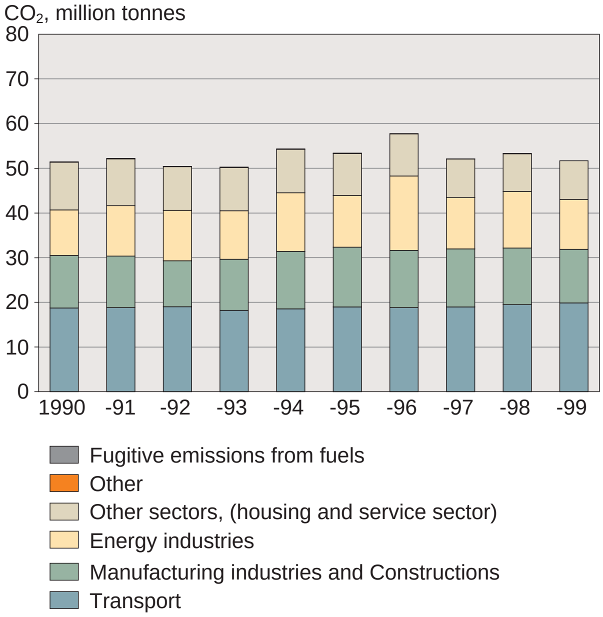
More fossil fuels are used when there is a sharp rise in the demand for energy (for heating). Precipitation also affects energy use because of its influence on hydropower supply. "Normal-year correction" has been carried out to allow analysis uninfluenced by climate effects. Account has been taken of 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.

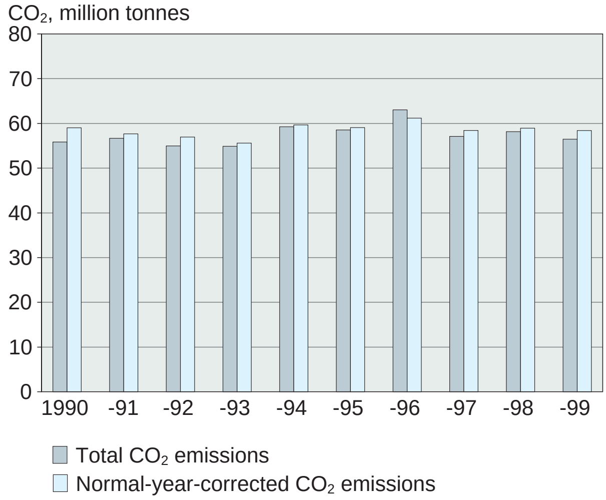
Emissions varied in the 1990s, being at their lowest in 1993 and 1994, when Sweden was in recession (see

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.

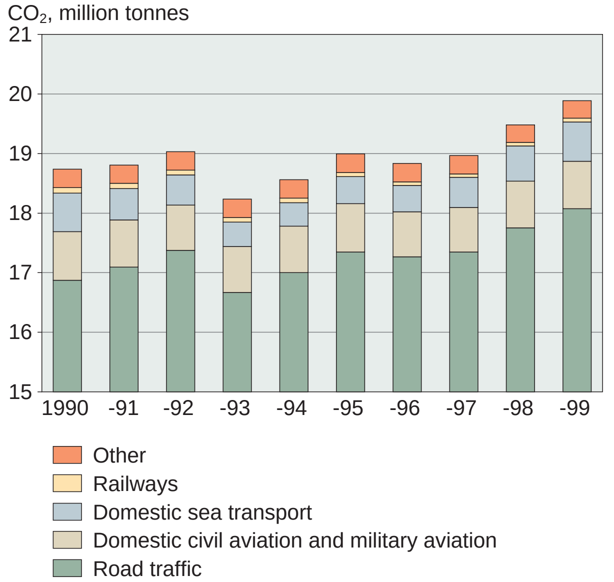
All in all, growth in transport has led to an increase in total fuel consumption and hence emissions of greenhouse gases, particularly carbon dioxide.

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.

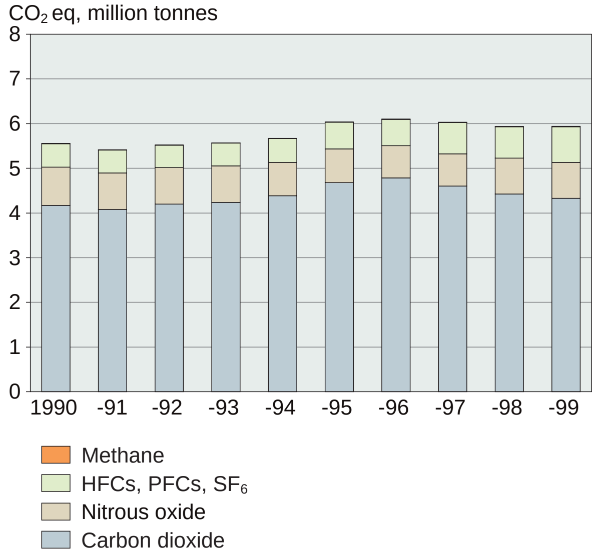
[1] Swedish transport authorities' joint environmental report 2000
[2] ibid.

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

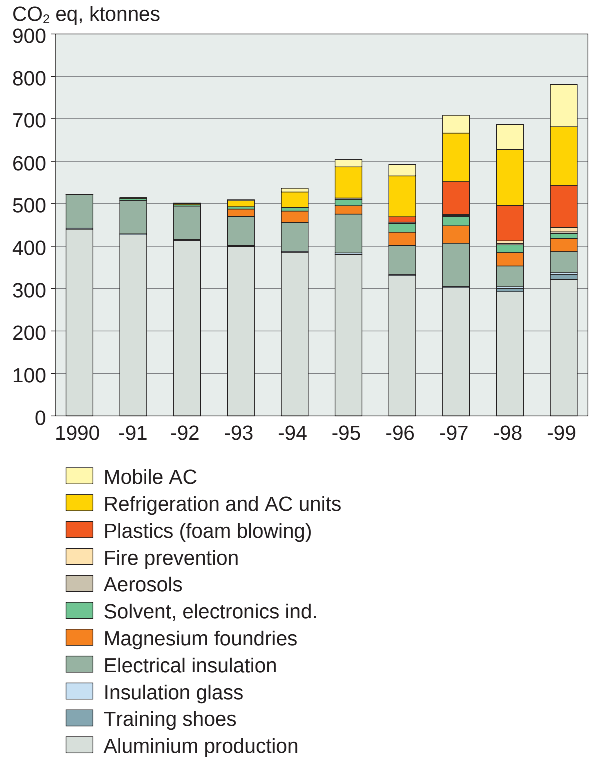


Source: Swedish Environmental Protection Agency

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

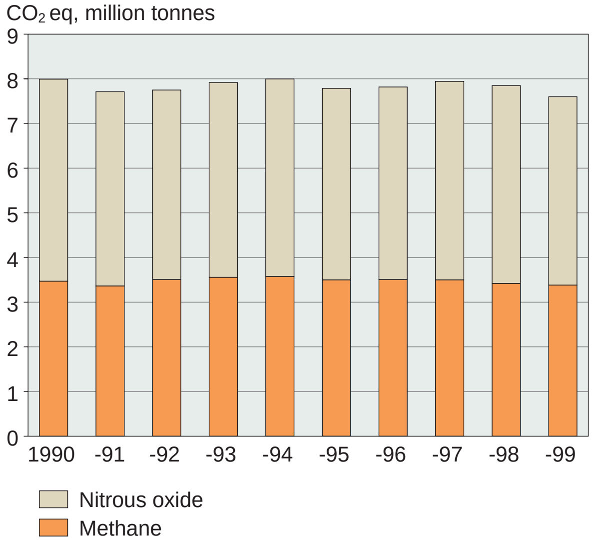
Solvent use causes emissions of VOCs. It is assumed that the carbon content of these emissions oxidises to carbon dioxide. These carbon dioxide emissions are included in the figures for total emissions. Since the uncertainty as to the size of the emissions and variations from year to year is considered 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.

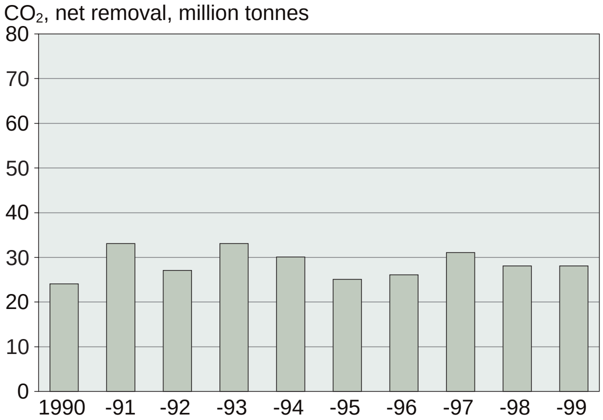
Following EU entry in 1995, the number of beef cattle in Sweden has remained fairly constant, or has fallen slightly, which has led to a slow fall in emissions.

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.

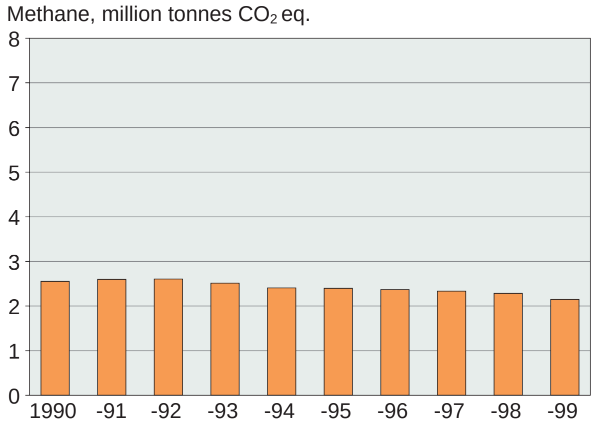
[4] Natural wastage may be in the form of assemblage losses caused by pests, forest fires, storm damage etc.

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.

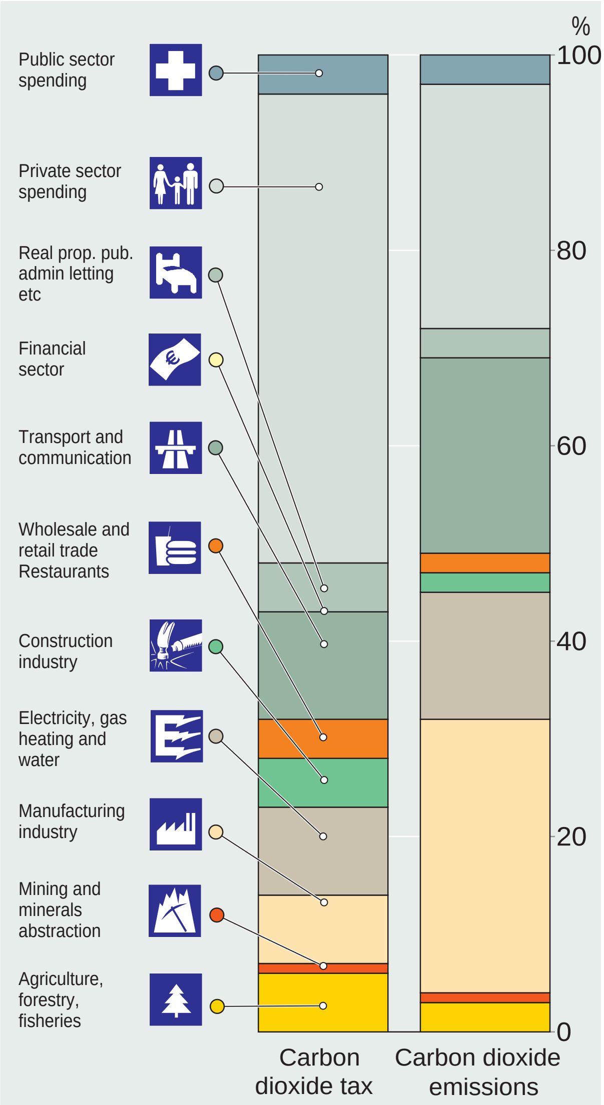
However, the tax on petrol is not related to the purpose for which it is used. LP-gas and natural gas

[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 intermunicipal 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	Main greenhouse [6]gases 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 Procurement of new energy technology Testing, labelling and certification	Reduce energy consumption	CO_2	I E E	O (98–02) O (98–02) O (98–02)	STEM STEM KOV	N.I.U. N.I.U. N.I.U.	200–400	200–400
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 gases concerned[6]	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	Miljövårdsberedningen	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);
Pl = 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.

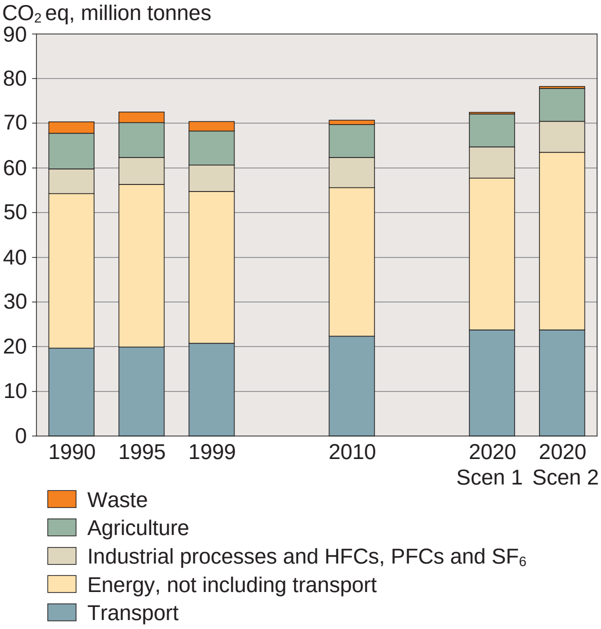
4 Projections and the combined effects of policy and measures

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

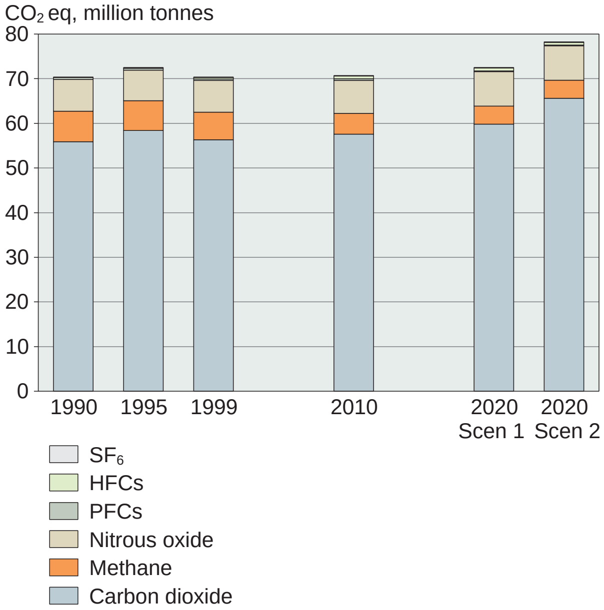
The scenario calculations and future emission levels depend on several factors: the extent of economic growth, fuel prices, the rate and nature of technological developments, and changes in the political framework. A description of some central assumptions in the scenario calculations is given below.

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"

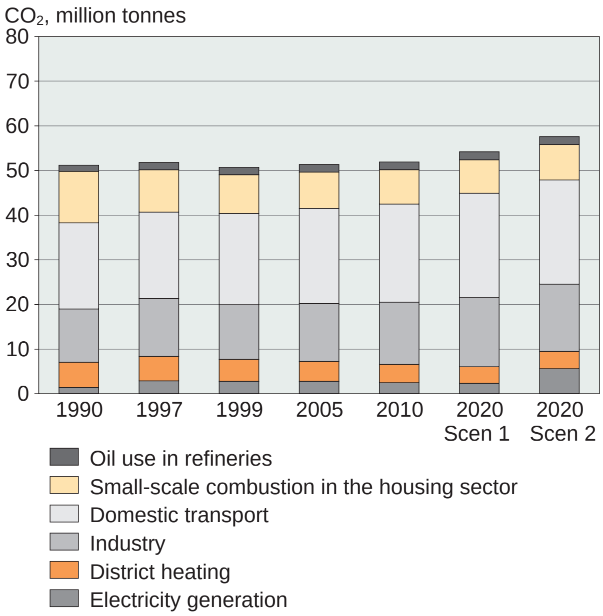
[6] The production cost varies depending on the assumptions made as to conversion efficiency and operating time.

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.

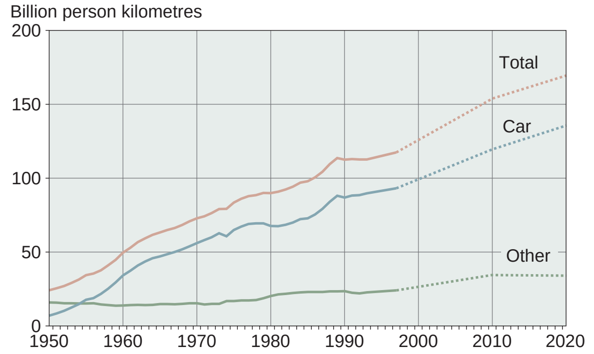
A number of sensitivity analyses have been made to determine how sensitive the scenario results are

[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 hydro-power 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.

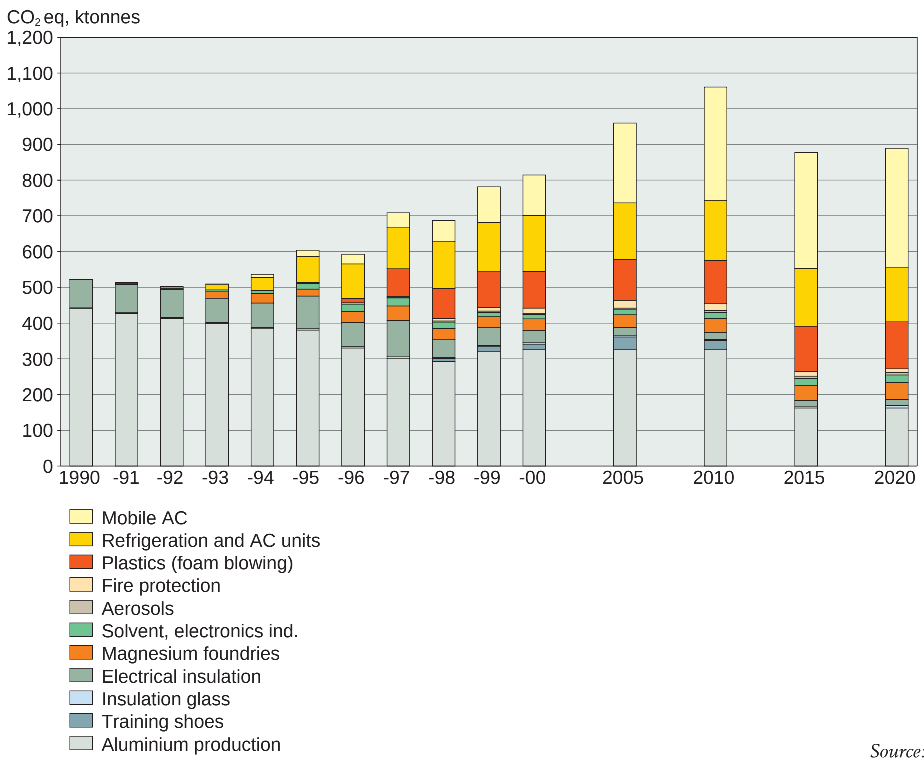


Figure 4.5
Estimated emissions (Tier 2) between 1990 and 2020 from various applications (ktonnes CO_2 equivalent emissions)

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.

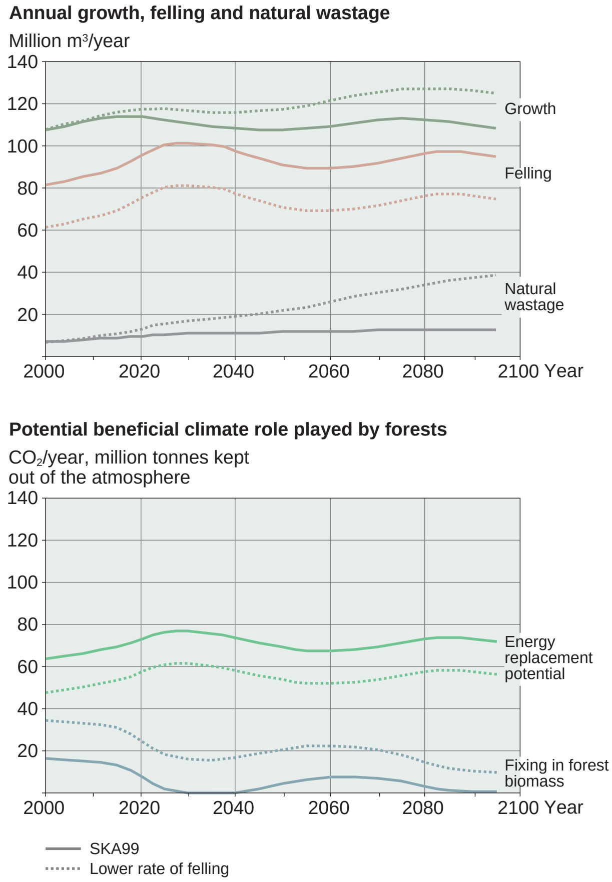
The impact of forestry on emissions and removals of greenhouse gases has been analysed to a degree as part of a scenario analysis (SKA99[28]) performed jointly by the National Board of Forestry, the Swedish University of Agricultural Sciences, the National Energy Administration and the Swedish Environmental 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)

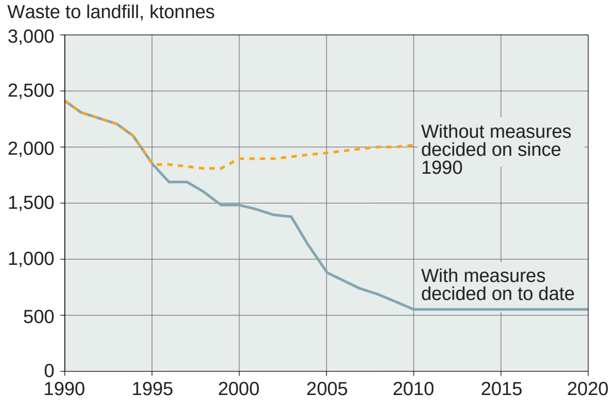
Future forest carbon sinks are heavily dependent on future felling rates. Current forecasts indicate a felling rate in line with that during 1998 – 2000. The future carbon sink in Swedish forests is therefore expected to be approximately the same as that during 1998 – 2000, subject to fluctuations in 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.

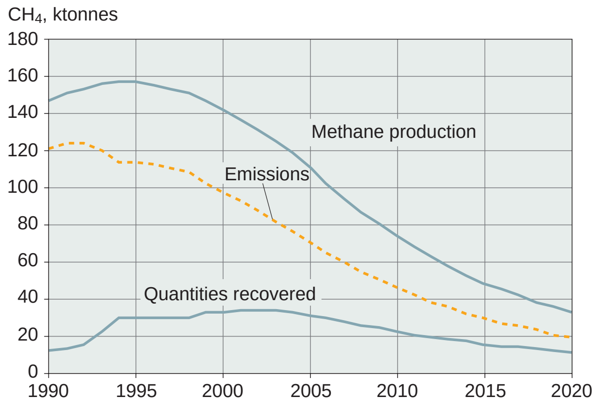
79 per cent of landfilled material was sent to sites with gas collection facilities in 2000. An average of around 60 per cent of gas was recovered there, which gives an overall collection figure of 47 per cent. It is expected that 100 per cent of waste will be landfilled at sites with gas collection 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.

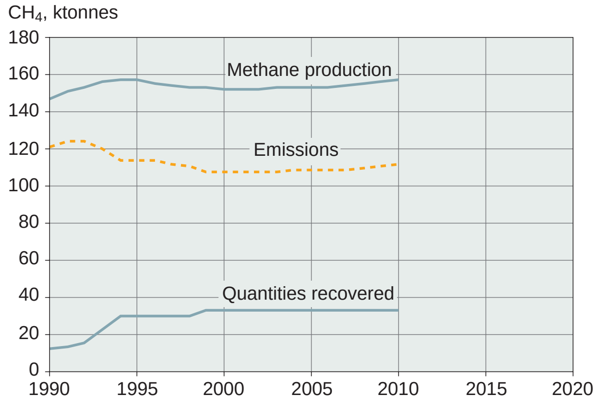
[29] Ongoing project at five landfill sites in Sweden; monitoring and evaluation is being performed by Tema vatten at Linköping University and Chalmers University of Technology.

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.

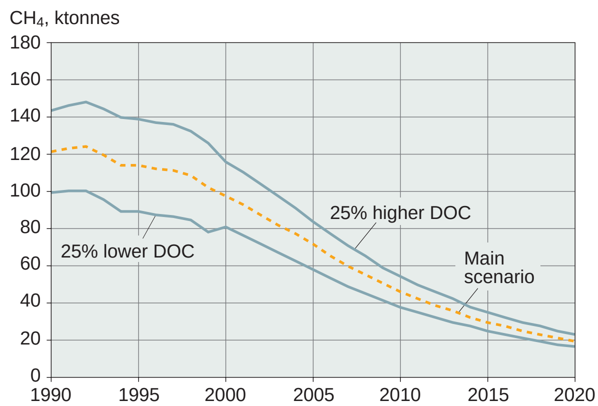
For the sake of comparison, emissions of methane from landfill sites without any measures being taken in the 1990s have been estimated. This provides a basis for estimating the combined effects of measures in the waste sector.

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.

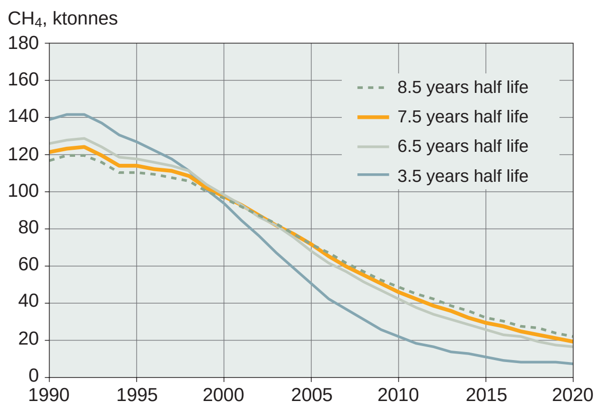
Since the scenarios mainly cover periods further in the future, the historical assumptions are even less important. The significance of the parameter measuring the proportion of degradable organic carbon that is turned into methane (DOC_F) was also analysed. This has a great impact on calculation results, 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.

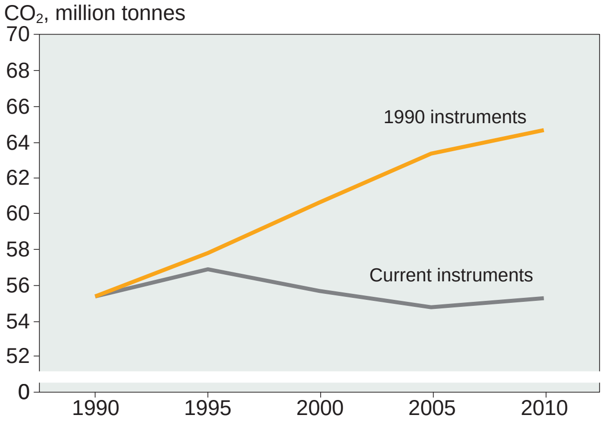
[34] The reason we include this certificate system in the "current instruments" scenario is that parliament has decided that a system of this kind is to be introduced as of 2003. The form the system should take is currently being studied (by "the ELCERTH Commission").

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 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.

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

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.

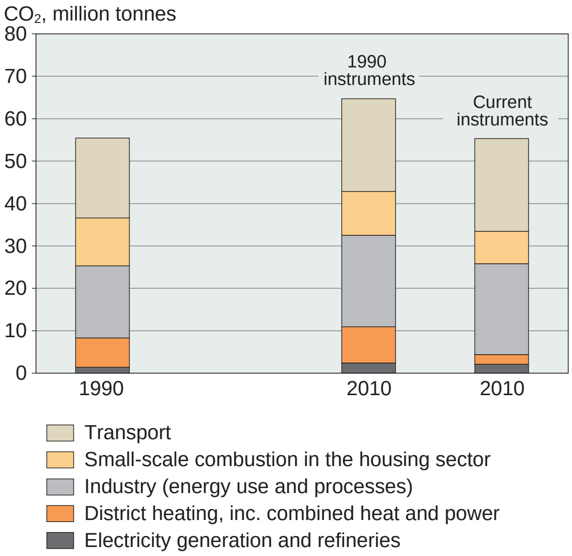
In all likelihood, the estimated difference in emissions is an underestimate of the actual effect, since calculation using the MARKAL method does not include the impact on energy use of differences in energy prices. In most cases, taxes are lower in the 1990 instruments scenario and a greater demand 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

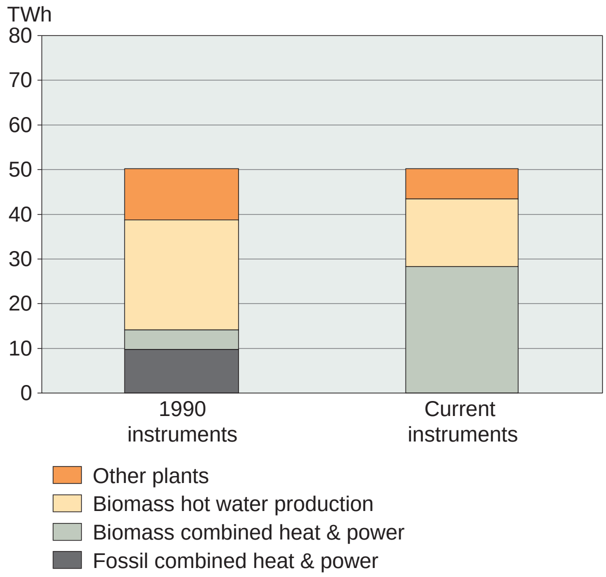
District heating is the sector where the effects of changes in instruments are greatest. The increase in carbon dioxide emissions in the 1990 instruments scenario can be explained by greater use of fossil fuel-based combined power and heat production. The reason the increase is not greater is that biomass 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.

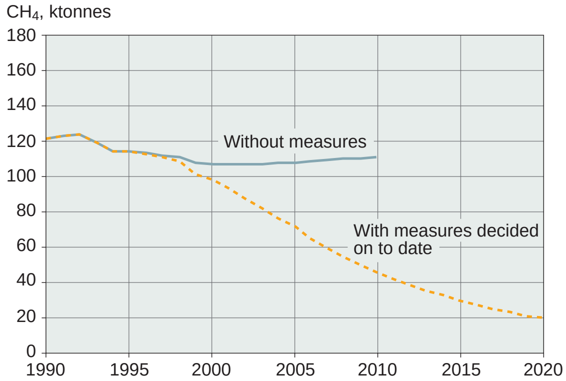
4.2.2 Waste

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.

5 Vulnerability analysis, impact on climate and adaptation to climate change

5.1 Expected effects of climate change

The third IPCC assessment of climate change concludes that there is increasing evidence that man is affecting the global climate system.[1] The mean global temperature has risen by approximately 0.6°C over the last hundred years; in Europe the mean temperature has risen by about 0.8°C during the same period. The 1990s was the warmest decade so far recorded in Europe.[2] Sweden has become warmer and wetter over the last 140 years. However, from a more detailed perspective, fluctuations have been downwards as well as up. The rise in temperature has been most evident in spring. All seasons are wetter, except for summer, which does not display a clear trend. As for extreme weather conditions, such as cold, heat, heavy precipitation in a single day and storms, there may be a tendency for more maximum temperature records and fewer minimum records to have been set in recent decades. Otherwise, it difficult to see any lasting changes.[3]

The global scenarios for economic, technological and social development and accompanying emissions of greenhouse gases, together with land-use changes, have formed the basis for IPCC assessments of future climate change and its impact on man and the environment. Taking into account the sensitivity of various climate models to changes in concentrations of greenhouse gases, the IPCC thinks that the mean global temperature may have risen by a further 1.4 - 5.8°C by 2100.

The global climate change scenarios also indicate major impacts on the hydrological cycle, which are expected to become more intensive. However, regional and local effects on climate may differ considerably from the mean global figures. In some regions the risk of flooding will increase; in others there will be a greater risk of drought. Nor can surprises or sudden changes in global or regional climate systems be ruled out. If the Gulf Stream weakens, which a number of model calculations suggest will happen over the next hundred years or so, the effect on the climate of northern Europe will be grave indeed, and all land (and water) use in the region would be severely affected.[4] Assessment of a given country's vulnerability to climate change must also be made in relation to other expected changes in the natural and human environment, also taking account of uncertainties.

According to the IPCC, vulnerability is "the extent to which a natural or societal system may incur damage caused by climate change". Vulnerability depends on the systems's sensitivity and ability to adapt. Vulnerability analyses are intended to illustrate potential future damage. Social, economic, cultural, environmental and other conditions may have changed when the future arrives. The time frame of a vulnerability analysis may vary of course – the further ahead we look, the more uncertain our forecasts will be.

Sweden's Second National Communication under the Climate Convention presented impacts and vulnerability to climate change. Those assessments were based on the first assessments of expected impact on climate in Sweden and focused on the impact on technical systems, corrosion, hydrological systems, geotechnical systems and the energy system. Most of those assessments were of a general nature; for the Third National Communication they have been extended to cover more areas and provide a more detailed assessment.

The analysis of vulnerability to climate change is based on the SWECLIM climate scenarios, developed at the Rossby Centre at the Swedish Meteorological and Hydrological Institute (SMHI). The analysis also takes some account of important long-term changes in the natural environment, such as acidification and eutrophication/nitrogen saturation of soil and water, as well as certain social factors such as demographic trends. Many assessments of Sweden's vulnerability to climate change are therefore more qualitative and descriptive, rather than purely quantitative.

5.1.1 Basis for vulnerability analyses – SWECLIM climate scenarios

Analyses of the vulnerability of society or of natural ecosystems to climate change is essential for effective

[1] Climate Change 2001: Impacts, Adaptation & Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). 2001

[2] Assessment of Potential Effects and Adaptations for Climate Change Europe: The Europe ACACIA Project. 2000

[3] Effekter och sårbarhet av klimatförändringar i Sverige ("Impacts of, and vulnerability to, climate change in Sweden"). Swedish EPA Part of report 5171, 2001

[4] Climate Change 2001: Impacts, Adaptation & Vulnerability. Contribution of WorkingGroup II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). 2001

measures to control emissions and adjustment plans. A proper description of future climate conditions is needed as a basis. Global climate simulations like those summarised by the IPCC, for example, form the basis for Sweden's climate scenarios for the Nordic region and Sweden. Since 1997, this has been carried out as part of the SWECLIM programme, in which the Rossby Centre at SMHI has developed an advanced regional climate model system (see also Chapter 7). The system has been used to make detailed studies of the potential impact of global climate change (as predicted by global climate models) on the climate of the Nordic region. A key advantage of regional calculations is that a considerably higher level of detail can be used in the calculations and that typical regional features, such as the Baltic Sea, river systems, lake systems and the mountain chain can be described more realistically. Regional features influence the simulated climate and may give rise to locally important feedback to a general climate trend. The regional simulation only covers a small part of the globe and must therefore be run in parallel with the large-scale climate trend predicted using global climate models.

The same technique is commonly used in regional weather forecasting, eg, by national weather services.

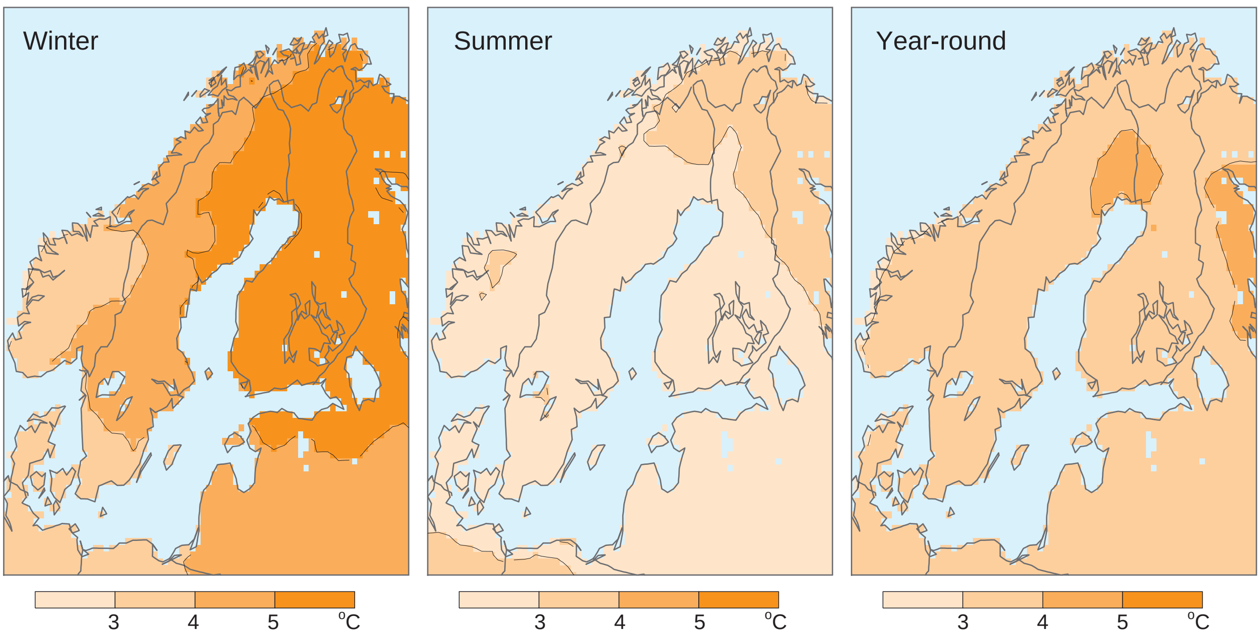
The latest IPCC assessment shows that when the entire range of emission scenarios is examined using a number of climate models, the mean global temperature is expected to have risen by a further 1.4 - 5.8°C between 1990 and 2100. The range given in the previous assessment in 1995, which assumed more extensive future emissions of sulphur, was 1 – 3.5°C. SWECLIM has based its approach on two global climate scenarios, one from the Hadley Centre at the UK Meteorological Office at Bracknell, Berkshire in the UK, and the other from the Max-Planck-Institut für Meteorologie in Hamburg, Germany. Both these centres are engaged in advanced climate modelling. SWECLIM has based its scenarios on two 10-year periods from each centre. In both cases, one of the two periods is used as a control, representing "no climate change", ie, current climate conditions. The other period represents a degree of future climate change. The basis for the SWECLIM scenarios is an increase in the content of greenhouse gases in the atmosphere (expressed as carbon dioxide equivalent emissions) of 100 – 150 per cent, and a rise in the mean global temperature of 2.6°C. The latest IPCC report indicates that this rise may occur in 50 to 150 years. The time horizon in the SWECLIM scenarios can therefore be simplified and expressed as "in 100 years". In this time frame, the regional scenarios do not appear to be extreme assumptions; rather they are representative of a central result based on the estimates in the various emission scenarios and climate models of climate sensitivity.

Summary of important results – temperature and growing season

The Nordic climate is considered more sensitive to emissions than is the global climate as a whole.

[5] Albedo (Latin): the proportion of incoming radiation reflected by a surface, here the earth's surface.

Figure 5.1 Increase in mean temperature in the SWECLIM regional climate scenarios "in 100 years". Warming in the area is somewhat higher to the north and east than along the Atlantic coast in the west and in the south



Source: SWECLIM/SMHI

Although most terrestrial areas are expected to heat up more than marine areas, this effect is exacerbated in northern Europe by a feedback effect via albedo[5] as a result of the effect of warming on winter snow cover and sea ice. Another typical feature of the area is uncertainty as to future changes in thermohaline circulation in the Atlantic Ocean and of the route taken by storms, as well as possible changes in the configuration of atmospheric circulation patterns. It is also assumed that emissions of sulphur, which produce airborne sulphurous particles that create a cooling effect, will decline further in the future.

The regional scenarios suggest that the mean annual temperature in Sweden will change by about 4°C. This is over 40 per cent more than the mean global change of the underlying calculations. The mean winter temperature is expected to rise somewhat more, by 4 – 5°C. The rise in summer is expected to be somewhat lower, 2 - 3°C (see Figure 5.1).

Temperature changes affect various climate variables and processes. Evaporation is affected by temperature, for example. Seasonal snow and sea ice are also affected by temperature. One central parameter in impact analyses is the length of the growing season. The regional scenarios predict that this will be prolonged by 1 – 2 months in Sweden. This will affect forests and agriculture, among other things.

An initial analysis has also been made of extremes of temperature, even though 10-year simulations of current climate and climate "in 100 years" are much too short to make representative analyses of them. However, results show that whereas annual maximum temperatures will be raised about as much as the mean change in summer (2 - 3°C), there will be a substantial rise in annual minimum temperatures, as compared with the mean change in winter temperature (see Figure 5.2).

Precipitation and evaporation

The regional climate scenarios suggest there will be significant changes in precipitation and evaporation in the region in the future. Figure 5.3 shows results for mean annual precipitation (P) and net precipitation/evaporation (P-E). The latter is an approximate measure of available water for the formation of aquifers, soil moisture and drainage into watercourses. The greatest increases in both precipitation (P) and Precipitation-evaportion (P-E) are along the Atlantic coast and in northern Scandinavia. A slight decline is predicted in south-eastern Sweden, however. Annual changes in precipitation of over 10 per cent are significant compared with modelled natural variability. Significant changes occur in the west and north. Moreover, P-E reacts with greater relative increases in the north and a decrease in the south-east. Precipitation increases more than evaporation in the north; the contrary applies in the south-east. When the analysis is performed for different seasons, the result is that the northern increase in precipitation and precipitation-evaporation becomes substantially greater in the autumn. But the indications of drier conditions are clear and more widespread in southern Sweden in summer.

As with temperature, changes in certain extremes have been analysed in the regional scenarios. Heavy precipitation, eg, the average maximum annual precipitation over 24 hours, is expected to increase in the

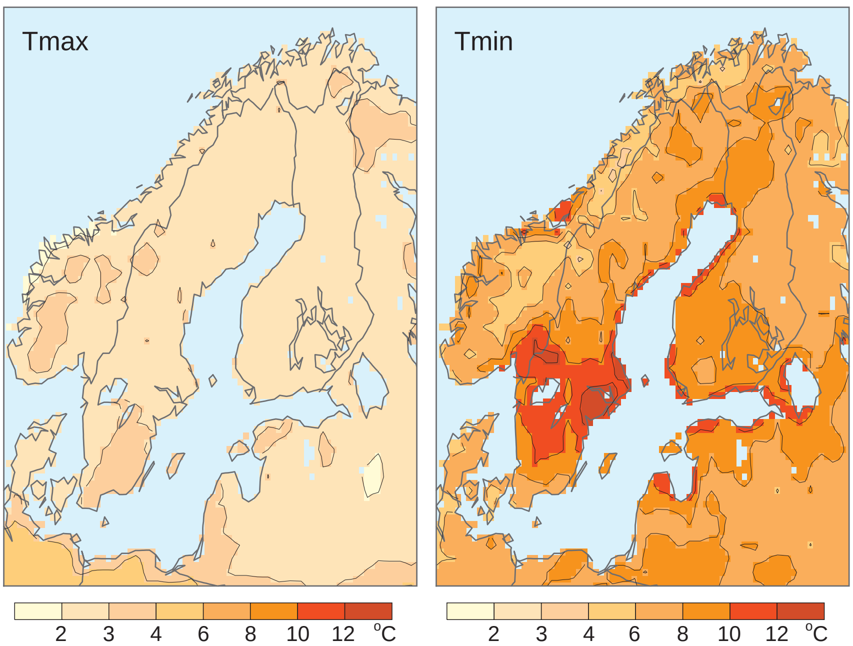


Figure 5.2
Estimated average changes in annual maximum temperature (Tmax) and minimum temperature (Tmin)

Source: SWECLIM/SMHI

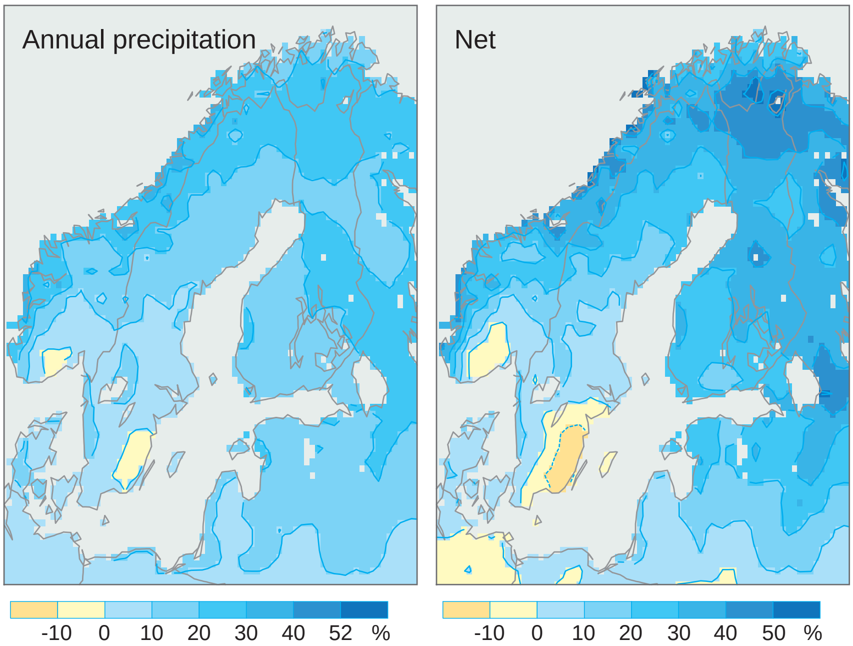


Figure 5.3
Estimated regional scenario changes in mean annual precipitation (P) and net precipitation/evaporation (P-E)

Source: SWECLIM/SMHI

region, in areas both where mean precipitation rises and where it falls.

Wind

The regional climate scenarios suggest moderate changes in ground-level winds. There is some increase in coastal regions, out to sea and over large lakes, where ice cover will diminish on average. Increases in specific areas are a few per cent up to 10 – 15 per cent at most. Changes in wind speeds in summer are expected to be limited. There are some indications of moderate increases in mean wind speed in montane areas in autumn.

However, the fairly short regional climate simulations performed to date only provide a basis for limited conclusions as to wind changes. Possible changes in extreme weather conditions, such as storms, have not yet been studied.

Snow

Higher temperatures will cause the snow cover to shrink, notwithstanding increased precipitation over

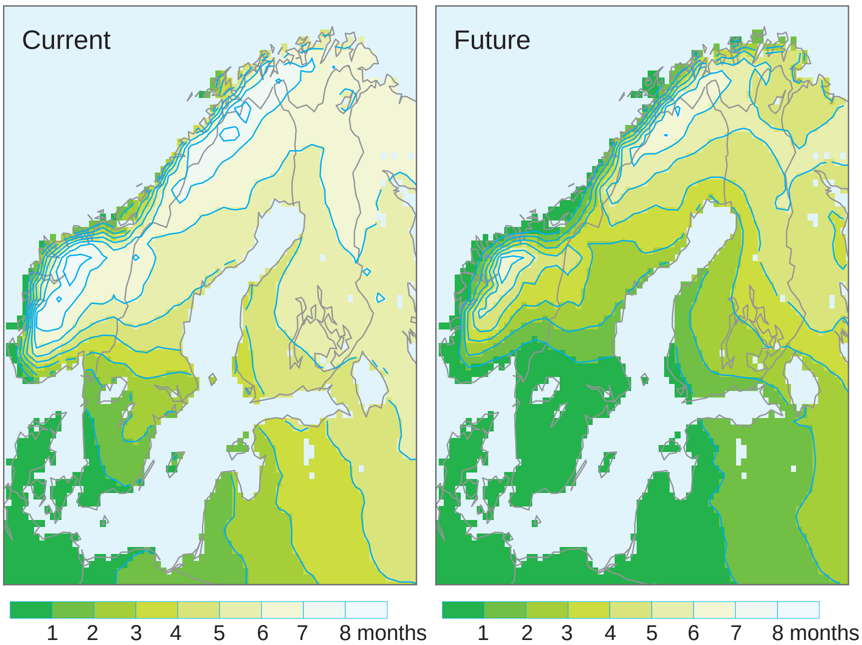


Figure 5.4
Average period of snow cover during the year in the region according to the scenarios. The current simulation (on the left) represents typical conditions during the most recent normal climate period (1961 – 1990). The map on the right shows results from the regional scenarios.

Source: SWECLIM/SMHI

large areas. The snow season is shorter and maximum snow depth less throughout Sweden in the SWECLIM scenarios (see Figure 5.4). The effect on the depth to which the ground freezes is a more complicated issue. Higher temperatures will reduce this depth where there are snow-free surfaces, such as roads. A thinner snow cover over snow-covered surfaces may have the opposite effect, because the ground beneath the snow will be less well insulated from the atmosphere. Here, the ground may freeze to a greater depth, despite higher winter temperatures.

Water resources

SWECLIM has also translated the regional climate scenarios into water resource scenarios, using separate hydrological modelling. These scenarios have been produced both for various areas of Sweden, and for the entire Baltic catchment area. The estimated changes in water supply largely conform to the changes in precipitation-evaporation: increased water supply in the north, but no clear change or a fall in the south. One important conclusion to date is that the characteristic spring flood of today will be more irregular and less intense, on average. This is because the snow period will be shorter and the snow depth less due to the warming effect. However, the water supply is expected to increase in winter and also in autumn as a result of heavier precipitation. Accordingly, the risk of flooding will diminish in spring but increase in late summer and autumn, particularly in the north. The scenarios are considered to be most uncertain in relation to central parts of the country, in the transitional zone between the increase in the north and the tendency towards a decrease in the south.

Drainage into the Baltic will also be affected. The scenarios indicate that the quantity of fresh water entering the Baltic will increase in the north but be less affected, or perhaps decrease, in the south. Here too, the differences between the seasons will become less pronounced.

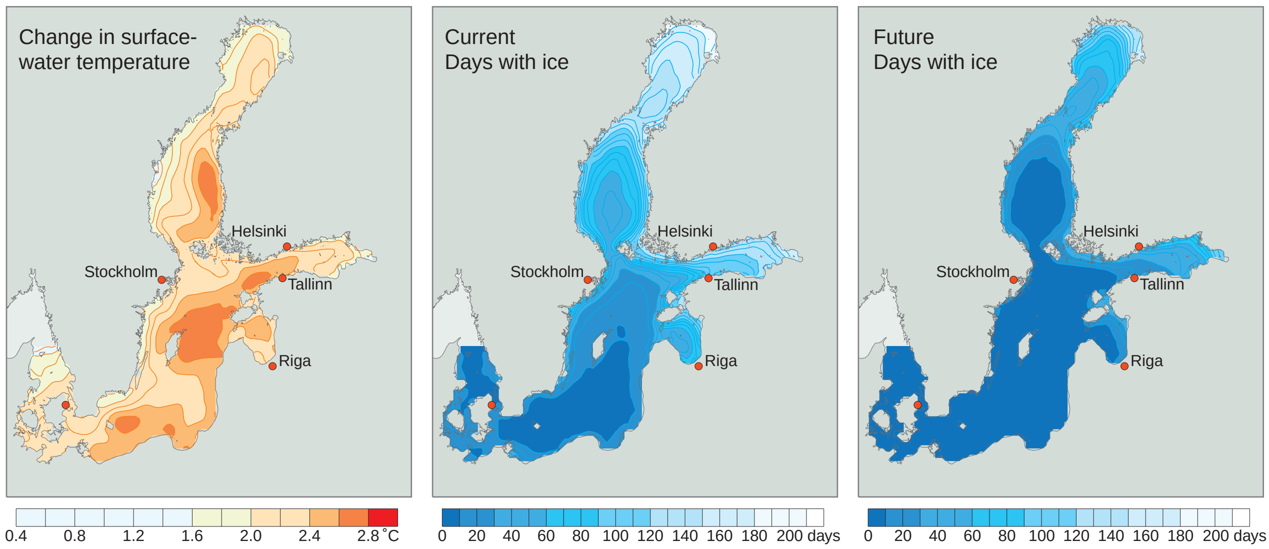
The Baltic Sea

The SWECLIM regional modelling system also includes models for the regional sea, the Baltic, which is too small to be realistically represented in current global climate models.

Regional warming will naturally affect the Baltic. The surface layer of the sea will warm up down to the halocline. The latest scenario calculations suggest that warming will be greatest in the north in summer but greatest in the south in winter and spring. According to the calculations, the depth of the halocline and thermocline will not be substantially altered. In addition to temperature changes, the impact of wind on mixing and the impact of saltwater intrusions on Baltic salinity may cause changes in the stratification of the water column. On an annual basis, the sea surface will warm up by a maximum of just under 3°C.

At different times of the year local temperature changes of up to 4°C or slightly more may occur. Circulation effects ("upwelling" and "downwelling") will cause large variations in water warming to occur between different parts of the Baltic. Regional warming will greatly ameliorate average wintertime ice conditions

Figure 5.5
Estimated regional scenario changes in the surface temperature of the Baltic Sea, on an annual basis (left). Mean number of days with ice in a regional Baltic simulation. Current conditions (centre) and "in 100 years" (right).



Source: SWECLIM/SMHI

in the Baltic (see Figure 5.5). The scenarios indicate that ice will be confined to parts of the Bay of Bothnia and far into the Gulf of Finland in a normal year.

The increasing precipitation in much of the Baltic catchment area will generate more fresh water, which will affect the Baltic. There may also be somewhat less drainage into the Baltic from southerly catchments. More fresh water may have a dilutive effect, thereby reducing salinity. However, the critical factor governing salinity is the frequency and size of saltwater intrusions from the North Sea. These inflows and outflows are driven from the atmosphere and might also be affected by drainage. Changes in these driving forces may occur, but this has not yet been studied in the regional scenarios.

Warmer seas around globe will raise the level of the oceans as the warmer water expands.

Melting continental glaciers outside the Antarctic will also add to this effect. The global rise has been estimated at an average of 9 – 88 cm by 2100, compared with 1990. Even if the mean global temperature rise stabilises, it is believed that sea levels will continue to rise for a long time owing to the enormous inertia of the oceans. Estimates of regional changes in sea level calculated in global models are more uncertain; changes may be non-existent or double the average. For example, global simulations give contradictory indications for the level of the North Sea. However, a SWECLIM study suggests that the level of the Baltic will closely follow that of the North Sea. Hence, a rise there will be accompanied by a similar rise in the Baltic.

The SWECLIM regional scenarios provide a basis for vulnerability analyses, and they are used to give a regional description of the impact of future regional climate change. In addition to scenarios showing mean changes, it is important to obtain better background data on potential changes in variability and extremes. Further quantification of the uncertainty in scenarios is also important to enable the results to be used in societal planning.

5.1.2 Other factors affecting vulnerability to climate change

Natural ecosystems changes as a result of physical factors, such as land use, and chemical factors, such as deposition of acidifying and eutrophying substances. Ecosystems are also inherently dynamic, as when one species replaces another, for example. This may impact on the sensitivity and vulnerability of the natural environment. As for man, developments in a given society depends on national policy as well as events in the outside world. Sweden and other small countries engaged in free trade with the rest of the world are greatly affected by events in the world around us. Swedish membership of the EU is a particular factor affecting vulnerability. Assessments of vulnerability in the event of climate change are therefore heavily dependent on the way these other factors develop alongside climate change.

Changes in the natural environment

Acid deposition has reduced pH in lakes and watercourses and has caused serious damage, such as loss of plant and animal species. Nearly 17,000 of Sweden's 95,000 lakes are affected by acid deposition. Many of them have seen their pH fall by 1 point. Some 10,000 lakes have therefore been limed to counter the adverse effects.

Deposition over forests has also lowered pH in our forest soils, which increases the risk that metals, such as aluminium, will leach out and harm the biota. But acid deposition has also affected soil nutrient balance. Important base cations such as potassium and magnesium ions have leached out of forest soils. Some weak soils in south-western Sweden have lost almost their entire reserves of available base cations. This has damaged the ecosystem. Forestry also affects the store of base cations and other nutrients in the soil.

Acid deposition has declined throughout much of Sweden following reduced emissions in Sweden and Europe as a whole. However, deposition has not yet fallen to a level where no harm is done to ecosystems, known as the "critical load" of acidifying substances. Soil recovery is a very slow process, one that also has a great influence on the rate of recovery in lakes and watercourses. Acidification will therefore persist for a very long time; only the areas least sensitive to acidification will recover within 50 to 100 years.

The input of nutrients such as nitrogen and phosphorus to lakes, watercourses, seas and soils has a major impact on ecosystems. Growth in northern ecosystems is often limited by a lack of nutrients. Greater availability of these substances therefore produces a dramatic increase in biomass. Lakes, watercourses and coastal regions become overgrown and undergo dramatic changes in flora and fauna. A greater supply of organic matter often results in oxygen deficiency on lake and sea beds, particularly in the Baltic. The main reason for the excessive nutrient levels in lakes, watercourses and other waters is leaching from agricultural land and input via waste water. Some steps have been taken to reduce these discharges. But the store of nutrients in lake and marine sediments is sufficient to maintain a high nutrient level in the water for a long time to come, in most cases for many decades, and in some instances for several centuries.

For forest soils and other soils on which fertiliser is not used, atmospheric deposition is a major source of nitrogen. the supply of nutrients encourages biomass growth in forest and soil. When the soil becomes nitrogen saturated, some will leach into lakes and water-courses, and finally into coastal waters. The effects of this nutrient supply may persist for several decades after supply has ceased.

Changes in society

The sensitivity and vulnerability of society to climate change depends very largely on societal development. Welfare in a country like Sweden depends on external as well as internal factors. An important internal factor is population growth or decline, which influences aspects of socio-economic development, such as the construction of new housing, educational needs, health care and family structure. The current ageing population trend in Sweden is expected to continue for at least another 25 years. Economic theory predicts that demographic changes of this kind result in less saving, high inflation and low growth.

Environmental and climate issues may then be given lower priority owing to a lack of resources. Thus, future demographic trends may impact vulnerability to climate change and the ability to take steps by reducing emissions of greenhouse gases and adapting various sectors of society to the effects of climate change

Crises and conflicts may arise within or between countries, where a shortage of food or other vital resources caused by climate change may be one of many factors. A shortage of resources may exacerbate an existing crisis caused by migration and economic decline, for example.

Trade, economies and transport are becoming increasingly global. It is therefore likely that crises and conflicts in the world around us will have a decisive effect on Sweden. Thus, we must adopt a global view of risk and security, a view that integrates features of social, economic and ecologically sustainable development.

5.2 Vulnerability analysis

The climate and weather we have today can have a major impact on the Swedish environment and society, particularly when it comes to infrastructure. Violent storms, often in combination with high water levels, cause particular damage. The vulnerability analysis for the various sectors is based on current weather phenomena that may seriously harm the environment and society. This information has then been combined with climate scenarios and other societal and environmental factors. This analysis shows that fairly uncommon and extreme weather phenomena, such as high winds and flooding, have the greatest significance in terms of vulnerability. However, there is an element of vulnerability in slow, long-term changes in mean values, such as mean annual temperatures and annual precipitation; these factors have been included in the analysis.

There is a considerable degree of uncertainty, both in the scenarios and in the vulnerability analysis. This is because there is a still a lack of basic knowledge about the effects of climate change on society and ecosystems, and also because it cannot be ruled out that sudden rapid changes or surprises may occur in climate, the environment and society.

5.2.1 Water resources

Generally speaking, Sweden has a plentiful supply of good quality water. Water quantity or quality may be lacking in dry years in some parts of southern Sweden and on the islands of Öland and Gotland. A very high proportion of drinking water comes from surface sources, ie, lakes and watercourses.

In the SWECLIM scenarios, a warmer, wetter climate will increase water supply in the north, whereas in southern Sweden the effect may be less water supply in some cases and more in others. There will also be a general effect on seasonal distribution, with more water supply in winter and an earlier but less severe spring flood. Water supply may become more extreme in autumn, particularly in northern and central Sweden, with a greater risk of flooding. The larger water supply during this period will also exacerbate leaching of nutrients such as nitrates and ammonium nitrogen, which are highly mobile.

A study of the entire Baltic catchment gives a broader perspective on the issue of climate and water resources. The area covers approximately 1.7 million square kilometres[6] and includes 14 countries. A study has shown how drainage into the various basins of the Baltic may change "in 100 years" according to the SWECLIM climate scenarios. The effect will be a dramatic change in the annual rhythm of flow in rivers and increased drainage from the north of the region. This will naturally have a major impact on Baltic salinity, nutrient supply and hence the ecosystem.

Changes in water flow in regulated watercourses will also greatly affect electricity generation in the country, perhaps offering potential for greater and more even production.

However, restrictions on water levels in dams, reservoirs and aquifers and on flow rates imposed by current and future water court judgments, which are intended to reduce risks and protect other interests,

[6] Rummukainen, M., et al., 2000

may limit the scope for more hydropower. The increased flow in our regulated watercourses may increase the risk of dam breaches, since they were built to withstand the vagaries of the climate as it is at present.

Higher lake temperatures may greatly affect drinking water quality in terms of taste, odour and colour. There will be a greater risk of infectious diseases and toxins spreading if flooding upstream spills out pollutants into lakes and watercourses used for drinking water supply. Water supply infrastructure has a very long lifespan and is vulnerable to climate change: a long-term strategy to reduce vulnerability must therefore assure alternative sources of water supply, particularly aquifers. The south and south-east of the country are particularly vulnerable in this respect.

High flow levels in watercourses and higher levels in lakes and watercourses affect shores physically and also affect their ecology. Regulation of flow and water levels can to some extent counter the adverse affects of high flow and high levels.

To sum up, water resources are, to a degree, vulnerable to climate change, particularly in southern Sweden, where water shortages may occur in dry years. Hydropower dams and other dams may also become more vulnerable.

5.2.2 Land and soil

Climate change, involving changes in temperature and hydrology, affects biological, chemical and physical processes in soil. Several processes central to essential ecosystem functions are dependent on these soil processes. Key processes include mineralisation of organic matter, which releases important nutrients and alters soil structure, weathering of minerals, which releases trace elements (including calcium, magnesium and potassium) but also causes leaching of soluble substances. These essential functions also form the basis for sustainable agriculture and forestry. If there is more water in the soil, its structure may deteriorate as a result of ploughing (in autumn, for example); which may affect essential functions in agricultural soils. Increased drainage from forest soils may accelerate leaching of important minerals and lead to the formation of podsols.

Land and soil can also be affected by a greater presence of sea salt if the climate becomes more maritime. These effects are expected to be significant in coastal areas.

Higher soil temperatures accelerate decomposition of organic litter, although warmer and wetter conditions will increase biomass production in many ecosystems. The balance between these two processes: decomposition and supply of organic matter, affects the quantity of organic carbon in the soil. Temperature is a factor limiting decomposition of organic matter and mineralisation in many boreal, subarctic and alpine ecosystems. Growth in these ecosystems may also be limited by climate factors. Climate change is expected to increase the rate of turnover of organic matter, but it is not clear whether the overall effect will result in a net accumulation or net decomposition of organic matter. The SWECLIM climate scenarios indicate a large net effect in Swedish forest soils. Estimates suggest that nearly 14 Mtonnes of carbon dioxide could be taken up in soils annually "in 100 years".

Water supply and hydrology are also important factors influencing soil structure and stability. A rising water table, increased drainage into lakes and watercourses and higher flow rates in water courses may increase the risk of landslip and subsidence. Several valleys, including Klarälven and Göta Älv, have soil strata comprising marine clay deposits ("quick clay"). Saturation and mechanical movements in these strata cause extensive landslip.

The Swedish land mass has risen rapidly since the last ice age. This land elevation continues in northern and central Sweden, whereas a slight depression of the land is occurring in the far south of the country. If the mean sea level rises in the region, some land would therefore be lost. The southernmost coast of Sweden is particularly vulnerable because the combination of wave movements, strong currents and a rising sea level will rapidly lead to coastal erosion there, since the soil often comprises loose deposits such as sand. Coastal erosion is already occurring and action has been taken to avoid further land loss. Southern coastal wetlands will also face the risk of being flooded by saltwater if the mean sea level rises.

Land and soil is potentially highly vulnerable to climate change because we do not know enough about the nature and extent of possible effects, and because it may be difficult to find efficient and cost-effective remedies.

5.2.3 Ecosystems

Scandinavian ecosystems are limited in their growth and species diversity by a number of factors, such as availability of nutrients, barriers to distribution and climate (eg, temperature and precipitation). The predominant ecotypes are temperate mixed forest (the nemo-boreal biome), coniferous forest (the boreal biome), and subarctic ecosystems (the subarctic-alpine biome). Much of our biodiversity is found in lakes and watercourses close to these terrestrial ecosystems. This biodiversity may be affected by climate change. The Baltic may be regarded as a separate, brackish, ecosystem, whereas the Kattegat and Skagerrak form part of the larger North Sea and North Atlantic Ocean. Extreme conditions also have a great impact on biodiversity. In particular, the low winter temperatures may determine whether or not many species survive in Sweden.

The SWECLIM scenarios indicate that climate change may have a dramatic impact on the Swedish environment. The rapid changes predicted in these scenarios include a rise in mean temperature of about 0.4°C per 10-year period. Precipitation is also forecast to rise by up to 2 per cent per decade. The climate zones determining the range of the various biomes may move north by 50 to 80 kilometres a decade. It is possible that conditions will allow entirely new ecosystems and biomes, such as temperate deciduous forests of oak and beech to predominate in southern Sweden. There may also be much greater potential for individual plant and animal species occurring south of Sweden to become established here.

However, there is a considerable time lag between the necessary changes in climatic conditions and establishment of a new ecosystem, particularly when it comes to ecosystems inhabited by species with a long reproductive cycle and/or little ability to increase their range.

The combined effects of climate change in increasing concentrations of carbon dioxide will affect primary biomass production. For example, it has been estimated that forest biomass production (wood) could theoretically double in southern Sweden and increase fourfold in northern Sweden if the shortage of nutrients did not limit growth.

Effects on the Baltic ecosystem are potentially dramatic. Temperature change has a direct impact on various species, as do changes in the extent of ice cover. Increased precipitation in the Baltic catchment area is expected to increase the supply of fresh water, which, if it is not counterbalanced by more frequent saltwater intrusions, may substantially reduce salinity.

An increased supply of water entering the Baltic is expected to increase nutrient input, particularly in the event of wetter autumn weather. However, a greater supply of water in the northern Baltic catchment and less in southern areas of the entire Baltic catchment may result in lower concentration of nutrients in the sea because most agriculture is in the south of the country. The overall effect could threaten marine species (eg, cod) and favour freshwater species (eg, perch, pike, zander (pike-perch) and cyprinids). There is a risk of non-native species spreading into the Baltic. The dynamics of algal blooms in the Baltic may also be affected. Lake fauna is expected to change; species tolerant of warmth (perch, pike and cyprinids) will benefit, but with changes in population dynamics, such as more rapid growth, earlier sexual maturity and shorter lifespans. Other species, typical of cold water, such as cisco and salmonids, will suffer and may disappear from shallow lakes and running waters in southern Sweden.

Higher temperatures are expected to allow a number of southerly species to become established on land (in terrestrial ecosystems), although there are also some obstacles to colonisation (the Baltic, the arable plains of southern Sweden). The spread of non-native species, which is currently inhibited by cold winters, may become a much more serious problem. Some endangered species of southerly origin may benefit from a warmer climate.

Other, more northerly, species and ecotypes may suffer seriously owing to a combination of warmer climate, more nitrogen leaching and the current high levels of atmospheric nitrogen deposition.

There is a very great risk that arctic-alpine species in subarctic-alpine areas of the Swedish mountains may become extinct, unable to compete with species favoured by greater warmth and nitrogen availability.

Wetlands

The term "wetlands" covers a fairly disparate group of ecosystems covering much of Sweden's surface area, which therefore represent important elements in the environment and are of great ecological value in terms of biodiversity and other criteria. The vulnerability of these systems ultimately depends on the way climate change effects hydrological characteristics, since wetlands by definition are areas with a high water table.

It should also be emphasised that relatively small hydrological changes in a wetland area may have a fairly major impact on its ecological processes, even though the change is not great enough to place the system outside the definition. However, the tools currently available are not sufficiently accurate to allow proper quantification of wetland vulnerability.

Nevertheless, on the basis of the SWECLIM scenarios, it may be inferred that vulnerability is particularly pronounced in relation to the distribution and occurrence of wetlands in those parts of southern Sweden where the water table may drop as a consequence of significantly less precipitation. In northern Sweden, on the other hand, vulnerability ought to be lower because of higher precipitation. Nor can it be ruled out that a damper climate in northern Sweden could increase the area of wetlands, topography allowing. Extreme seasonal fluctuations in water flow in watercourses and lakes may also render surrounding wetlands vulnerable as a result of changes in the hydrological dynamics.

The sensitivity of biodiversity in wetlands is particularly great in areas where these ecosystems are more isolated features of the landscape, since many species will then face an effective barrier to migration.

Peat bogs play an important part in the global carbon cycle. Accumulation of carbon in peat bogs is governed by a combination of temperature and hydrology and studies have shown that peat bogs can change from sinks of carbon to sources of this element from one year to another. In many cases this fluctuating pattern has been explained by annual variations in climate, which indicates that the carbon balance in these systems is heavily dependent on climate. However, the tools currently available are not accurate enough to allow proper quantification of this.

Sudden changes and surprises cannot be ruled out, which shows the need for long-term planning and a precautionary approach to conserve biomes, ecosystems and biodiversity.

Many complex processes related to biodiversity are important to man, but we nonetheless know little about their vulnerability to climate change. These include mycorrhiza-tree growth symbiosis, decomposition, fixing and release of substances in soil and water.

Seen as a whole, ecosystems are potentially highly vulnerable to climate change. The montane and Baltic ecosystems are particularly vulnerable. Other ecosystems are also potentially at risk because of the rapidity of climate change. Southern Sweden may see the arrival of completely new species, although barriers to migration will considerably delay their establishment. Man can help all these species by creating a "patchwork" landscape with a variety of microclimates within the migration range of the species. At present we do not know enough about the impact on wetland ecosystems or their vulnerability.

5.2.4 Forestry

Forest growth is governed by a number of factors. The main ones are water supply and nutrients, sunlight and the air and soil temperature. Each species is also subject to inherent limitations. The relative importance of the various determinants varies throughout Sweden.

In the north temperature and nutrient availability are often the limiting factors; in the south it is usually water supply.

There is currently net growth in Swedish forest biomass, which can be used for timber, pulp and other forest products. This net biomass growth is largely the result of earlier felling and planting of new trees, and the fact that a large proportion of forest is approaching maturity. Another contributory factor is atmospheric nitrogen deposition, since a shortage of this element often limits growth.

The primary production factor for photosynthesis and growth is the quantity of sunlight. According to the SWECLIM scenarios, the number of hours of annual sunlight may diminish somewhat if cloud cover increases. However, it seems more certain that the amount of sunlight during the growing season (when the temperature remains constantly above 5°C) will increase substantially. The sole reason for this is that the growing season will be about one month longer in spring as well as autumn. The effect of the longer growing season will be greatest in northern Sweden (a 15 – 18 per cent increase). The increase in the south will only be 9 - 12 per cent. The reason for this difference is that there is more sunlight to be gained, relatively speaking, from a longer growing season in northern Sweden than in the south.

At present water is not normally a factor limiting photosynthesis and growth in northern Sweden, but may be so in southern Sweden, particularly the south-east, where current water shortages during the growing season may reduce production by between 40 and 50 per cent some years. The SWECLIM scenarios suggest that water supply will increase by between 50 and 75 mm during the growing season in northern Sweden, whereas the latest scenarios indicate a decrease during the growing season in the south. Increased water supply in the north is unlikely to have an appreciable impact on production there. But lower water supply in the south will certainly reduce production on healthy soils. Spruce and deciduous trees would suffer more than pine, because they need more water. In the long term, an excessively wet climate may turn some productive forest land into boggy forest, which would reduce production. The SWECLIM scenarios indicate that this could be a problem in inland areas of northern Sweden, in particular.

The production of new shoots in spring by spruce, pine and most deciduous trees is affected by day length and air temperature. Higher air temperatures ought to mean that this process starts earlier. Using results from a large number of field experiments, where trees have been exposed to differing temperatures, and a simple simulation model to reflect shoot bursting, it has been concluded that this should occur about two weeks earlier in the south and about four weeks earlier in the north of Sweden. In some circumstances, this will involve a risk of frost damage. Frost damage may be serious in stands of saplings and young forests if frost occurs when shoots have begun to burst or immediately afterwards.

Saplings may die if they are exposed to spring frosts year after year. The frequency of spring frosts indicated by the SWECLIM scenarios has been compared with the estimate time for shoot bursting in a future climate. It was found that the risk of spring frosts did not seem to be any greater. However, more scenario data will be needed to make a better assessment of the effect of climate change on spring frost frequency.

Apart from the fact that production in Scandinavia is limited by the short growing season, it is also severely limited by a lack of nutrients in soil. Warmer soils resulting from climate change will increase biological activity in soil, which will affect decomposition of organic matter and recycling of important nutrients. A field experiment has been conducted in northern Sweden. Soil temperature has been raised 5°C over the natural level using electric cables. Tree nutrient status has improved and stemwood production has increased by over 100 per cent. Further experiments will reveal whether this production increase is a lasting one. As part of the same experiment, a study has been made of the way soil warming affects trees that already have optimum access to nutrients. Here, the production increase is much more modest – about 15 per cent higher than in soil at natural temperature. This increase can probably be ascribed to an earlier ground thaw and water availability in spring, which ultimately enables photosynthesis to start earlier.

Higher carbon dioxide levels over a period of hours to several months dramatically increases the rate of photosynthesis. However, after a time, the photosynthesising needles seem to adapt to the new levels and photosynthesis falls back to its rate under normal carbon dioxide conditions. Field experiments in northern Sweden, where entire trees have been exposed to elevated carbon dioxide levels for several years, have demonstrated a 10 to 15 per cent increase in photosynthesis. Further field experiments will reveal whether this effect is a lasting one, or whether it declines or increases once again.

Transpiration, unlike photosynthesis, releases carbon dioxide. This process is heavily dependent on temperature and increases greatly as temperature rises. The mean annual temperature is between 6 and 8°C in southern Sweden and between 0 and 4°C in the north. An increase of between 3 and 4°C will increase the cost of maintaining the function of living plant cells. Increased transpiration will cause more carbon dioxide to be emitted from living biomass, which may affect the overall carbon balance in Swedish forests. It was also found in the above soil warming experiments that transpiration from the heated soils did not rise; the soil seemed to adjust to the higher temperature and maintain the same level as the unheated soils.

A conservative estimate, based on the SWECLIM scenarios and including the above effects but not the effects of higher carbon dioxide concentrations and markedly higher nutrient turnover in the soil, is that production in Sweden could increase by between 10 and 20 per cent. In volume terms, annual growth in total volume over bark might increase by approximately 15 million cubic metres. At current growth and felling rates in Sweden, it is estimated that trees remove about 7,000 ktonnes of carbon each year (equivalent to carbon dioxide removal of approximately 26,000 ktonnes a year). Forest soils remove between 2,000 and 5,000 ktonnes carbon a year (equivalent to carbon dioxide removal of between approximately 7,000 and 18,000 ktonnes a year). The SWECLIM scenarios suggest that trees could eventually remove a further 4,000 - 5,000 ktonnes of carbon a year, ie, a total of 12,000 - 13,000 ktonnes of carbon a year. (The carbon balance in forest soils has not been included in this calculation). This forest removal can be seen in the context of Swedish carbon dioxide emissions from fossil fuels, which total 16,000 - 17,000 ktonnes of carbon per year.

A rise in productivity in submontane forests and higher tree lines will impact other important sectors and interests, such as outdoor leisure and tourism, reindeer husbandry, nature conservation and biodiversity.

Over the last 70 years four storms have caused significant windthrows; a total of 70 million cubic metres of stemwood has been blown down. The worst windthrows occurred in 1969, where about 37 million cubic metres of stemwood was felled. Windthrows occur when wind speeds reach full storm or hurricane force. There are no SWECLIM scenarios for increased storm frequency at present, but the question of extreme weather phenomena will be the subject of research. More frequent occurrence of these wind speeds would naturally cause problems for forestry. Large quantities of wet snow freezing onto tree branches can also cause trees to fall, particularly in windy conditions during or after the snowfall. Good forest management can mitigate the extent of storm damage.

A warmer and wetter climate with a longer growing season will extend the northerly limits of various tree species. This is likely to apply to many broadleaf species currently only found in southern Sweden. However, drier conditions during the growing season in southern Sweden may act to the detriment both of broadleaf species and spruce on healthy and damp soils.

Insect populations may also expand in a warmer climate with longer summers. Insect pests and other organisms harmful to trees display a clear north-south gradient. These include pine weevil, pine sawfly and honey fungus, which cause greater problems in southern Sweden. Some pests and diseases may move northwards and become more frequent. It is also conceivable that new parasites could become established in southern Sweden.

Overall, the SWECLIM scenarios indicate that Swedish forestry will produce substantially more wood and other forest products. It is conservatively estimated that productivity may rise by 10 to 20 per cent. Attacks by pests, insects, fungi and other pathogens are also expected to increase.

5.2.5 Agriculture[7]

Climate has an enormous impact on the quantity and quality of crops grown in Sweden.

Crop yields can vary greatly from year to year. These wide fluctuations are due to variations in precipitation, sunlight and temperature, as well as attacks by various pests, fungal diseases, insects, viruses and nematodes.

Not only quantity, but quality of crops is highly dependent on the weather. Grain crop quality can suffer greatly as a result of wet weather in late summer: often it will then only be of use as animal feed. Various fungal diseases can also increase the quantity of mycotoxins in grains, which will reduce the prospects of using the crop to make flour.

Potato crops may suffer from leaf and then tuber blight in wet summers, with a resulting drop in quality. Crops will be unusable some years.

A warmer and wetter climate over the coming 100 years will have a great impact on future crop production and also on the occurrence and distribution of various pests.

Current crop production and fluctuations in yield

There are currently about 2.7 million hectares of arable land in Sweden. The area of arable land and grazing land has declined over the last 50 years. This, in combination with rationalisation, greater field size and other factors, has changed the landscape.

An area of about 800,000 hectares has been under feed grain (mainly barley and oats) in recent years. Bread grain has taken up 400,000 hectares, potatoes 35,000 hectares, oil seed rape and turnip rape 50,000 hectares and sugar beet about 55,000 hectares. Much arable land comprises seeded grassland (about 35 per cent). The total annual value of crop production (including ley) may be estimated at SEK 12 – 14 billion, not including various forms of farming support, which total some SEK 3 – 4 billion.

Crop yields vary significantly from year to year and region to region owing to variations in precipitation, temperature, sunlight and other factors. Average spring barley yields have been 4,000 kg per hectare in recent years; autumn wheat yields have been about 6,000 kg per hectare. Yields vary greatly from year to year, however. In 1992 the spring barley yield was 2,000 kg per hectare in south-eastern Sweden. Hot, dry weather is likely to have been the main reason, although aphids may also have been a factor. Spring barley yields may fluctuate widely from year to year as a result of current weather variations: from 6,000 kg per hectare down to 2,000 kg per hectare. Other crop yields also vary a great deal.

Impact of climate change on cultivation

On the basis of the general correlation between temperature and natural vegetative production, crop yields could increase by 20 – 40 per cent if the mean temperature rises by about 3°C. But we may expect sizeable differences, depending on crop. By comparing current differences in crop statistics for various regions of Sweden with differences in temperature between these regions (ie, by moving entire regions north), it has been concluded that yields may increase dramatically in the Mälar valley region west of Stockholm. However, depending on the crop, yields per hectare may vary between a few per cent for rape to up to 30 per cent for cereals and 100 per cent for potatoes if the temperature rises by 2°C.

This method of extrapolation moves soil types, crop varieties and cultivation techniques northwards. In some cases this is a reasonable assumption, but the method may indicate too high an increase for potatoes. The relative extent of the areas over which various crops are grown must be taken into account in order to determine yield changes in Mälar valley region. If the distribution remains unchanged, the regional increase will be about 25 per cent. If the cultivation pattern changes to that currently prevailing in the far south of Sweden, however, the increase would be 55 per cent. Another factor is a possible change in the total area of arable land. The relative changes are expected to be generally greater in northern Sweden.

Simulations using dynamic soil-crop models for specific sites have been employed as an alternative to the above calculation method. These simulations also take into account changes in soil and water conditions and are essentially a projection of research findings in a future climate change scenario. If the temperature rises by 1.7°C, autumn wheat yields on clay soil in Uppsala (60 km north of Stockholm) are expected to increase by almost 20 per cent, but by under 10 per cent on sandy soils. Even though nitrogen mineralisation from the soil is expected to increase by about 20 per

[7] Jordbrukets känslighet och sårbarbet för klimatförändringar. ("Agriculture's sensitivity and vulnerability to climate change") Swedish EPA Report 5167, 2001

cent, the quantity of nitrogen in the crop rises by only a per cent or so, and even falls on sandy soils. These findings thus suggest that protein content might fall if fertiliser use remains constant and the climate changes.

There is much to suggest that crop yields will increase if climate change occurs as generally predicted by the climate models. The choice of crops is a highly significant factor governing the size of yield increase at regional level. Regional differences in climate also have an impact on crop size, as does soil type. These two factors also greatly influence potential changes in nitrogen leaching. It should be added that these conclusions assume that climate variability will remain as it is at present.

At higher temperatures, higher carbon dioxide levels and higher precipitation, most crop yields are likely to be higher than at present. It will also be possible to grow some crops, such as autumn wheat, autumn barley and autumn oil plants, further north. In parts of south-eastern Sweden, such as Kalmar county and the island of Öland, dry summers may cause greater variations in yield than is now the case. Potato crops may also be greatly affected if irrigation is not available.

It will be possible to grow some crops that require higher temperatures in the south of Sweden. Maize is one example; it will probably be cultivated more widely. It may also be possible to grow sunflowers, although here profitability will also be affected by factors other than purely biological aspects. It will also be possible to establish vineyards in the south of the country, although it is very difficult to assess their potential profitability.

Insect pests, plant diseases and weeds

As in other countries, various harmful insects, plant diseases and weeds may have a great economic impact in Sweden. It is estimated that damage to all Swedish crops may be reduced by 5 – 15 per cent using current cultivation methods and pesticide doses. Pesticide use currently costs about SEK 1 billion each year.

Infestations vary a great deal from year to year and from region to region. There are a number of reasons for this. Apart from cultivation techniques, choice of varieties and crops and varying degrees of resistance to pests, various weather factors may also have an impact.

Weather affects pests in several ways. Temperature, precipitation, humidity, sunlight, wind and snow cover influence the occurrence and range of various insect pests and plant diseases. Temperature affects insect life cycles, range and airborne activity. Fungi growth is also influenced by temperature, although their development is even more dependent on precipitation and humidity.

The wind also plays a major part in the spread of insects and spores of fungi. For example, aphids may be carried long distances on the wind. Infestations some years in the south-east of the country are the result of wind-borne aphids originating from the other side of the Baltic. Infestations of diamond-back moth in oil plants and brassicas in the eastern parts of central and northern Sweden in 1995 were caused by insects carried into the country on easterly or south-easterly winds. In the 1960s a fungal disease of wheat occurred for the first time in the south and south-east of Sweden. The spores may have entered the country with seed, but the most likely cause was airborne spores carried from the south-east of what was then the Soviet Union.

Effects of pests on crops in the event of climate change

A warmer and, in most places, wetter climate will favour a number of pests and diseases that attack various crops. These include fungal diseases, viral diseases, bacteria, nematodes and insects.

Aphids are likely to become a greater pest in Sweden. At present virtually all of them overwinter as eggs on various winter hosts. If the temperature rises by 3 – 4°C, most of them are likely to be able to overwinter on various crops and weeds, as is currently the case in Britain and the continent. Some 30 of the 500 plus species of aphids currently found in Sweden have an economic impact on crop yields. It is likely that several of them will become more important in terms of direct damage and also as carriers of various viral diseases.

Cereal dysentery virus, which is mainly spread by oat and grain aphids is only a moderate problem for spring cereals, but it is likely to become a greater threat, particularly to autumn cereals.

Viral diseases spread by aphids also affect oil plants, but these diseases currently pose little threat. Peach aphids, which carry viral diseases affecting autumn oil plants, will thrive in a warmer climate and will thus pose a greater threat to these crops.

Several cereal diseases that prefer a warmer climate will probably become more widespread. These include rust and mildew of grass. Higher precipitation will result in more cases of leaf spot fungi in cereals, eg, barley and wheat. The quality of bread grain may also deteriorate as a result of late summer rain. Wheat crops may be rejected for use as bread grain owing to lower falling numbers and more widespread occurrence of fusarium fungi. High concentrations of certain fungi on the grain may also increase mycotoxin concentration. Wet conditions also favour fungi such as ergot on cereals, which may render it unfit for eating.

Potato leaf blight and tuber blight are likely to become more common. Organic farmers will be particularly badly affected, since they cannot use pesticide to combat the disease.

Viral diseases of potatoes may also become more common, the most likely culprit being the peach aphid, which spreads leaf roll virus.

Several insect species not presently found in Sweden may become established in the south of the country. Examples include the Colorado beetle, which attacks potato crops in Germany, Poland the Baltic States and elsewhere. It may be carried by the wind to southern Sweden, where a warmer climate is unlikely to prevent it becoming established.

Fungal diseases like sclerotinia and black spot may become more prevalent among oil plants. As for insects, the cabbage stem flea beetle, which at present occurs mainly in the south of Sweden, may become more widespread. Sugar beet will probably be more frequently afflicted by certain viral diseases, particularly those spread by the peach aphid.

Effects and vulnerability in agriculture

Climate change as indicated by the SWECLIM scenarios is likely to increase some crop yields and allow cultivation of new crops in southern Sweden. The climate will also probably influence the occurrence and distribution of pests that attack various crops. Many pests and diseases are kept at fairly moderate levels by prevailing climate conditions. Pest increases can be combated by greater use of chemicals, but this is undesirable for other reasons, such as the harm they cause to flora and fauna, as well as contamination of streams and rivers, drinking water and groundwater. Greater efforts will probably have to be made to prevent infestation. Better cultivation techniques, increased use of resistant varieties and good crop rotation will therefore assume greater importance.

Organic farming will be particularly vulnerable to pests. In addition to the above preventive measures, production of virus-free seed will be essential. Use of biological methods will also increase. Notwithstanding preventive measures and steps taken during the growing season, shortages of organically grown produce will probably occur in years when pest infestations or inclement weather have occurred.

5.2.6 Fisheries

Plentiful fish stocks are largely dependent on policy, in which quotas, minimum sizes and protection of breeding areas are important factors in achieving sustainable fisheries.

Natural conditions, such as the status and supply of nutrients, as well as climate-related factors, are also important to the industry. The importance of the fishing industry in Sweden has declined over the last 30 years, one reason being the process of rationalisation that has taken place. Cod fishing in the Baltic, which is economically significant, has declined dramatically in recent decades; insufficient salinity and low levels of oxygen have inhibited cod reproduction. Lake fishing is also of some economic importance to the fishing industry, although nowadays most lake fishing takes the form of angling and other forms of leisure fishing.

Several models for general water circulation and climate change indicate a decline in thermohaline circulation in the North Atlantic and the Gulf Stream. This could have a decisive effect on fisheries in the eastern North Atlantic and hence on fisheries throughout Europe. Swedish coastal and Atlantic fisheries could also suffer as a result.

The Baltic Sea, Kattegat and Skagerrak

Climate change as indicated by the SWECLIM scenarios may cause widespread and radical changes in the ecosystems existing in the Baltic Sea, Kattegat and Skagerrak. The scenarios suggest less extensive ice cover in the Baltic and possibly a greater supply of nutrients from land. The increased flow of fresh water may affect salinity. However, the critical factor determining salinity is how climate change will affect the inflow of saltwater from the North Sea. This is currently an open question. In the scenarios, the surface water in the Baltic will be warmer, particularly in the north in summer and in the south in winter and spring. The period during which the water column is stratified will therefore be longer.

This will cause the thermocline to move downwards, which will reduce the living space available for species thriving at low temperatures. The longer period with stratified conditions increases the risk of oxygen deficiency in coastal waters, both at night close to the bottom in highly productive waters, and in areas of deep water that are isolated under the thermocline. These problems will also be exacerbated because less oxygen dissolves as water temperature rises, while the metabolic rate of organisms accelerates and oxygen consumption therefore increases. Warmer water is also considered to favour blooms of certain potentially toxic algae, eg, cyanobacteria. Lower salinity would reduce the occurrence of marine species – cod, turbot and plaice could disappear from the Baltic.

Reduced salinity may also eliminate crab and lobster from southern areas of the west coast.

Higher temperatures favour warm water fish, which, in the Baltic, may result in more rapid growth and possible larger populations of perch, pike and zander (pike-perch), particularly if salinity drops and suitable breeding areas are available. However, warmer water may be bad for cold water species, such as cod, whitefish, salmon and trout, at least in areas where they cannot compensate by moving into deeper water. Experience has shown that cold winters are good for flatfish recruitment; warmer winters may therefore reduce populations of plaice along the west coast.

Lakes and watercourses

A warmer climate "in 100 years" may be expected to have differing effects on fish assemblages, depending on depth conditions in their habitats. Generally speaking, the thermocline will develop earlier in spring and disappear later in autumn in a warmer climate. It will also occur at a greater depth. Major changes may therefore be expected in shallow lakes. Simulations indicate that typical cold water species in shallow lakes lose weight in summer if temperatures exceed the optimum. However, at even higher temperatures weight loss will cause the species to die out. Some cold water species will die out when there are no cool refuges available in summer.

Cold water species generally spawn in autumn; the roe does not hatch until spring. Stable, low winter temperatures are required if a good proportion of roe are to survive. It is therefore possible that ice-free conditions and a few degrees above zero may have an adverse effect on survival in southern Sweden.

The scenario "in 100 years" predicts that flow rates in water courses will change. The greatest risks in south-western Sweden are an excessive reduction in flow combined with high water temperatures. It is probable that cold water species like salmon and trout will disappear from many of watercourses in these areas. The main factor expected to affect conditions for fish in northern Sweden is a more constant flow rate. Many fish species undertake annual migrations, which are governed by, and dependent on, existing annual river drainage cycles. Spawning and fry development are also adapted to plankton production peaks occurring in conjunction with the spring and early summer floods, both in rivers themselves and in estuarine areas.

Increased precipitation may favour fish that spawn in fast-flowing streams, since these streams will be less inclined to dry up. If the temperature rise is not too great, this may benefit the sea trout, since its presence in coastal waters is largely dependent on reproduction in small streams, which now often dry up in summer.

Climate change as indicated by the SWECLIM scenarios may produce substantial effects on primary production, which may increase in most lakes, watercourse and adjacent marine areas. But the balance of species will also change, cold water species losing out to species that thrive in warmer conditions. Overall, fisheries in Swedish lakes and the Baltic Sea will become more vulnerable, particularly if overfishing is not prevented. The industry may be able to adjust to some extent by increasing its catches of species more tolerant of warmer conditions.

5.2.7 Transport, energy and industry

The vulnerability of the transport, energy and industrial sectors is largely dependent on socio-economic developments in these sectors. Infrastructure is sometimes built without sufficient account being taken of weather phenomena (high winds, extreme temperatures and heavy precipitation) that occur very rarely in our present climate. Long series of climate data can be reanalysed to provide a better basis for assessing sensitivity and vulnerability under present and future climate conditions. Vulnerability often arises when several factors interact or following a chain of events that are improbable under more normal conditions. Violent storms accompanied by wet snow may damage electricity distribution on local and regional grids, which will have a knock-on effect on transport, other energy supply and industry.

Transport

Hydrology influences the stability of roads, railway embankments and shipping lanes. Other climate factors, such as mean and maximum/minimum temperatures and wind conditions, also play a part.

Correct drainage is necessary to ensure that roads and railway embankments retain their carrying capacity. Carrying capacity depends on climate factors such as water availability, cold and heat, freezing and thawing processes, as well as type of soil. Silty soils, which are common in Sweden, cause particular problems. Parts of the national road network must be closed each year during the spring ground thaw because roads lose carrying capacity.

Some clay soils are prone to landslip. "Quick clay", which is deposited in saltwater, can suddenly become unstable when pore water pressure increases as the water table rises.

Entire sections of road embankment may then start moving. Landslip can also occur in running ground following heavy rain in conjunction with the spring ground thaw. Steep, sandy riverbanks may also fall or collapse because of undermining, internal destabilisation or heavier loads or vibration. Much of the road and rail network crosses clay and silty soils and requires special attention in connection with spatial planning.

Erosion of road embankments is a recurring problem around culverts, bridge supports and along ravines and upland stream beds. Erosion is ultimately caused by high water levels or heavy rain/snow, which may occur more often if the climate changes.

To some extent, transport is vulnerable for safety reasons limiting the use of bridges such as the recently opened Öresund Link in high winds. Frequent high winds exceeding the safety level may therefore cause more frequent disruption of traffic between Sweden and Denmark.

Extensive safety regulations govern bridge construction. Road building is not subject to anything like the same plethora of detailed regulations. Culverts, for example, can be highly sensitive to climate factors such as high water levels.

Energy

The SWECLIM scenarios suggest a high rate of flow in watercourses and hence increased potential for hydropower generation in Sweden. A higher mean temperature will reduce the need for energy to heat homes and commercial/industrial premises.

However, society will continue to become increasingly vulnerable to energy shortages, particularly shortages of electric energy. All our systems are directly or indirectly dependent on a reliable supply of electricity. An acute energy shortage, perhaps resulting from a breakdown in distribution, will rapidly cause secondary effects in all other systems, such as telecommunications, water supply, sewage treatment and transport systems. This will paralyse society.

Perhaps socio-economic and technical developments are the factors most increasing our vulnerability to energy shortages. Climate change may exacerbate this. Vulnerability engendered by climate change will mainly relate to extreme weather phenomena, such as high winds, heavy rain or snow and extreme cold. The scenarios indicate that extreme cold will become less common in the future, whereas the trend for high precipitation and strong winds is less certain.

Some of the effects and vulnerability to climate change can be combated by making the energy supply system more robust and increasing safety margins.

Industry

Manufacturing industry is particularly vulnerable to disruptions in supply of energy and raw materials. Swedish manufacturing industry is largely dependent on a supply of domestic raw materials from forestry and mining. However, increasing globalisation of trade and industry renders Swedish industry more dependent on the outside world.

On balance, a more reliable supply of energy in all sectors is the most important way of reducing society's vulnerability. Climate change may affect the energy supply system, particularly if extremely high winds and heavy precipitation become more common.

5.2.8 Health

Global climate change will affect health in various ways. Heat waves, storms, floods and weather-related landslip affect health directly, whereas changes in seasonal climate harm health indirectly by their impact on terrestrial and marine ecosystems.[8] Regional food production and water supply will be affected, supply probably improving in northern temperate zones and deteriorating in areas already hard hit. Rising sea levels will increase the risk of flooding, salt water contamination of water supplies and offer new breeding grounds for disease-carrying insects. Low-lying, densely populated areas, such as the Ganges delta and Po valley, are particularly at risk. These changes may lead to massive migratory movements, entailing everything from epidemics to armed conflicts. In global terms, adverse health effects will predominate, although some diseases may abate or disappear locally because conditions are too dry or wet or hot.[9] Cold-related health problems may become less common.

The risk of climate change causing health effects in a given area depends on a number of factors. Obviously, the degree of regional climate change is one key factor. But biological, logistical and socio-economic conditions are also significant. Biologically speaking, the vulnerability of different areas varies depending on the function and structure of local ecosystems, and the state of health and genetic susceptibility and immunity of the local population. The vulnerability of various constructions, road networks and electricity grids, sanitary systems and health sector capacity are of especial interest in emergencies. The socio-economic and technical capacity of a local community to take immediate and long-term remedial measures will be crucial in determining whether potential effects will in fact occur.

Effects in Sweden

From a socio-economic and technical viewpoint, Sweden is well equipped to take adequate remedial action. To do this in time, it is essential to identify potential climate-related health effects in various parts of the country.

Heat waves increase the incidence of deaths and illness due to cardiovascular and pulmonary disease.[10] The SWECLIM scenarios have not yet examined the

[8] Epstein 1999

[9] Climate Change 2001: Impacts, Adaptation & Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). 2001

[10] For example, Jendritsky et al., In press

effect of future heat waves. Annual maximum temperatures are expected to rise about as much as the mean summer temperature, ie, by about 3°C. Lengthy periods of very high temperatures, ie, heat waves, must be studied in greater detail.

On the other hand, winters are expected to be considerably milder throughout the country, which will reduce the number of cold-related conditions, such as frostbite and angina. The SWECLIM scenarios indicate a slight increase in wind speed and a greater risk of flooding throughout the year. In addition to the risk of physical injury, this may cause contamination of drinking water and outbreaks of disease. For example, leptospirosis, which is spread by rats, has been found to increase after flooding in central Europe, when these rodents are flushed out of their burrows.[11]

There will be a greater risk of diseases of this kind spreading in Sweden if floods become more common.

Swedish summer temperatures are not expected to increase as much as those in winter. But urban air quality may still be affected. Moreover, ground-level ozone forms more readily at higher temperatures. Furthermore, the combination of air pollution and higher temperatures exacerbates respiratory problems.[12] Air pollution is also suspected of exacerbating hay fever by causing nasal blockage, which increases membranal pollen accumulation.

The growing season is expected to be prolonged by 1 – 2 months, which will affect both the distribution of various pollen-producing species and the length of the pollen season. Hot and wet summers and autumn seasons will prolong pollen production. This will add to the risk of several types of pollen being present in the air simultaneously, with an accompanying risk of more severe attacks. Higher concentrations of carbon dioxide in the air will, in itself, also increase production of certain kinds of pollen.[13]

Mould, fungi and mites might also thrive indoors in a warmer and wetter Swedish climate. This would in turn affect the frequency of allergies.

Water quality is affected not only by contamination by particles, soil organisms and saltwater from flooding and rising seas. Diseases spread by water and food, such as salmonella and campylobacter tend to be seasonal in their occurrence. Higher temperatures could lead to outbreaks starting earlier in the season and persisting longer. A correlation has been identified between outbreaks of cryptospirosis and giardia and heavy rain in Great Britain and the USA.[14] The effect in Sweden has not yet been studied.

The SWECLIM scenarios for Sweden, with milder winters, increased precipitation, earlier springs and later autumns create ideal conditions for harmful insects and animals. Flies, cockroaches and rodents spread contagion. Diarrhoeic illnesses (caused by E. coli) may therefore increase at certain times of the year. Rodents also provide a natural reservoir of blood containing a number of infections, which can be transmitted to man in their urine and faeces, by fleas on their fur or, as is more common in Sweden, by blood-sucking carriers like mosquitoes and ticks.

Vector-borne diseases

Borrelia is the most common vector-borne disease in temperate regions of the northern hemisphere, including Sweden. Infection is spread by blood-sucking ticks from rodents (and other animals) to man. Ticks also spread other diseases, such as TBE (tick-borne encephalitis) and erlichiosis. Ixodes ricinus, a disease-carrying tick species, has been the subject of particular study in Sweden in relation to climate change. Milder winters and warmer early and late summer nights since the mid-1980s have enabled this tick, which lives for up to three years, to spread northwards in Sweden along rivers and the north Swedish coast.[15] Central Sweden has witnessed a substantial increase in tick numbers during this period, which has been explained by a significant correlation between milder winters and a longer growing season – conditions that increase year-to-year survival rates among ticks and their hosts alike. Southern Sweden has not yet been studied in this context. The increase in TBE cases in Stockholm county during the same period has also been found to be related to shifts in the seasons. In a milder climate, ticks could become increasingly common, even in the north of the country. Ticks are potential carriers of numerous infections. Climate change could allow the spread of new diseases and possibly also enable new tick species to survive in Sweden. It is very difficult to reduce the number of ticks occurring naturally; efforts must instead concentrate on identifying new risk areas, informing the public how to avoid being bitten and developing vaccines where possible, as in the case of borrelia, for example.

Mosquitoes spread a number of diseases. Malarial mosquitoes are still found in half the livestock buildings in the southern and central areas of Sweden, although there is little risk of contracting malaria here.[16] Early treatment prevents further spread of the disease, since malaria only occurs in man and mosquitoes, not in

---

[11] Kriz et al., 1998

[12] Climate Change 2001: Impacts, Adaptation & Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). 2001

[13] For example, Ziska & Caulfield, 2000

[14] For example, Rose et al., 2000

[15] Lindgren et al., 2000

[16] Jaenson, 1998

other animals. But the mosquito population may increase in a warmer and wetter climate. Thus, if malaria mosquitoes are present, someone who has been infected abroad could have time to cause a short-lived local epidemic before receiving treatment. Malaria is expected to become more common in Europe, as are other mosquito-borne diseases, such as leishmaniasis and certain kinds of encephalitis, like West Nile fever.[17] Tropical diseases like dengue fever might also spread to the far south of the country. With the exception of West Nile fever, there is little risk of these diseases gaining a foothold in Sweden. However, the number of people returning to Sweden having contracted these diseases abroad will rise. This will make greater demands of Swedish hospital and medical personnel. The range of mosquito and midge species in Sweden and their relative abundance will probably change. More insects will survive in a milder climate. Increased precipitation in parts of south and central Sweden may create new wetland areas, which will offer more breeding grounds. These may diminish in the north as a result of less widespread frozen ground conditions. New species may also become established. For example, reproduction of one particular disease-bearing mosquito is dependent on flooding. We need to know more in order to identify the diseases transmitted by insects that may be spread in various parts of the country owing to climate change.

To sum up, climate change may cause health effects in Sweden, but the country is considered to have the resources to prevent many of the epidemic diseases that may become more widespread. Training and information should be supplied to medical personnel to help them in their diagnosis, treatment and prevention of these new diseases.

5.2.9 Coastal zones

A large proportion of Swedish cities, town, villages and important factories are situated in coastal regions. These coastal zones are also environmentally important due to the biodiversity on land and in water. Coastal zones are also important spawning grounds for many fish species. These zones are affected by a number of climate-dependent factors such as wind, water level and the supply of nutrients entering the sea.

Climate change as indicated by the SWECLIM scenarios would produce a warmer and rainier climate. SWECLIM does not yet offer an unequivocal assessment of future weather variability. More violent and more frequent storms, and greater short-term variations in temperature and precipitation are quite likely to be the result of climate change.

Impact on coastal waters

In the scenarios, the surface water in the Baltic will be warmer, particularly in the north in summer and in the south in winter and spring.

Warmer winters will reduce the period of ice cover. There will probably be no ice cover along the west coast and the ice season in the Baltic proper will be much shorter. However, it is predicted that the Bothnian Bay, at least, will normally be covered with ice in winter in the scenario "in 100 years".

Warmer winters are expected to create more even flows in streams and rivers because wintertime precipitation will not accumulate as a deep, long-lasting snow cover; it will drain away fairly quickly. However, more rain and snow is expected, with more freshwater draining into the Baltic, particularly in the north of the catchment. If it is not counterbalanced by an increased frequency of saltwater intrusions, the considerably higher mean annual freshwater supply entering the Baltic will reduce salinity there. A sensitivity study of this suggests that salinity in the Baltic proper could fall to the levels currently prevailing in the Bothnian Bay. These predictions are obviously highly uncertain. For example, no adjustment has been made to take account of the fact that a rising sea level may create the right conditions for influxes of saltwater into the Baltic. However, there is a well-established historical correlation between accumulated precipitation in the Baltic catchment area and the salinity of the Baltic Sea.

Effects on biodiversity

One of the greatest threats facing terrestrial biodiversity is the northward shift of climate zones, which many organisms will find it difficult to keep pace with. The majority of marine organisms may be expected to find this much less of a problem, since they can travel long distances with the help of marine currents. The most dramatic effect of predicted climate change over the next hundred years will arguably be the consequences of higher precipitation. Many marine organisms are highly sensitive to even a slight fall in salinity and may become extinct across much of their range. Only at very low levels of salinity will the number of freshwater species begin to increase. This change may be particularly dramatic in the Baltic proper. If salinity there falls to 0.3 – 0.4 per cent, the common sea mussel, bladderwrack, cod and perhaps even sprat will disappear. With no common mussels, eiders will decline or disappear altogether. Salinity may also fall in the Kattegat and Skagerrak, and certain marine organisms suffer a decline, if the Baltic surface current along the west coast of Sweden will be stronger and

[17] Martens et al., 1997; Kuhn, 1997

more heavily diluted by freshwater. Warmer conditions will probably enable some southerly species to increase in numbers or become established in Swedish waters, provided that they can tolerate brackish conditions.

For example, oyster farming may become economically viable in south-western Sweden, since oysters can withstand fairly low salinity, while requiring high summer temperatures.

Mullet is a popular feature of the cuisine in countries further south in Europe. It has hitherto been recorded in the warm water off the coast close to the Ringhals nuclear power plant in south-western Sweden, but may become more common if the Kattegat and Skagerrak become warmer. However, Sweden may become host to species highly detrimental to our interests as well as those with culinary appeal. One example worth mentioning is Mnemiopsis leydyi, a North American species of jellyfish that feeds on zooplankton and fish fry. Its introduction in the Black Sea in the 1980s caused a crisis in the fishing industry there. The species has recently reached the Caspian Sea. However, it needs such high temperatures to reproduce that there is little risk at present of it invading the Baltic. But if the temperature of the Baltic rises as now predicted, an invasion might be possible.

Eutrophication and production conditions

As already pointed out, warmer summers will probably prolong stratification of the water column, which, per se, increases the risk of oxygen deficiency in coastal waters, an effect exacerbated by an increased nutrient load. Unless effective countermeasures are taken, a longer frost-free season and increased precipitation will most likely increase nitrogen leaching from agricultural land, although phosphorus leaching may decrease.

At present, availability of nitrogen (or lack of it) is the factor limiting growth across much of the Baltic, and so increased nitrogen leaching may be expected to exacerbate eutrophication. However, if nitrogen emissions increase while phosphorus emissions fall, the area of the Baltic where nitrogen availability limits growth may decrease, which may reduce blooms of nitrogen-fixing cyanobacteria. Since these are a natural feature of Baltic ecology, their disappearance would fundamentally reshape Baltic ecosystems. One result might be a change in the Baltic production season, with an earlier and perhaps more extensive spring bloom, but less production during the summer. Since the summer production provides food for herring and cod fry in the form of tiny zooplankton, a change of this kind could have an adverse effect on recruitment of these species. A heavier spring bloom could exacerbate oxygen deficiency in deep Baltic waters, since the organic matter thus produced normally sinks much more rapidly to the bottom in spring than it does in summer and autumn.

Since some species of nitrogen-fixing cyanobacteria may be toxic, the disappearance of large-scale blooms of this kind may also be positive for man. But if this were to occur, they would probably become more common in the Kattegat instead, where they are currently uncommon because of the higher salinity there.

5.2.10 Montane areas

Climate change in montane areas would cause the various ecosystem zones and species to shift upwards or downwards since temperatures fall with increasing altitude. A rise in the mean temperature of 4°C would cause climate zones to move almost 700 metres higher up.

This would mean that many subarctic, often low-growing, species (such as lichens and mosses) would lose out and be replaced by other, often higher-growing, species that require more warmth (such as bushes and trees). Higher temperatures mean increased biological and chemical decomposition of organic matter and a greater supply of nutrients, at least for a short time. This would benefit species that require more nitrogen. The overall effect is expected to be that the tree line would move higher up the mountain side. However, submontane forest is also dependent on favourable conditions over a number of consecutive years so that young plants can germinate and survive the most vulnerable stages of their development. Landslides and avalanches also influence the extent to which new ecosystems such as forest can become established. Existing montane forest may become denser owing to increased nutrient supply and higher temperatures.

Changing conditions in the ecosystem will also affect reindeer husbandry, which will suffer if lichens become less common in the mountains as the slopes are colonised by bushes, and sparse submontane woodlands become denser.

In addition to effects on biological systems, hydrological processes will change. Ground freezing will be affected; in some areas the ground will freeze to greater depths if the protective winter snow cover is thinner. Frozen ground may be less widespread in some areas where the snow cover comes later. The presence of water in soil affects physical soil processes in mountainous areas. Lengthy periods with temperatures above zero degree celsius and more precipitation may cause more landslip and more serious landslides.

Overall, mountainous regions like those in Sweden are highly sensitive and vulnerable to climate change. Several ecosystems such as the alpine-subarctic zone are in danger of disappearing altogether.

5.3 Adjustment measures

A review of the design flow rates in rivers feeding all major Swedish hydropower dams has been under way since 1990 in line with new guidelines produced by the Committee for Design Flood Determination and the regulations published by the hydropower industry itself (RIDAS). Several installations have been modified and further upgrading is planned.

The principal aim is to ensure dam safety under current climate conditions. We do not yet have sufficiently reliable data to incorporate the effects of global warming in this planning.

However, where possible without incurring too much additional expense, safety margins are sometime increased because of the doubts as to design specifications created by climate change.

There are few other examples of specific action being taken to achieve adjustment. Until adjustment has taken place, the best possible systems will be needed during the period ofadjustment to eliminate and monitor risks and react in the event of emergencies.

5.3.1 Necessary research and development

Research and development is needed to produce more quantitative assessments of vulnerability to climate change and to decide what form adjustment measures should take.

Important areas are:

Development of models and climate scenarios to study extremes in relation to changes in mean values.

- We need to know more about how to interpret large-scale calculation results simulated using global models so as to be able to apply them at regional level.
- Improved integration (eg, interlinking) between various models describing meteorology, hydrology, oceanography and ecosystems.
- Longer data series (30 years) to identify situations occurring rarely (low frequency), eg, violent storms or heavy precipitation.
- Better quantitative assessment of sources of error and uncertainty.
- Research to provide data for impact studies in other areas and sectors (agriculture, forestry, ecosystems, social structure, coastal zones etc).

Studies on the basis of climate scenarios of impacts on all sectors sensitive to climate are also important. Some areas of importance are:

- Agriculture and forestry, fisheries, reindeer husbandry.
- Hydrological processes, soil and groundwater conditions and their importance to landslip and erosion.
- Limnic, marine and terrestrial ecosystems, the initial focus being on important processes, indicative and unique species and habitats, also taking account of other factors affecting these ecosystems.
- Sweden is in a unique position to study epidemiology in relation to a climate gradient. These studies can constitute an important link in assessing the impact of future global climate change on human health.

Studies to formulate strategies for adjusting to climate change. Examples of key areas where adjustment will be needed are:

- Basic knowledge of dynamic processes in ecosystems.
- Ways in which account can be taken now of future changes in conditions affecting the construction of infrastructure with a long lifespan (eg, roads, bridges, water supply and sewage systems, dams, power lines). There is some information about the effects of climate on infrastructure. It ought to be possible to use this more consistently when making risk assessments for infrastructure investments.
- Methods of conserving environmental assets (the mountain, forest and agricultural andscape, coastal zones) and biodiversity by creating and safeguarding migration corridors and micro-environments, which will enable ecosystems to withstand climate change better.

References and literature

Epstein PR. Climate and Health. Science 1999;285:347-48.

Jaenson TGT. Myggburna infektioners ekologi i Fennoskandinavien – en översikt ("The ecology of mosquito-borne infections in Fenno-Scandinavia – an overview") . Läkartidningen 1988;85:2255-58.

Jendritsky G et al. Atmospheric heat exchange of the human being, bioclimatic assessments, mortality and heat stress. Int J Circumpolar Health, i tryck.

Kasimir-Klemedtsson, Å. & Lilliesköld, M.(Red.) Växthusgasflöden från myrar och organogena jordar ("Greenhouse gas flows from bogs and organic soils"). Swedish Environmental Protection Agency Report 5132. Swedish Environmental Protection Agency publications. Stockholm, 2001.

Kriz B et al. Monitoring of the epidemiological situation in flooded areas of the Czech Republic in year 1997. Conference Proceedings May 1998 Podebrady.

Kuhn KG. Global warming and leishmaniasis in Italy. Bull trop Med Internat Health. 1997;7:1–2.

Lindgren E et al. Impacts of climatic change on the northern latitude limits and population density of the disease-transmitting European tick, I. ricinus. Environ Health Perspect 2000;108:119-23.

Lilliesköld, M. (Red.) Effects of climate change in Sweden : 2021 Swedish Environmental Protection Agency Report 4583. Swedish Environmental Protection Agency publications. Stockholm, 1996.

Lindgren E, Gustafson G. Are recent increases in the incidence of tick-borne encephalitis in Sweden caused by changes in climate? Lancet 2001;358:16-18.

Martens et al. Sensitivity of malaria, schistosomiasis and dengue to global warming. Climate Change 1997;35:145-56.

McCarthy, J. Canziani, O., Leary, N., Dokken, D. and White, K. (Eds.) Climate Change 2001: Impacts, Adaptation & Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, UK, 2001.

Parry, M. (Eds.) Assessment of Potential Effects and Adaptations for Climate Change in Europe: The

Europe ACACIA Projekt. Jackson Environment Institute, University of East Anglia, Norwich, UK, 2000.

Patz J et al. The potential health impacts of climate variability and change for the United States: Executive summary of the report of the health sector of the US national assessment. Environ Health Perspect 2000;108:367-76

Rose JB et al. Climate and waterborne outbreaks in the US: a preliminary descriptive analysis. J Am Water Works Assoc. 2000;92:77-86.

Rummukainen, M., et al. SWECLIM – The first three years. Reports Meteorology and Climatology No. 94. Swedish Meteorological and Hydrological Institute, Norrköping, Sweden, 2000.

Sigvald, R., et al. Jordbrukets känslighet och sårbarhet för klimatförändringar. ("Analysis of the sensitivity and vulnerability of agriculture to climate change"). Swedish EPA Report 5167. Swedish EPA, 2001.

Sonesson, M. & Lilliesköld, M. (Red.) Fjällens ekosystem i ett förändrat klimat ("Montane ecosystems in a new climate"). Swedish Environmental Protection Agency Report 5085. Swedish Environmental Protection Agency publications, Stockholm, 2000.

Sykes, M.T. & Prentice, I. C. Modelling the effects of climate change on Swedish forests. Swedish Environmental Protection Agency rapport 5029. Swedish Environmental Protection Agency förlag, Stockholm, 2000.

Ziska LH, Caulfield FA. Rising Co2 and pollen production of common ragweed, a known allergy-inducing species: implications for public health. Austr J Plant Physiol 2000: 27.

Workshops om klimatfrågor inför national rapporten ("Climate workshops in preparation of NC3") Swedish EPA Report 5171, Swedish EPA, 2001

6 Financial support and technology transfer

Financial support and transfer of technology to developing countries in the form of aid or development assistance, is an important aspect of international progress in the climate´field. Swedish development assistance aims to create the conditions for sustainable development, which will alleviate poverty in developing countries and help to achieve peace, democracy and sustainable use of natural resources. The Swedish parliament has laid down six main objectives for development assistance. One of these is to contribute to far-sighted conservation of natural resources and environmental protection.

Compared with other OECD countries, Sweden spends a high proportion of its gross national income (GNI) on development assistance. Sweden is also in the "Top 10" in absolute terms. Between 1997 and 2000, Sweden devoted just over 0.7 per cent of GNI to development assistance each year. About two-thirds of Swedish bilateral development assistance is channelled via Sida, the Swedish International Development Cooperation Agency. Table 6.1 shows the Swedish budget for development assistance administered by Sida and other bodies, including the Cabinet Office. Swedish aid will increase over the next few years, in relative as well as absolute terms. The aim is that aid in 2003 should represent 0.81 per cent of GNI, which is forecast to be approximately SEK 13 billion.

6.1 New and additional support

Swedish development assistance is long term; much of it takes the form of programmes for individual countries. It is therefore difficult to draw a clear distinction between new and ongoing support. A parliamentary decision was taken in the late 1980s to add a further objective of development assistance (the environmental objective), and to allocate funds in the form of a "Special Environmental Appropriation". These funds have been used to supplement other development assistance and to carry out environmental projects of strategic importance, such as methods development and trial and pilot projects. The appropriation is primarily used for bilateral assistance, but also for multilateral support to achieve the objectives laid down at the United Nations Conference on Environment and Development (UNCED).

Most new and additional Swedish support is provided via the Global Environment Facility (GEF).

[1] Exchange rates:
1997: USD 1 = SEK 7.6346
1998: USD 1 = SEK 7.9471
1999: USD 1 = SEK 8.2623
2000: USD 1 = SEK 9.1606

Table 6.1
Sweden's government-funded development assistance, in total and as a percentage of GNI, also the "Special Environmental Appropriation"

	Total 1997	Total 1998	Total 1999	Forecast 2000
Total development assistance (SEK millions[1])	13,212	12,518	13,495	12,487
Development assistance as a percentage of GDP	0.79%	0.72%	0.70%	0.72%
Special Environmental Appropriation (SEK millions)	174	205	160	210

Source: Sida

Table 6.2
Swedish financial contributions to the Global Environment Facility (GEF)

	Financial contributions (SEK millions)			
	1998	1999	2000	2001
Global Environment Facility (commitment):	448			

Source: Sida

6.2 Support for developing countries particularly sensitive to climate change

Swedish development assistance generally concentrates on combating poverty. Most of Sida's "programme countries" have a low or very low GDP per capita. Many are among the least developed countries and, in addition to poverty, are struggling under a heavy debt burden. This makes it even more difficult for them to finance measures to reduce emissions, increase removal of greenhouse gases and take steps to adjust to climate change.

Table 6.3 shows Swedish support given to least developed countries (USD millions) and as a percentage of all development assistance and of GNI in 1998 and 1999. Swedish development assistance is fairly sizeable in comparison with other countries belonging to the OECD Development Assistance Committee.[2]

Sweden has long supported efforts to improve conditions in drought-affected areas of southern Africa, in the fields of sustainable agriculture and forestry and sustainable use of water resources. These projects mainly focus on the objectives of the "Deserts Convention" but also aim to assist adjustment to climate change. Similar work is also being done in India.

6.3 Financial support

6.3.1 Multilateral support

International organisations have increasingly contributed to the creation of various systems and methods for achieving sustainable development, particularly during and after the UN environment summit in Rio de Janeiro in 1992 (UNCED). By using their own networks and with the help of their partners, they also help to disseminate and improve knowledge of these methods.

Approximately one third of Swedish development assistance is channelled via multilateral organisations. Contributions are given in the form of regular payments and as support for specific projects or programmes. Funding supplied to multilateral institutions totalled SEK 13.184 billion between 1997 and 1999. Sweden is making a total contribution of SEK 448 million to the GEF between 1998 and 2001. Funding is also given to the UN Development Programme for general purposes, for specific projects and to support its efforts to implement environmental management systems. Table 6.4 summarises multilateral development assistance going via international institutions. Sweden is also working actively to fulfil the objectives set at the Rio conference on environment and development (UNCED) in 1992, and is also working on standardisation issues with a number of international organisations and fora in the field of multilateral development assistance.

Sweden also makes contributions via Sida to the International Union for the Conservation of Nature (IUCN), the World Resources Institute (WRI) and the International Institute for Environment and Development (IIED). The main purpose of this funding has been to enable these institutions to make an active contribution to inter-sectoral know-how development, and, secondly, to enable Sida to establish a greater dialogue on these issues so that it will eventually be possible to integrate this know-how in bilateral projects and programmes.

Sweden is also funding a number of of international research institutions in the agricultural and forestry sectors. These include the Consultative Group for International Agricultural Research (CGIAR), the International Council for Research in Agroforestry (ICRAF) and the Center for International Forestry Research (CIFOR). The areas bearing a relation to the climate issue are research and further education in the fields of of biodiversity, livestock production, land management, forest ecosystems and food crops.

[2] OECD DAC: Organisation for Economic Co-operation and Development, Development Assistance Committee

Table 6.3 Total financial support for least developed countries in total per year and as a percentage of GNI, according to DAC

Net payments	1998 USD millions	% of donor's total	% of donor's GNI	1999 USD millions	% of donor's total	% of donor's GNI
Sweden	446	28	0.20	407	25	0.17
Total, DAC countries	10,770	21	0.05	10,650	19	0.05
including EU member states	6,607	24	0.08	5,420	20	0.06

Source: Sida

Table 6.4
Financial support supplied to multilateral institutions and programmes

	Financial support[7] (SEK millions) 1997	1998	1999
Multilateral institutions			
1. World Bank	966	1,000	865
2. International Finance Corporation	0	18	0
3. African Development Bank	0	0	0
3b African Development Fund	224	278	143
4. Asian Development Bank	115	180	188
5. European Bank for Reconstruction and Development	20	55	57
5b Via the European Union	707	707	741
5c European Development Fund	0	60	0
6. Inter-American Development Bank	17	15	12
7. United Nations Development Programme	460	474	490
- specific programmes	261	235	262
8. United Nations Environment Programme	20	20	20
- specific programmes and funds	28	34	28
9. UNFCCC	0.8	1.0	1.0
- Supplementary Fund	0.2	0.2	0.3
- Trust fund for participation	0.2	0.6	0.5
10. Other (WFP, IFAD, UNCTAD, et al.)	1,427	1,496	1,556
Total, Multilateral institutions	***4,245***	***4,574***	***4,365***
Other multilateral research, technology and occupational training programmes (some examples):			
1. Consultative Group for International Agricultural Research (CGIAR)*	42	43	66
2. International Union for the Conservation of Nature (IUCN)**	30	30	30
3. World Bank Environment Fund	10	2	4
4. World Resources Institute (WRI)	2	2	8
5. UNEP-CEP	2	0	2
6. Global International Water Assessment (GIWA)	0	0	3
* Non-tied support to the organisations; targeted support of SEK 5 – 15 million per year has also been paid.			
** NB: SEK 15 million of 30 million for 1999 was not paid out until 2000 due to the cap on public spending. A total of SEK 45 million was paid out in 2000.			
Total (examples of support for multilateral programmes, not exhaustive):	***86***	***77***	***112***

Source: Sida

6.3.2 Bilateral development assistance

Sida supports projects in almost 120 countries, including those in central and eastern Europe. Most of these resources go to the twenty or so countries with which Sida is engaged in long-term in-depth cooperation. Its efforts are based on the development projects the recipients themselves wish to implement and on which they are prepared to devote resources. Sida's role is primarily to supply competence and capital. This is provided via a network of some 1,500 partners including companies, popular movements, public authorities, colleges and universities. Some 300 Swedish NGOs receive government funding for development assistance projects each year.

Environmental issues are an important and integral part of Swedish foreign aid. Sida's sustainable development programme, entitled Omsorg om miljön[3] ("Caring for the Environment"), comprises a policy and an action plan. The programme describes the objectives of operations, approach, important principles, working methods and priority areas. Without the environmental dimension, development assistance will not contribute to sustainable development. Another key principle is to make environmental impact assessments of all Sida projects. The methods particularly emphasised are skills development and interaction between the state, municipality, NGOs and the private sector.

Swedish cooperation on the environment gives priority to the following sectors.

- Sustainable agriculture, forestry and land management
- Marine environment
- Urban environment
- Sustainable energy
- Water resources

Since 1998 all Swedish projects have been classified in accordance with the OECD DAC system for classifying the environmental relevance of projects. Table 6.5 shows the proportion of environmentally-related projects in which Sida was involved between 1998 and 2000. Environmentally-related projects have increased in absolute terms, although the proportion has remained constant at about 50 per cent.

A study was made in 1998[4] to identify and analyse the links between the Climate Convention and Sida's operations. The study describes the contents of the Climate Convention and objectives from Sida's perspective and also describes the ways in which Sida's operations relate to the convention. The study concluded that the content of several projects is an indirect result of, or is linked to, the Climate Convention, and that many aspects of operations are important from a climate viewpoint. However, only a limited number of projects make direct reference to the convention.

The tables in Appendix 5 include all projects linked to the convention. The figures shown represent total project funding, not only the portion relating to the objectives of Climate Convention.

6.3.3 Measures to reduce emissions and increase removals of greenhouse gases

Via Sida, Sweden funds projects in various sectors of importance for the reduction of greenhouse gas emissions and for increasing or maintaining carbon dioxide sinks in forests and soil. Efforts are primarily being made in the fields of energy, transport, industry, forestry and agriculture. Most of these projects do not have emission reductions as their main aim. In some areas, such as energy and transport, they are often included as a secondary aim or an integral part of activities. In others, eg, land management, forestry and agriculture, no mention is usually made of the project's contribution to reducing climate change. Several projects can nonetheless be considered to do so, eg, by increasing

[3] Omsorg om miljön ("Caring about the environment"), Sida 1998
[4] Sida and the Climate Convention, Sida 1998

Table 6.5
Sida's development assistance and environmentally-related projects

Environ. classification – all Sida	1998		1999		2000	
(SEK millions)	Contribution	%	Result	%	Result	%
Primary environmental objective	1,134	15%	1,201	14%	1,226	12%
Subsidiary environmental objective	2,618	35%	2,830	33%	3,754	37%
Environment not relevant	3,652	49%	4,448	52%	5,287	51%
Total	7,404	100%	8,479	100%	10,267	100%

Source: Sida

biological production and hence carbon sequestration, or indirectly by promoting an holistic approach to conservation of resources and long-term sustainable development.

Energy

Sweden also supports measures intended to promote more sustainable energy sources and a transition to sustainable development. Some of this support takes the form of loans and credits. Direct action in the energy field taking place in cooperation with the Baltic States, such as the pilot phase of joint implementation, is described in the chapter on Objectives and Measures. Other support in the form of development assistance is described below.

Swedish development assistance in the energy sector is designed to improve the energy situation for the great majority of the world's population who do not have access to safe and efficient energy at present. Another important objective is to help in the development of efficient and sustainable energy systems. Assistance is designed on the basis of Sida's policy on aid for sustainable energy. An important principle is to encourage economically and environmentally sound energy systems.[5]

Sida's activities in the field include developing bodies of regulations, skills, energy efficiency and promoting new sustainable energy sources, such as solar energy and wind power. For example, support is given to the African Energy Policy Network (AFREPREN), from which several projects have received funding in areas such as energy efficiency, alternative energy sources and development of policies for reducing greenhouse gas emissions, among other things.

Sida supports two research networks in Asia: the Asian Regional Research Programme in Energy/Environment and Climate (ARRPEEC), and Renewable Energy Technologies in Asia (RETsAsia). Research under the auspices of ARRPEEC is intended to develop scenarios, strategies and policies for reducing emissions of greenhouse gases and other air pollutants by improved energy efficiency and substitution of fossil fuels. The areas covered are transport, electricity generation, industry and biomass. Bangladesh, the Philippines, China, India, Indonesia, Malaysia, Sri Lanka, Thailand and Vietnam are involved in the programme.

The RETsAsia programme is intended to promote the use of sustainable renewable energy technology. The areas of research comprise solar cell systems for household use and small transformer stations, drying of agricultural products (solar heat and biomass fuel), manufacture of briquettes from agricultural residues and development of cookers. Institutions in Bangladesh, Cambodia, Laos, Nepal, the Philippines and Vietnam are participating.

Sida also supplies funding for increased dissemination of information in the field of renewable energy via the Stockholm Environment Institute (SEI). This includes funding for the SEI library, publication of newsletters, seminars and visits to developing countries by experts working in the field of renewable energy.

One way of promoting environmental awareness in the energy sector is to set up environment units at electricity companies. One such unit was established several years ago at the Zambia national electricity company (ZESCO), with the help of Swedish funding.

The first stage was to fund a technical adviser and some equipment for the unit. Phase two focused on integrating the work done by the environment unit with all operations at ZESCO, developing environmental impact assessment skills and improving environmental monitoring and inspection of existing energy plants. Following completion of the final phase (in 2000) the unit was considered to be working well and could serve as an example to other electricity companies in the region.

A project funded by the World Bank and Sida is in progress in Vietnam. It aims to improve efficiency and even out loads occurring in the national energy system. Rural electrification programmes are in progress in a number of countries receiving development assistance from Sida. Renewable energy production, particularly in the form of wind and solar power, constitutes a key element in these programmes. A study of solar and wind conditions for future investment in renewable energy is being conducted in Eritrea. A pilot project to find a model for rural electrification based on solar panels is under way in Zambia.

Funding provided by Sida for energy projects relating to the Climate Convention totalled SEK 1.007 billion between 1997 and 2000. This figure comprises aid and credits.

Transport

The rapid increase in road traffic in many developing countries accounts for a large proportion of those countries' rising emissions of greenhouse gases. Sida gives support for intercity and urban transport.

Assistance in the field of urban transport is based on guidelines adopted in 1999.[6] The overall aim is to help to develop efficient and sustainable urban transport systems that promote economic and social development, improve the environment and reduce the hazards to human life and health.

[5] Policy för miljöanpassat energibistånd ("A policy for sustainable energy assistance"), Sida 1996

[6] Urban transport in Swedish development cooperation. Published by Sida, 1999

The priority areas are:
- reduced environmental impact and better land use, particularly by means of urban and transport planning, public transport, non-motorised transport, traffic safety and environmental monitoring;
- reduction of transport needs, eg, by improving public transport and city planning;
- traffic planning programmes to improve efficiency, reduce emissions and improve safety;
- and regulation and monitoring of fuels, vehicles and emissions to reduce harmful emissions.

Projects designed to improve public transport have been carried out in countries like Bangladesh, Chile, India, Jamaica and South Africa. An international course entitled "Environment and Public Transport Management" is arranged annually in Sweden by the Swedish Road and Transport Research Institute.

Funding for sectoral reform is an important area. Reform of this kind in Namibia involved raising fuel prices. This will probably reduce fuel consumption.

The feasibility of producing and using biomass motor fuels in African countries has also been studied more generally. The aim is to stimulate interest in using ethanol as a motor fuel instead of fossil fuels, and to thereby help to reduce carbon dioxide emissions.

Another example is funding for restructuring Zambia Railways Ltd with a view to improving and rationalising that company's operation.

Swedish government funding for transport sector projects in developing countries directly or indirectly designed to reduce greenhouse gas emissions totalled SEK 76.36 million between 1997 and 2000.

Forests

The overall aim of development assistance in the field of forestry is to increase the contribution made by that sector to economic, social and ecologically sustainable development for people in less developped countries. Sustainable forestry improves human welfare by the products it supplies and the jobs it provides in the wood and pulp processing industries. Sustainable forestry also involves safeguarding the various ecological functions of forests, such as its role as a carbon dioxide sink.

Swedish development assistance for forestry has been increasingly integrated with agriculture and land management, which requires broad conservation programmes. The operational focus is influenced by international conventions and the "forest principles", as they are called. It is seldom explicitly stated that projects are intended to reduce the impact on climate, although several programmes are in fact increasing carbon removal and, in some cases, also aiding adjustment to climate change by focusing on sustainable development. The main forest programmes are in progress in Vietnam, Laos, India, Ethiopia, Tanzania, Bolivia and Nicaragua. Sustainable forestry and development of an efficient forest products industry are being supported in Bolivia. As a result, Bolivia is now one of the world's foremost producers of products from certified natural forests. One project receiving support in India is a programme designed to transfer responsibility for forest and land management to the local population.

An international course entitled "Development of National Forest Policies and Strategies", which is run each year by the National Board of Forestry, deals with the importance of forests from a climate viewpoint.

The projects included in the summary of support for the forest sector are mainly those involving extensive planting of trees, regeneration or projects to save forest under threat of destruction.

Funding totalled SEK 136.53 million during 1997 – 2000.

Agriculture

At the same time as growing populations in Africa and Asia demand increased food production, climate change is expected to cause a deterioration in conditions for cultivation in a number of areas that are already severely affected.

Swedish development assistance supplied as part of the agricultural programmes is based on the aim of increasing productivity using sustainable methods. Increased biological production increases carbon dioxide removal. Important areas are integrated systems for sustainable agriculture, combined agriculture and forestry, land management, biodiversity in agriculture ("agrobiodiversity") and plant genetics.

Funding for climate-related projects in the agricultural sector totalled SEK 287.18 million during 1997 – 2000. Many of these projects involve lowering greenhouse gas emissions, promoting carbon sinks and adjustment to climate change.

Waste management

Swedish assistance in the field of waste comprises projects to produce biogas from solid waste and improved waste management and processing. An international course entitled "Solid Waste Management" has been run each year. The course is intended for officials at national and local public authorities in developing countries who are responsible for environmental protection and waste management, central and local administrators in the waste sector and teachers of waste management. The aim of the course is to improve efficiency, professional skills and solid waste management capacity in developing countries.

Swedish government funding for waste management intended to reduce methane emissions totalled SEK 42.07 million between 1997 and 2000.

Trade and industry

Sida's operations in the field of trade and industry are intended to create favourable business conditions in recipient countries and to make it easier for enterprises to break into the global market. Environmentally-related projects are in progress in all operational areas to varying degrees. Examples include development of institutional frameworks, skills development, alliances between enterprises and promotion of trade. Projects include supporting the introduction of environmental management systems, energy efficiency, environmental education and training, and sustainable production. A series of international courses are arranged in the field, including Energy Conservation in Industry (ISO 14000).

An action plan[7] on trade and the environment was completed in 1998. It focuses on four areas:

- strengthening negotiating capacity in developing countries;
- improving environmental awareness – sustainable consumption
- institutional infrastructure for sustainable production and eco-labelled products;
- and sustainable technology.

Examples of projects in trade and industry include support for the creation and development of environmental units at Bolivian chambers of commerce for the purpose of giving advice on environmental improvements in industry. A project is under way in Vietnam to reduce emissions from industrial companies in Ho Chi Minh City. Support for consumer interests has also been given in several countries, so as to put pressure on industry to produce more environmentally compatible products.

Funding for Swedish development assistance in this area totalled SEK 160.94 million between 1997 and 2000.

Efforts to combat air pollution and other projects to reduce emissions of greenhouse gases

Some Swedish development assistance that is wholly or partly intended to reduce emissions of greenhouse gases involves several sectors and is therefore difficult to categorise under any single one of the five sectors included in this account. This applies to efforts being made at policy level to improve air quality and capacity building and research on environmental economics, for example. Work of this kind is therefore described under a separate heading in the tables in Appendix 5 under "Air quality/other".

Examples of projects to improve air quality are Swedish funding channelled via the Stockholm Environment Institute (SEI) for development programmes for Regional Air Pollution in Developing Countries, which mainly relate to the situation in Asia. In India Sweden supports the Centre for Science and Environment (CSE), which is attempting to reduce air pollution in Delhi.

Another example is funding for the publication of a magazine called "Tiempo", which deals with issues on climate change and is mainly intended for scientists and others working in the climate field, particularly in the developing world. Tiempo has been published by the International Institute for Environment and Development (IIED) each quarter since 1991.

The periodical also has a very detailed homepage: **http://www.cru.uea.ac.uk/tiempo.**

Sweden also provides part-funding for the Economy and Environment Program for Southeast Asia (EEPSEA). This is a regional research network that aims to improve research into economic aspects of environmental change. In 1999 the institute published a report on the direct and indirect economic implications of Indonesian forest fires. The report had a great impact and was used in policy discussions on the environment in South-east Asia. Support is given in the form of technical assistance in the development of air quality monitoring in China, the Philippines and Chile.

6.3.4 Adjustment to climate change

Adjustment to climate change is rarely an explicit aim of Swedish aid. Several projects in the field of water resource management, agriculture, forestry, land management and rural development are designed to achieve sustainable development, and can thus be considered to be indirectly intended to aid adjustment to climate change. Important features are conservation of natural resources, water resource aspects and education, training and research into sustainable cultivation methods and crops adapted to a warmer climate.

Capacity building

Capacity building forms the basis of Swedish foreign aid. The action programme for sustainable development identifies development of recipient countries' ability to cope with their own environmental problems

[7] Trade, Environment and Development Cooperation. Published by Sida, 1998

as one of the most important elements. Capacity building constitutes the main aim in some programme areas, such as institutional development/environmental administration and environmental teaching/education.

The aim of environmental efforts in the administrative field is to support the ability of recipient countries to formulate policies, plan, implement and monitoring achievement of environmental action plans. Priority areas are environmental statistics, green national accounts, environmental economics and environmental impact assessments.

The aim of environmental efforts in the field of teaching, culture and media is to create greater awareness of environmental problems and their solution. In recent years, Sida's teaching unit has made strenuous efforts to integrate and develop the environmental dimension in its work. One result has been a policy and an action programme for environmental education. Priority is given to developing networks and donor coordination.

Sida has allocated funding for the development of environmental education networks in southern Africa; an international course in environmental education was held in spring 2001 in cooperation with these countries.

Capacity building is an important feature of Sida's programmes for conservation of natural resources, water resource management and land management. An important area from a climate viewpoint is education and research into sustainable cultivation methods and crops adapted to a warmer climate.

Swedish funding in this field totalled SEK 923.75 million between 1997 and 2000.

Adaption in coastal zones

A policy document on Sida's support for coastal zones and the marine environment, entitled "Sida's Marine Coastal Zone Initiative", was produced in 1997[8]. Activities in this field focus on:

- sustainable use of aquatic resources and conservation of biodiversity;
- regional coordination, establishment and implementation of legislation on water and the environment; and
- consideration of interplay/impacts in relationships between cities, towns and coastal areas.

Climate change is expected to considerably increase pressure on coastal zones; large areas will end up under water and people will be forced to move. The marine environment will also change, and aquatic resources will be affected by rising sea temperatures. It is essential to devote particular attention to activities concerning, on the one hand, development and use of natural resources and, on the other hand, protection of the marine and coastal environment. Most funding in this area goes to projects in Central America/the Caribbean, East Africa, southern Africa and South-east Asia.

Swedish funding in this field totalled SEK 126.19 million between 1997 and 2000.

Other efforts to reduce vulnerability

Specific vulnerability analyses represent a limited part of Sida's development assistance. On the other hand, action taken to reduce vulnerability, ie, the stage following a vulnerability analysis, constitutes a significant part of development assistance in the field of natural resources. One example is funding given to the Global Water Partnership (GWP), whose head office is at Sida's headquarters in Stockholm. The GWP is a network operating globally, whose overall aim is to further sustainable use of water resources, particular at local and regional level. The projects shown in the "other vulnerability projects" column in the tables in Appendix 5, include specific vulnerability analyses and other efforts directly or indirectly intended to achieve adjustment to climate change. Management of catchment areas ("watershed management"), is one area of importance in the process of adjusting to climate change, since it involves a study of the way physical management of water flows can even them out over the year so that both flooding and drought can be avoided.

6.3.5 Other climate-related activities

Indirectly, projects to achieve sustainable development, eg, local Agenda 21 projects, also play an important part in reducing greenhouse gas emissions and adapting to a warmer climate in the long term.

Development assistance in the climate field is expected to become more important. In 2001 Sida initiated an internal project and strategy development process designed to increase the number of climate-related projects within the scope of development assistance.

6.4 Activities related to technology transfer

Technology transfer is an important part of Swedish development assistance. It is a particularly important element in some of Sida's operational areas, eg, energy and industry.

Operations described under the heading "Efforts to

[8] Marint Kustzons Initiativ ("Marine Coastal Zone Initiative"). Published by Sida, 1997

combat air pollution and other projects to reduce emissions of greenhouse gases" above largely comprise technology transfer.

One way of transferring technology, and also developing capacity, are the international courses attended by participants from developing countries and eastern Europe. Climate-related courses are run on topics such as improving energy efficiency, renewable energy, sustainable transport, industrial environment and waste management. The course entitled "Architecture, Energy & Environment – Tools for Climatic Design" focuses on energy-efficient building design and architecture that does not require air conditioning.

Other examples of technology transfer are "Start Syd" and "Start Öst". Sweden supports joint operations between Swedish companies and companies in developing countries via these programmes. The aim is to initiate productive operations in the recipient country and contribute to effective transfer of skills and know-how.

Sweden is making great efforts to introduce more energy and resource efficient technology nationally, which may also influence the kind of development assistance it is able to offer developing countries.

The Swedish Trade Council and voluntary organisations

In addition to government-funded development assistance administered via Sida, Sweden supplies support via other organisations. This support is often funded partly via government grants, guarantees and loans. However, it is difficult to quantify the amount of this support that is of significance in relation to all climate-related aid. Important organisations involved are voluntary and government-run organisations, such as the Church of Sweden, the Swedish Trade Council and the Swedish Export Credits Guarantee Board.

With the help of government funding (SEK 12 million in 1999), the Swedish Trade Council, whose task is to promote Swedish export, has designed a specific programme for export of goods and services involving the use of environmental technology. This programme ("Export of Swedish Environmental Technology"), has been created to increase the export of environmental technology for applications such as water treatment, waste management, recycling and treatment of emissions to air, all of which have a bearing on climate. An important feature of the programme has been to create a forum where Swedish companies can establish contact with companies and public authorities abroad. A comprehensive homepage has therefore been created on the Internet, which gives access to almost 650 Swedish companies engaged in developing and producing environmental technology.

The task of the Swedish Export Credits Guarantee Board is to promote Swedish export by offering guarantees protecting against the risk of losing money on transactions abroad. Its sphere of operations is global and includes many developing countries (non Annex-I-countries). The Board has an environment policy, with guidelines to ensure that environmental issues are considered when credits are issued. Major projects must have an environmental impact assessment. This environmental policy is intended to promote ecologically sustainable Swedish exports and boost the export of Swedish environmental technology and know-how. The environmental policy has been in place for only a short time and its effects cannot yet be quantified.

Examples of projects for transfer of environmental technology

An outline description is given below of four projects/ programmes to promote measures to facilitate and/or fund the transfer of, or access to, environmental technology.

Table 6.6
Sugarcane resources for sustainable development: a case study in Luena, Zambia

Project/programme title: Sugarcane resources for sustainable development: a case study in Luena, Zambia

Purpose:

To examine the feasibility of establishing a new sugar cane and/or ethanol factory in an underdeveloped region of Zambia, the focus being on sustainable development.

Recipient country	Sector	Total funding	Number of years
Zambia	Energy/transport	SEK 2.2 million	2

Description:
The study shows that there are many relevant scenarios having a positive effect on the environment and the Zambian economy (particularly in terms of saving foreign currency). Ethanol and co-generation from biomass fuels (based on a plant called bagasse) offers environmentally compatible resources that can be used as a tool of sustainable development. But sizeable investment is required and implementation is complicated, so effective cooperation between various state agencies and between the government and the private sector will be needed.

State factors contributing to the successes of the project:
Funding is the most important factor, although trends in the market for sugar, ethanol and electricity also have a bearing. The study itself was innovative in that it integrated social, economic, technical and environmental aspects.

Technology transferred:
Combined power and heating and ethanol production

Impact on emissions of greenhouse gases/sinks (voluntary):
Carbon dioxide emissions will be reduced if a new sugar cane and ethanol factory is built and ethanol is substituted for petrol.

Source: Sida

Table 6.7
PAIB – Protección en la Industria Boliviana (Environmental protection in Bolivian industry)

Project/programme title:
PAIB – Protección en la Industria Boliviana (Environmental protection in Bolivian industry)

Purpose:
National programme for theoretical and practical training in industrial environmental protection.
Practical training at a number of key factories, which are thus able to benefit from its results.

Recipient country	Sector	Total funding	Number of years
Bolivia	Industrial environment	SEK 14.3 million (PAIB+F)	1998 – 2001

Description:
The training programme was conducted in two phases in Bolivia's four largest cities: La Paz, Santa Cruz, Cochabamba and Oruro. 13 trainers were trained in the first phase. They then helped to carry out the main training programme involving a total of 120 people in the four cities.

As part of their training, participants performed tasks in the field of environmental auditing, supervision and environmental protection, and environmental management systems at a total of 15 key factories in various sectors.

A supplementary project entitled "PAIB-F" was conducted between September 2000 and April 2001. 25 PAIB participants received further practical training at five additional factories so as to gain the necessary experience to begin working as independent environmental consultants.

State factors contributing to the successes of the project:
Practical application of theoretical studies. This has twin advantages: (i) participants gain practical experience of environmental protection in industry; (ii) the key factories participating can derive benefit from the results of the practical exercises.

Technology transferred:
Environmental auditing methods, gas and water monitoring technology, environmental protection in industry, use of environmental management systems and risk analysis.

Impact on emissions of greenhouse gases/sinks (voluntary):
Only indirect impact as a result of improved combustion technology at some key plants, and an interest shown at some factories in replanting forest in the surrounding area to improve their environmental image.

Source: Sida

Table 6.8
Solar cells pilot project

Project/programme title:

Providing electricity services using photovoltaic solar systems through energy service companies in rural areas of Zambia

Purpose:
To supply 400 rural households with an ecologically sustainable energy source in areas not on the national grid.

Recipient country	Sector	Total funding	Number of years
Zambia	Energy	SEK 4.8 million	1998 – 2000 (2 years)

Description:
Photovoltaic panels are an alternative way of supplying rural areas not on the national grid with electricity. The problem is not the technology; it is methods and systems enabling users to afford the equipment and have it maintained. This project is testing a method where users rent the panels.

State factors contributing to the successes of the project:
Many people living in rural areas cannot afford to invest in photovoltaic panels. Instead, the project is trying out a system of renting panels to local inhabitants.

Technology transferred:
Developing methods of supplying photovoltaic panels to rural areas.

Impact on emissions of greenhouse gases/sinks (voluntary):
The areas involved had no electricity supply before the project began. The project may help to avoid future electrification based on fossil fuels.

Source: Sida

Table 6.9
Environmental Protection Training and Research Institute (EPTRI), Hyderabad, India

Project/programme title:
Environmental Protection Training and Research Institute (EPTRI), Hyderabad, India

Purpose:
Overall aim: To increase knowledge and awareness of environmental issues in Indian industry by training and consultation.
Aim of project: To establish the EPTRI as a leading and self-supporting industrial environmental protection institution in india by offering training and consultancy services in demand in the market.

Recipient country	Sector	Total funding	Number of years
India	Industrial environment	SEK 15 million	1997 – 2001 (4 years)

Description:
The following areas are to be developed during the project with the help of Swedish know-how:

1. An information centre
2. A laboratory for physical, chemical and microbiological tests
3. Business skills
4. Know-how for certification under ISO 14 001
5. The ability to manage hazardous waste
6. The ability to survey environmental profiles to locate hazardous industrial plants using the GIS method
7. Proper planning and financial accounting and control systems

Swedish assistance includes a certain amount of equipment.

State factors contributing to the successes of the project:
To some extent, know-how has been transferred by Swedish consultants working together with EPTRI staff in joint projects, ie, commercial projects. This has enable EPTRI to become more businesslike in its consulting capacity.

Technology transferred:
See above.

Impact on emissions of greenhouse gases/sinks (voluntary):
No information available.

Source: Sida

7 Research and systematic observation

7.1 Overall objectives of research and systematic observation

The aim of Swedish research policy is that Sweden should be a leading research nation.

Important areas are environment and sustainable development, in which climate is one of the central elements. Both these research areas require long and quality-assured observations. The systematic observations of climate variables and the state of the environment form the basis for research into climate processes and the impact of climate on ecosystems. In the same way, systematic observation of central societal activities is the foundation for research into impacts on societal systems and is used to produce material on which to base measures of various kinds. Several of the important projects presented below contain elements both of research and of systematic observation.

A key field of research is technological development to improve energy efficiency and develop energy systems based on renewable natural resources. This research and development has received increasing support in Sweden over the past decade.

7.1.1 Research and development

Swedish research policy

Sweden conducts approximately one per cent of global research and development. For several years in succession, Sweden has been the country spending the greatest proportion of its GDP on research. Research funding totalled almost 4 per cent of GDP in 1999, ie, SEK 75.8 billion. Most funding comes from trade and industry, which accounts for 68 per cent of funding. The public sectors provides about 26 per cent. The remainder comes from private research funds and foundations, as well as foreign financiers. The major foreign financiers are companies, although contributions under the EU framework programme for research and development also represent a significant source of funding.[1]

The basic principles governing Swedish research policy and the role of the state were laid down by parliament in 1999 when debating the bill entitled "Certain Research Issues"[2]. The aim of government research policy is that Sweden should be a leading research nation.

Achieving this will require further strenuous efforts and sizeable investment by the government as well as trade and industry. The Research and Renewal Bill[3] emphasises that knowledge is the foundation stone of modern society and that research shares society's democratic ideals and fundamental values. Government policy is designed to reinvigorate Sweden and pave the way for "the know-how society".

Swedish research on transboundary and global environmental issues has been given high priority and maintains high quality, which will enable Sweden to press for action and take initiatives in these areas. This research comprises basic scientific research as well as technological and socio-economic research to influence developments and limit environmental impacts. In other words, it has breadth as well as depth. One of the most obvious transboundary environmental issues is the threat of climate change engendered by man's activities.

The research system

Climate-related research takes place in the form of basic research and also in the form of applied research and research on remedial measures. Swedish research has been funded from a large number of mutually independent sources during the period 1997 – 2001. In addition to departmental funding made available for basic research by universities and colleges, this kind of research, most of which is conducted at universities and colleges, receives funding from research councils. Sectoral authorities fund a large proportion of research and development in specific areas, the main sources being the National Energy Administration. The main foundation providing funding for climate research is the Foundation for Strategic Environmental Research (MISTRA). At Sida (the Swedish International Development Cooperation Agency), which is responsible for Swedish foreign aid, there is a research body known as SAREC, which supports competence development projects and development of environmental monitoring in developing countries. In addition to government research councils, foundations and public authorities, private research funds

[1] Statistics Sweden

[2] Gov. Bill 1998/99:94

[3] Gov. Bill 2000/2001:3

and foundations also provide funding for research on climate. The Royal Swedish Academy of Sciences provides funding for logistics for polar expeditions, many of which have a climate dimension. The Wallenberg Foundation has helped to fund a station on the island of Svalbard for monitoring atmospheric gases and particles. In addition to these Swedish sources of funding, the EU provides a great deal of funding for Swedish research taking place via participation in EU projects.

Coordination

Since Swedish research has had many sources of funding over the last 15 years, coordination has been achieved by the financiers dividing responsibility for research among themselves every three years. This joint approach has been described in a strategy document entitled "Research and development for a better environment". The most recent document (1998:13) was produced as a sub-project in connection with a government- initiated study entitled "Research to support sustainable development" (1998:21). The seven topic areas identified include a certain amount of basic research, but focus on applied research and research on remedial measures. Climate-related research is included in all topic areas from the perspective of sustainability, but is not treated as a separate area.

Swedish research has been organised differently since 1 January 2001. The aim is to concentrate resources on important scientific areas, promote cooperation between research fields and improve the dissemination of information about research and its findings. The new organisation of Swedish research and development, in which a number of funding bodies have been amalgamated, will help to improve coordination of research programme design and funding. In the field of climate research, FORMAS, the newly-established Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, is responsible for coordination. The National Energy Administration has the task of coordinating research and development relating to remedial measures in the field of energy.

On the international plane, scientific research on global climate change is coordinated via two international programmes: the International Geosphere-Biosphere Programme (IGBP) and the World Climate Research Programme (WCRP). The IGBP is mainly concerned with geological, biological and chemical processes, whereas the WCRP focuses on physical processes related to climate change. In Sweden this research is coordinated via the Swedish National Committee for IGBP/WCRP at the Royal Swedish Academy of Sciences. The international secretariat for the IGBP is also based at the academy.

Research bodies

Government-funded research is primarily conducted at universities and colleges. Some research is carried out at public authorities and independent research institutions, funded wholly or partly by the government.

The Swedish Meteorological and Hydrological Institute (SMHI) funds research and also carries out research itself. Its research unit is divided into four sections: Meteorological analysis and forecasting, Atmospheric research, Oceanography and Hydrology. Research on environmental problems spans all disciplines. The Rossby Centre is a separate research unit specialising in regional climate modelling, and belongs to the SWECLIM programme.

The Environmental Research Institute (IVL Svenska Miljöinstitutet AB) performs research integrated with application, often funded both by the government and by trade and industry (joint funding). One of its fields is climate analysis. IVL produces data to describe the contribution to the greenhouse effect derived from energy, transport, forestry and agriculture, and also individual companies. Its analyses involve producing emission data for various scenarios and assessing the contributions these emissions make to the greenhouse effect.

The Atmospheric Research Programme (MRI) was established in 1996 with the help of EU and Swedish government funding. MRI is currently running three programmes, all of them more or less climate related: the Climate Impact Research Centre, the Atmospheric Physics Programme and the Spatial Modelling Centre.

7.1.2 Systematic observation

Climate monitoring

Responsibility for systematic observation in Sweden is shared by a number of agencies. The Swedish Environmental Protection Agency has overall responsibility for environmental monitoring; the Swedish Geological Survey is responsible for monitoring of groundwater status. An important part of SMHI's main responsibility for supplying data for planning and decision making in relation to weather-dependent activities is monitoring of climate variables. The Swedish National Space Board is responsible for developing satellite systems for systematic observation and research using remote analytical methods. The National Land Survey is responsible for systematic observation of the land mass.

The Swedish Environmental Protection Agency and coordinated environmental monitoring

The Swedish EPA has overall responsibility for coordinating all environmental monitoring in Sweden. This includes national and regional sub-programmes.

Responsibility for the various sub-programmes is shared by a large number of central and regional authorities. Large quantities of data are also generated by municipalities, non-profit organisations and other activities at county administrative boards. The overall aim of environmental monitoring is to ascertain the extent to which the national environmental quality objectives are being achieved and provide coherent information about the state of the environment.

A further primary aim is to examine the impact on society of phenomena that are significant in relation to sustainable development. A subsidiary objective of environmental monitoring is to monitor achievement of the environmental quality objective termed Reduced climate impact.

More funds have been allocated to monitoring; funding in 2000 for all environmental monitoring totalled SEK 84 million, of which SEK 53 million was spent on national monitoring and SEK 18 on its regional counterpart.

Climate-related environmental monitoring mainly consists of monitoring emissions/concentrations of greenhouse gases, although national forest inventories and forest biotope surveys are important sources of information showing changes in the soil's mor layer, carbon content, tree growth etc. Long-term data series are needed to validate climate models, as a basis for research into impacts and to produce vegetation scenarios.

SMHI

The task of the Swedish Meteorological and Hydrological Institute (SMHI) is to supply meteorological, hydrological and oceanographic data on Sweden and surrounding marine areas. This responsibility includes producing data for society's general needs, for research, education and training, for national and international partners, as well as for commercial processing and operations.

SMHI also has a long-term responsibility for developing and operating the national meteorological, hydrological and oceanographic databases, and acting as an expert body on climate issues.

It has an extensive production of data, products and services, including the gathering and storage of terrestrial and satellite climate observations. Important end products are analyses of status, trends and extremes for climate variables.

SMHI's climate operations follow the guidelines developed by the WMO. Its observation operations are closely linked to its real-time forecasting. Observation operations are developing rapidly, particularly in the field of remote analysis and automation. Efforts are made to maintain long-term continuity, since this is essential to the identification of climatological trends. It should be noted that it is fairly difficult to maintain continuity. It is often difficult to find suitable observers in rural areas and stations must be moved to inhabited areas. On the other hand, development of housing and infrastructure of various kinds in areas of growing population has a great effect on local climate, and thus also on monitoring results.

Table 7.1
Allocation of funds for climate-related environmental monitoring

Year	Total allocated (SEK)
1998	500,000
1999	500,000
2000	650,000
2001	950,000

Source: Environmental Monitoring Board, Swedish Environmental Protection Agency

7.2 Research

A wide range of climate-related research is conducted in Sweden, covering everything from basic scientific research to research on remedial measures. In the interests of increased efficiency, much research is integrated with other issues, particularly other aspects of sustainable development, cost-effective use of renewable energy etc. Responsibility for conducting and managing climate-related research is shared by a large number of actors at universities, colleges, foundations, companies, central agencies (including research councils and administrative authorities). The largest programme is the long-term adjustment programme for energy, which covers research, development and funding the introduction of new technology (see also Chapter 3).

It is no simple matter to draw a line between climate research and other research. The inventory presented here is based on assessments made by funding sources and by project managers and scientists. Research on specific climate issues is conducted in all five research areas, along with research and development of relevance to climate but primarily focusing on other areas such as energy or the environment, eg, research on sustainable development. All climate-related research is presented here, ie, specific climate research and research relevant to climate.

Funding of climate-related research in Sweden during the period 1998 – 2001 (not including the long-term adjustment programme for energy) totalled just over SEK 600 million (see Table 7.2). Research councils, foundations and public authorities provided

Table 7.2
Total funding of climate-related research and development 1998 – 2001, not including the long-term adjustment for energy. SEK millions (figures rounded up or down)

Source of funding	Specific research	Research relevant on climate	Total to climate
EU, foreign funding	30	28	58
University faculties	1.1	3.5	4.7
Research councils	154	141	294
Public authorities	89	139	228
Funding source unknown	0.3	1.1	1.4
Private companies/foundations	1.2	17	18
Total	275	329	604

Source: Swedish Environmental Protection Agency

most of this funding. Funding from EU projects is about SEK 10 million.

Most funding of climate research is provided in the form of government appropriations (including funding from MISTRA – the Foundation for Strategic Environmental Research).

Funding from the EU, private enterprise and foundations, as well as funding supplied by universities themselves, totals approximately SEK 75 million, ie, just over 10 per cent of total funding.

The five main areas of climate-related research are:

- Climate processes and climate systems, including paleo-climatological studies.
- Modelling and projections, including general circulation models.
- Research into the environmental impact of climate change.
- Socio-economic analyses, including analyses both of the impact of climate change and possible remedial measures.
- Research and development of technology capable of reducing emissions and increasing removals of greenhouse gases, and for adjustment.

Funds allocated to the five research areas are shown in Table 7.3. Three of the research areas have a major bearing on climate. The area most closely related to climate is research on climate processes and climate systems, including paleo-climatological studies. Research into the environmental impact of climate change has a pronounced primary climate dimension. A large number of programmes involving study of environmental impacts, relevant to climate, have been included. The research area in receipt of least funding is Socio-economic analyses, including analyses both of the impact of climate change and possible remedial measures, to which only slightly more than SEK 11 million has been allocated during the period.

Table 7.3
Funding of Swedish climate research 1998 – 2001, broken down into fields of research, not including the long-term adjustment for energy. SEK millions (figures rounded up or down)

Source of funding	Specific research	Research relevant on climate	Total to climate
1) Climate processes	97	5.1	103
2) Modelling	72	2.4	74
3) Environmental impacts	89	120	209
4) Socio-economic analyses	8.6	2.3	11
5) Remedial measures/adjustment	59	148	207
Total	326	279	604

Source: Swedish Environmental Protection Agency

7.2.1 Climate processes and climate systems, including paleo-climatological studies

A total of some SEK 100 million has been allocated to research on climate processes and climate systems, including paleo-climatological studies during the period. Research councils, foundations and public authorities fund most of this research, which is primarily climate related. The majority of the research itself is carried out at universities and colleges.

The Baltic Sea Experiment (BALTEX) is an important hydrological-oceanographic- meteorological project, whose geographical area covers the Baltic Sea and its catchments.

The project is intended to describe the role of the Baltic in the interplay between land and sea, since this catchment is a unique area, characterised by complex low pressure activity, which sometimes results in extremely large inflows of water from other parts of the area.

The Baltic is typically brackish, with complex hydrography and highly variable ice conditions. The net outflow of water each year via the Great Belt and Öresund is equivalent to the quantity discharged by the Mississippi river into the Gulf of Mexico. The BRIDGE project has been in progress since 1999. It is an attempt to bridge the gap between the participating disciplines and between a large number of research teams in some ten countries bordering the Baltic. The EU is funding campaigns to improve monitoring quality.

7.2.2 Modelling and projections, including general circulation models

The other main area of climate research is somewhat smaller. As may be seen from Table 7.2, funding for research in this area totalled just over SEK 74 million during the period.

Here too, research councils, government foundations and public authorities provide most of the funding.

The largest single Swedish project in this category is the Swedish Climate Modelling Programme (SWECLIM), which is administered by SMHI and includes SMHI itself, Stockholm University and Gothenburg University. SWECLIM began in 1997 and will run until 2003, with a total budget of just under SEK 90 million. The main purpose of the project is to interpret global climate change scenarios using regional climate models for atmosphere, land and soil, watercourses and the Baltic Sea. Account is taken of particular regional features of the climate system. Some research is being conducted into atmospheric, oceanographic and hydrological climate processes. Studies are also being made of the impact of climate change on water resources. To date, SWECLIM has produced considerably more detailed regional climate scenarios for the potential situation in a 100 years' time than those produced by global models. The progress made in this field has improved our knowledge of the regional climate system and also given specific indications at various levels of the way climate change may affect various sectors of society. The results are stored in simulation databases and are available for impact research in various areas.

Access to these detailed databases with their high temporal and spatial distribution gives those conducting impact research great scope for making quantitative studies of possible consequences and vulnerability. The databases are also used to produce information material for various target groups.

7.2.3 Research into the environmental impact of climate change

Research into the environmental impact of climate change is fairly extensive, receiving funding of just over SEK 200 million between 1998 and 2001. Unlike the two areas described above, much of the research being conducted in this area is relevant to the climate issue, but does not address it directly. Specific research on climate is mainly funded by research councils and public authorities, and is conducted at universities and colleges.

In practice, much of this research comprises energy research projects having a bearing on the climate issue.

The Climate Impact Research Centre (CIRC) is a central institution. The centre conducts research into the fundamental links between climate and various aspects of the northern environment, such as ecology, glaciological and vegetative dynamics over time. Environments and biotopes preserved in glaciers, marine sediments and tree rings are examined, and experimental and analytical studies are carried out to attempt to determine the interrelationship between current climate impact and ecological and glaciological processes.

This basic understanding of the interrelationship between climate and the northern landscape and its ecology will be used to estimate the probability of future rapid climate change in the north. CIRC's objectives are essentially scientific, although there is also a desire to develop and infrastructure for research in the region.

7.2.4 Socio-economic analyses, including analyses both of the impact of climate change and possible remedial measures

This is the area of Swedish climate research that receives least funding (approximately SEK 11 million). Specific climate-related research in this field at universities and colleges is funded by research councils, foundations and public authorities. Most of this goes to two projects. Little research of relevance to the climate issue has been conducted. Most of this research has been carried out at two government institutions: the National Defence Research Establishment[4], where there is research on building development and energy systems, and at the Transport and Communications Research Institute.

A new concerted research effort on the instruments of climate policy has been initiated in 2001. The aim is to study the way various external factors influence the potential for introducing and using various instruments when implementing the Swedish climate strategy.

7.2.5 Research and development of technology capable of reducing emissions and increasing removals of greenhouse gases, and for adjustment

Overall, the main area of Swedish climate-related research is research and development of technology capable of reducing emissions and increasing removals of greenhouse gases, and for adjustment. This research is conducted at more places (trade organisations, public authorities and private enterprise) than is other climate-related research. During the period in question, Sweden has spent just over SEK 1.5 billion on research and development in six areas as part of its strategy to create a sustainable energy system (the long-term adjustment programme for energy (see also Chapter 3).

7.3 Systematic observation

The Global Climate Observing System (GCOS) was established in 1992. Its central activities are funded jointly by the WMO, IOC (UNESCO), UNEP and the ICSU. GCOS is intended to be a long-term user-controlled system supplying the basic collected observations necessary to monitor climate systems, to identify and prove climate change, to estimate sensitivity to climate variations and change, and to provide data for supportive research for understanding, modelling and forecasting of the climate system. GCOS covers the entire climate system, including

- physical, chemical and biological characteristics;
- atmospheric, oceanographic, hydrological, cryospherical (snow, ice and glaciers) and terrestrial processes.
- GCOS plays no direct part in making observations or producing material; its role is to stimulate, coordinate and in various ways help international and national organisations to achieve their own and the common objectives. GCOS is based on cooperation between existing and new observation systems. These systems include GSN, GUAN, EUMETSAT, ECMWF and ERA (see below).

7.3.1 Systems for observation of atmospheric climate, including composition of the atmosphere

The WMO body World Weather Watch (WWW) forms a central element of GCOS and is developing as monitoring and analytical techniques are refined. The GCOS Surface Network (GSN), which should comprise at least 1,000 stations worldwide, is a special network providing reference for various climate studies, and offering particular quality, continuity and homogeneity.

Sweden has a long tradition of weather and climate observations. Six stations were originally designated for inclusion in the GSN. However, the list has been altered somewhat as of 2001:

1. Kvikkjokk – Årrenjarka (replacing the original proposal of Jokkmokk)
2. Haparanda
3. Holmögadd
4. Frösön
5. Malung (replacing the original proposal of Karlstad Airport)
6. Gotska Sandön.

Karlstad and Jokkmokk are continuing to report. Metadata (ie, information on data series in existence) and other information are reported. The GCOS Upper-Air Network (GUAN), GSN's counterpart, comprises 150 high-quality radiosonde stations worldwide. No Swedish stations have been designated. Reporting quality is good from our part of Europe. However, Swedish aerological monitoring of various kinds under WWW are an important part of GCOS, and data is stored nationally and internationally.

The European Meteorological Satellite system (EUMETSAT)

EUMETSAT is an important part of the WMO World Weather Watch. The USA, Japan and Europe share prime responsibility for this; Europe's responsibility is steadily growing.

The EUMETSAT monitoring satellite (METEOSAT) has been in geostationary orbit over the earth since 1978. The programme, which is now more than 20 years old, will be replaced by a more advanced satellite (Meteosat Second Generation) in 2002. The aim is to assure continuity and development of satellite data from EUMETSAT. The new satellites contain new sensors, partly using monitoring methods identical to those used by the previous programme. Raw data and data processing methods will be saved to allow reanalysis. Sweden is a member of EUMETSAT and is represented by SMHI. Swedish contributions are coordinated with those across areas of Europe via EUMETSAT. When the existing programme is replaced by new ones, a sufficient overlap will be created to allow necessary cross-calibration. Sweden is also a member country of the European Space Agency (ESA), which created EUMETSAT in 1986 to perform the then technically and operationally mature application of meteorological remote analysis. ESA and the Swedish space industry are heavily involved in developing the new space and terrestrial segments for EUMETSAT.

The ECMWF[5] and the reanalysis projects

Under the Climate Convention, one of the central tasks of GCOS is to encourage the development of special observation databases. These comprise quality-assured data compilations of long time series, which serve as a foundation and reference source for climate monitoring, as well as very extensive data compilations serving as a basis for detailed analyses of the entire climate system. Recurrent analyses of this data using the latest technology is perhaps the most important means of characterising and understanding climate variability and change. For example, with regard to the meteorological component of GCOS, 150 radiosondes have been defined as a reference system, whereas the entire World Weather Watch, with, for example, terrestrial monitoring, merchant vessels making voluntary observations, buoys, aircraft and, in particular, satellite observations, belongs to the wider system. These recurrent analyses also provide important data for further observation network planning.

Sweden contributes indirectly to development and analysis by its membership and contribution of expertise to the ECMWF in the first place, and secondarily via EUMETSAT. Over a period first of 15 years (the earlier reanalysis project – ERA15), and then 40 years (the current project – ERA40), the ECMWF has demonstrated the importance of, and potential offered by, a leading global institution using the latest technology combined with scientific cooperation. The ERA40 analyses are used to validate models and forecasts, including general circulation models, as well as climate impact models, eg, models describing vegetation in relation to meteorological and hydrological parameters. ERA40, which is an EU project within the Fifth Framework Programme for Research and Development, will enhance understanding of various components of the observation systems and involve an evaluation of new components, particularly the importance of satellite observations. The latter are central to the planning and development of new, costly, satellite systems. ERA40 is also intended to reinforce the European role in the global organisations under which GCOS and GOOS operate.

Radiation – ozone

SMHI possesses unique observation material and know-how in the field of aerosol optical depths (AOD). Some data series go back a very long time. Fairly simple observations are currently being made in the solar station network (at 12 sites in Sweden) and monitoring of AOD for three wavelengths in Norrköping. SMHI is actively engaged in climatological studies of AOD characteristics. This is crucial for atmospheric corrections of satellite observations of various terrestrial features, since erroneous assumptions when making corrections may result in erroneous conclusions as to impact on the climate system.

The radiation climate is directly linked to the composition of the atmosphere, and radiation is a significant part of the energy balance. Monitoring of radiation is often the only continual, physical and quantifiable measurement of cloud. Cloud types, cloud quantities and cloud base are more descriptive measures. Moreover, long climatological series of these parameters often incorporate subjective elements from the observers. SMHI's direct radiation monitoring is therefore an important element for use in climate studies and as verification for "parameterisation" of cloud and energy balance, among other things. Direct monitoring of radiation at ground level is also the backbone of radiation climate surveys, in which satellites are the main source of spatial data. Data is reported to the World Radiation Data Centre (WRDC) in St Petersburg, which operates under the auspices of the Global Atmospheric Watch (GAW). Data is regularly reported to the World Ozone and UV-radiation Data Centre.

---

[4] Now the Swedish Armed Forces Research Institute
[5] European Centre for Medium-Range Weather Forecast

Monitoring of carbon dioxide and particles in the air on Svalbard

Sweden has been monitoring carbon dioxide and particles on Svalbard since 1990. The Department of Meteorology at Stockholm University is responsible for the Swedish monitoring programme. This monitoring station is part of an international carbon dioxide monitoring network. Sweden is president country of the WMO Scientific Advisors Group for Greenhouse Gases, which decides the form of WMO global environmental monitoring. Funding of SEK 950,000 was allocated for environmental monitoring in 2001, including SEK 200,000 for particle monitoring. The station's most important task is to help us to gain a better picture of global dispersal of carbon dioxide. This requires monitoring in different regions.

Readings taken at Ny Ålesund on Svalbard provide important information in relation to the debate on sources and sinks.

The station provides important data for research into the feedback between the technosphere, the biosphere and the atmosphere. Data shows winter episodes with high carbon dioxide concentrations, probably resulting from industrial emissions in northern Russia (emitted from the Taiga). Spring and summer episodes, with rapid falls in carbon dioxide concentrations, are caused by carbon dioxide removals in the northern seas.

The intention is to attempt to quantify these sources and sinks.

The monitoring station has produced annual 24-hour data on carbon dioxide and particles since 1990.

Monitoring of ground-level ozone and particles

Systematic observations of ground-level ozone have been made under the Environmental Monitoring Programme since 1984/85. To start with, the observation network comprised five rural stations (Aspvreten, Norra Kvill, Rörvik, Vavihill and Vindeln). The Grimsö and Esrange stations have since been added to the network. The annual cost of the current network is about SEK 600,000. Ozone data is reported each year to international bodies such as the EU, EEA and EMEP.

Swedish municipalities take ground-level ozone readings in the urban environment. There were 19 urban stations doing this in 1999. Nitrogen oxide emissions, among other things, mean that ozone concentrations are always lower in urban areas than in the countryside.

From a climate viewpoint, data from rural stations is likely to be more representative, since they cover larger terrestrial areas.

Particles have been monitored since the mid-1970s as part of the Swedish Environment Monitoring Programme (EMEP) (Rörvik). Monitoring has been gradually extended and has been conducted at five stations since the mid-1980s, all of them in rural areas. Particle monitoring involves measuring soot particles, ie, the proportion of black particles that can be linked to emissions from human activities (including the burning of fossil fuels).

Monitoring soot using the EMEP method is inexpensive (approximately SEK 30,000 per year).

A shift towards monitoring of various particle fractions (eg, PM10 and PM2.5) occurred in the 1990s. To put it simply, this means measuring the mass of particles less than 10 or 2.5 um, often termed inhalable particles. Monitoring of PM10 and PM2.5 in rural areas of Sweden is relatively new. The first readings were taken in 1990. There are currently (2001) two EMEP stations (Aspvreten and Vavihill) monitoring PM10 and PM2.5, at an annual cost of SEK 300,000. Particles (PM10) in the urban environment have been monitored in Stockholm, Gothenburg and Malmö since the early 1990s. A further 10 or so PM monitoring stations have been established in 2000/2001.

A major PM10/PM2.5 inventory project was carried out between 1999 and 2001. It covered five urban areas, four streets, with two background stations. Levels recorded and interpretation of the data will be published shortly.

7.3.2 Marine observing systems

The most important oceanographic monitoring programme is conducted by SMHI in cooperation with the Swedish Environmental Protection Agency. There is a network of 25 main stations and 68 stations for special surveys. The main stations, at which hydrographical, chemical and biological parameters are recorded, are usually visited each month. The survey stations are visited once each winter to monitor nutrient and/or oxygen conditions. A brief description of the conditions in the seas around Sweden, based on monitoring at the main stations and survey stations, is given in the form of expedition reports, annual and quarterly reports, and also climatological reports. SMHI also performs marine monitoring for a number of regional coastal monitoring programmes. Regular expeditions are also made jointly with the National Board of Fisheries.

Exchange of data and other information takes place nationally and internationally. The Swedish Environmental Protection Agency has appointed SMHI the national oceanographic data centre for hydrographical and hydrochemical data. SMHI receives data from the National Environmental Monitoring Programme via the Umeå and Stockholm Marine Research Centre.

The data centre also receives hydrographical data from expeditions made by National Board of Fisheries vessels and from the coastal monitoring programme.

Most international exchange of marine environmental data is channelled via SMHI, which acts under the Intergovernmental Oceanic Commission (IOC) and other international bodies such as ICES, HELCOM and OSPARCOM.[6]

The data bank used for data exchange is called SHARK. This is the largest oceanographic data bank in Sweden and is based on observations gathered from Swedish and foreign research vessels, coastguard vessels, icebreakers, ferries, caissons, lightships and other platforms. SHARK also contains catalogues and expedition reports. The data available from many stations goes back 30 – 50 years. This makes the database an important tool in climatological studies. In the case of some stations, it is possible to go back to the beginning of last century and find data on temperature, salinity and oxygen conditions.

- **Wave measurement data:** There is data from six stations going back to 1978. Only three stations are still operational.
- **Water level:** Hourly observation data over long time series from the late 19th century.
- **Current data:** Caissons fitted with SMHI transmitters. There are only two at present. There are gaps in the data series.
- **Surface water temperatures:** Gathered via observations and ferries. Records go back to 1969.
- **Ice observations:** Made in a number of shipping lanes along the Swedish coast. There are observation series from 1931 and later, as well as some older data.

The above monitoring has been subject to funding cuts and interruptions over the past decade as a result of general changes in shipping infrastructure. A Swedish and international review of the observation system in the light, among other things, of current environmental and climate issues is currently in progress. Each winter, SMHI produces a daily map of ice conditions based on ice observations and satellite data. These observations are stored in national databases in cooperation with other institutions around the Baltic.

The Arctic and Antarctic Research Institute (AARI) has assumed responsibility for developing and maintaining a data bank for Baltic sea ice as part of the WMO Global Digital Sea Ice Data Bank. SMHI participates in this work, one purpose of which is to fill in the gaps in existing digital data series.

7.3.3 Terrestrial observing systems

Just as data bases and data series of atmospheric and marine data are being established for comprehensive analysis of climate for monitoring, research and other purposes, extensive monitoring of terrestrial areas is to be conducted in the form of systematic observations. There is not yet as much national and international exchange of terrestrial monitoring data as is the case with atmospheric and marine monitoring. This is partly because, historically speaking, there has not been the same need for global data exchange as within the field of meteorology and oceanography. The relevant terrestrial data and monitoring is that describing soil types, land use, vegetation, biomass, groundwater, water levels in lakes and watercourses, flow rates in watercourses, snow, glaciers, permafrost etc.

Hydrology

SMHI is the Swedish authority responsible for data on water flow and level in lakes and watercourses. The basic network currently comprises just over 300 stations. Most of these record both water level and flow, but six stations on large lakes only record water level.

There are continual data series dating back to the 19th century from six stations. Lake Vänern (1807) and Faggeby on the Dalälven river (1852) are the oldest. Water flow observations along many watercourses began between 1900 and 1919. Hence, there has been a fairly comprehensive network since some time around 1920. The number of water flow monitoring stations continued to increase up to the 1980s.

Snow

Systematic observations of snow began in the first decade of the 20th century. Snow depth is now monitored at some 400 sites in the SMHI network of climate stations. Most observations are made daily, with a minimum frequency of twice a month. The water content of snow is not recorded systematically; instead it is estimated on the basis of various meteorological data and developed validated procedures. Satellite-based snow surveys are currently being developed at SMHI and one or two other Swedish institutions.

7.3.4 Support supplied to developing countries to establish and maintain observing systems

A limited proportion of development assistance comprises support specifically designed to establish and maintain observing systems for reporting under the Climate Convention.

[6] ICES: International Council for the Exploration of the Sea; HELCOM: Helsinki Commission; OSPAR: Oslo and Paris Commissions

However, Sida (the Swedish International Development Cooperation Agency) does give fairly extensive assistance for institutional development and administrative development in the environmental field, which is indirectly relevant to the climate issue. Much of this support is included in the column headed "capacity building/research as displayed in appendix 5. Other important areas in this context are support for local Agenda 21 projects and support for inventories using remote sensing and geographic information systems, which represent a more direct form of support given to developing countries to establish and maintain observing systems.

References

Government Bill 2000/2001:3
Government Bill 1998/99:94
Sweden's communication on GCOS, November 2001

8 Education, training and public awareness

8.1 Public awareness of the climate issue

The Swedish public were fairly well aware of the implications of the climate issue as long as ten years ago. But people knew little about the cause and effects of climate change. The climate issue was often confused with ozone depletion. Since then, the Climate Convention has been negotiated and signed and coverage of the various negotiations has become a regular feature in the media. The reason people had some idea about the climate issue even ten years ago was probably that public awareness of environmental issues had been fairly high since the late 1960s. Generally speaking, Swedes have become more knowledgeable about the environment and more environmentally aware, although there are few studies testing public awareness in this field.

A survey performed in 2000 revealed that the Swedish public were well acquainted with the climate issue. The majority of people know about the link between higher temperatures and climate change and know that we need to use less oil and petrol. People also know that technological development and public transport are the solution to the problem. Most Swedes also think that the rise in temperature is already measurable.[1]

8.2 Treatment of the climate issue in the media

The media plays an important part in passing on information to the public. A study of the last two years' articles in Swedish newspapers has been made to gain an impression of the way the climate issue is presented in the media.[2] The study revealed an increasing awareness in society about the need for various actors to be more actively engaged in the climate issue. The issue is generally seen as a global problem that must be dealt with in international fora. It is also perceived as a political issue, requiring decisions as to objectives and targets to be achieved. It may be said that articles fail to make clear the link between international negotiations and domestic commitments. Few articles discuss what action is necessary and how it is to be implemented. There is no shortage of articles about new technology and renewable fuels. Articles about fuel cells, ethanol-driven cars, flexible fuel cars, energy-efficient cars, biomass fuels and wind power are common.

Taxes are often discussed by the Swedish media. A number of articles highlight the problem of high fuel taxes, particularly motor fuel taxes. But there are also articles emanating from political parties and articles drawing conclusions from government reports, which emphasise the need to raise taxes to reduce carbon dioxide emissions.

There are few articles discussing whether or not there is a climate problem at all. The number of articles indicating the need for "action" rather than "more evidence" would suggest that the climate debate has moved away from discussing doubts and towards discussing objectives.

8.3 The government's general standpoint

The government has highlighted the importance of consumer policies in a number of documents dealing with ecologically sustainable development. Among other things, the government's position is based on studies showing that Swedish consumers are responsible for about half of all emissions of harmful substances to air and water. It is also emphasised that consumer demand determines the industrial agenda. The purpose of an active consumer policy in the environmental field is to reduce household emissions, energy consumption and waste. Goods, transport, housing and societal planning are all involved.

The government places importance on the following:

- Increasing public awareness about consumption and the environment, among other things by ensuring that they have access to relevant information.
- Pressing for more information about the environmental impact and energy requirements of products.

---

[1] SIFO (2000)

[2] No study has been made of the way radio and TV have presented the climate issue, or whether their approach differs from that of newspapers. But abundant radio and TV coverage of severe flooding in parts of Sweden in 2000 ensured that all Swedes were aware of the situation. Events of this kind in Sweden and abroad are usually accompanied by discussions on radio and television as to whether they are a result of climate change.

- Supporting efforts to change patterns of consumer behaviour.

The government also stresses the need for better information to use as a basis for deciding measures and monitoring achievements in relation to consumer issues in the field of ecological sustainability. The following are among the areas where more information is required:

- The relationship between consumer behaviour and environmental impact, including the most effective ways of reducing the burden placed on the environment by consumers.
- The conditions necessary for consumers to act pro-environmentally.
- Conflicts of aims from a consumer perspective.
- Consumer priorities.

8.3.1 The Commission for Measures against Climate Change

The parliamentary Commission for Measures against Climate Change, appointed by the government in May 1998, identified information as an important instrument in its final report published in April 2000.[3] Among other things, the commission suggested that informative instruments be used to achieve the proposed objectives. The commission emphasised the importance of information to increase awareness of the risks associated with climate change and make people more aware of what they could do about them.

Information campaigns were proposed as a means of persuading people to accept the use of various instruments to reduce greenhouse gas emissions. The government will bring a Climate Bill based partly on the commission proposals before parliament in autumn 2001.

8.3.2 Agenda 21

As instructed by the government, the Swedish Environmental Protection Agency has drawn up a proposed national strategy for the supply of information and know-how about Agenda 21 and sustainable development. The aim has been to formulate a strategy capable of making people more aware of their own lifestyles and thereby helping to comply with the aims of Agenda 21. The strategy deals with national efforts to distribute integrated information via various media. It is essential to meet with representatives from industry and other actors to give accounts of lessons learned and examples of information about the environment and sustainable development. These efforts have been made in cooperation with the National Agency for Education and the Secretariat of the Agenda 21 Committee.

8.3.3 The Aarhus Convention

The EU members states and a further 35 countries within the Economic Commission for Europe (UNECE) have signed the Aarhus Convention, thus making a number of commitments as to greater openness, access to environmental information and public participation in the decision-making process on environmental issues. The EU member states, which signed the convention on 25 June 1998, are already taking steps to harmonise their legislation and are also expected to ratify the convention soon.

As a result of the convention, the public will have a greater say in decisions on planning, projects and strategies. The aim is that the public should be able to exert a greater influence over the decisions made at various levels in society. To do so, people must be aware of the issues and understand them, and also know what is needed to solve the problems and the part they can play in that process. Environmental education and training, information (eg, indicators and maps) and initiatives to raise awareness will be key elements in the process. Education and training lies mainly within the sphere of competence of the individual member states, although they are encouraged to incorporate environmental issues in their school curricula.

Even before the Aarhus Convention is ratified, the Swedish principle of public access to official information and proceedings already gives people in Sweden a good measure of access to various public decision-making processes.

8.4 Education and training

8.4.1 Basic education

Incorporation of the environmental dimension in Swedish schools is under constant development. All environmental issues are covered. The express aim is to ensure that everyone undergoing a school education gains an understanding of the need for a good environment and how the actions of the individual can contribute to this. The climate issue is part of this.

Overall school education is governed by curricula, which are set by the government. The education system comprises three curricula: one for pre-school (ages 1 – 5), one for compulsory school, the pre-school class and after-school centres (ages 6 - 16), and one for voluntary upper secondary school education (17 years and upwards). The responsibility of each school to provide education on environmental issues in general is expressed in approximately the same way in each curriculum. One of the curricula states:

"It is essential in all teaching to provide certain overall perspectives. An environmental perspective allows students to take responsibility for the environment they themselves are able to influence directly, and to acquire a personal attitude towards general and global environmental issues. Teaching must illustrate the ways in which the functions of society and the way we live and work can be adapted to create sustainable development."

The curriculum governs the syllabuses produced for each subject. Syllabuses are also set by the government.

The National Agency for Education has created an additional incentive – "the Green School Award" – for schools wishing to become actively engaged in environmental issues.

To receive the award, a pre-school or school must make an inventory of its activities from an environmental viewpoint, draw up an action programme and make efforts to develop its teaching and activities to achieve sustainable development. The award is granted for a maximum of three years. After that, the preschool/school must present new results. The purpose of the award is to encourage teaching on the subject of ecological sustainability. Pupils/students must be involved in planning and have a say in their learning.

Twenty-three school have so far received the Green School Award. A further 60 are working to achieve it.

The Keep Sweden Tidy Foundation also has a scheme for schools wishing to become actively engaged in environmental issues. The scheme is called "the Green Flag", and is the Swedish branch of Eco Schools, run by the Foundation for Environmental Education in Europe (FEEE). Just over 600 Swedish schools now belong to the Green Flag scheme.

One Swedish company uses an unusual method of disseminating information. The teaching pack, entitled "Natur & Miljöpärmen" ("the Nature and Environment File"), is distributed to schools free of charge. This is achieved by way of sponsorship by trade, industry and municipalities. The material explains how man affects nature and the environment and what we can do to adapt to the natural ecocycle. The material is intended to cement an interest in nature and the environment among pupils at an early age, so that they are better able to understand nature's terms and act pro-environmentally in the future. Some 80,000 information packs are distributed to each year of intermediate school annually.

The Swedish EPA instigated a survey in 2000 to find out how the climate issue was dealt with in school teaching. 1,200 teachers at secondary and upper secondary school level were interviewed. The results show that school and education are considered to be the issue of greatest importance for Sweden's future (31 per cent). The environment comes second (27 per cent). The climate issue ranks high among environmental issues. Some 70 per cent consider that the climate issue is included in their science and social science subjects. Many secondary school teachers think that the climate issue really belongs with the social sciences, whereas most upper secondary school teachers place it with the natural sciences.

The climate issue is mainly dealt with in teaching of science subjects, as well as social sciences and geography. A lack of time was given as the main obstacle to teaching on the climate issue. The teachers also felt that they needed better teaching materials and to improve their own knowledge.

8.4.2 Higher education

Universities and colleges are not subject to the same requirement that students should possess general environmental knowledge as that stipulated in the curricula for the compulsory school system. However, universities and colleges are included in the government's efforts to incorporate environmental management systems throughout public administration. Some 26 universities have so far been instructed to do so.

"Svenska Ekodemiker" ("Swedish Ecodemics") is an association for students interested in the environment and sustainable development. Its aims are ambitious: the idea is to influence activities at universities and colleges so that Swedish seats of learning become world leaders on environmental issues and Swedish graduates become the most environmentally aware, regardless of discipline.

There are currently 25 universities and colleges offering courses on the environment. There are a total of 63 courses with various environmental components. The climate issue is probably included to varying degrees in these courses.

8.5 Campaigns

8.5.1 Klimat.nu

Five Swedish organisations have received government funding of SEK 10 million to conduct a public information campaign on the climate issue. The campaign is being run under the name "Klimat.nu", after the

[3] Swedish Government Official Report SOU 2000:23: Förslag till Svensk Klimatstrategi ("Proposed Swedish Climate Strategy")

website of the same name, and involves a number of activities during 2001 – 2002. The National Federation of Adult Education Associations, the UN Association of Sweden, the Church of Sweden, the Swedish Society for Nature Conservation and the Swedish Red Cross are the participating organisations. The campaign aims to show that swift action can reduce carbon dioxide emissions; its target is to reduce Swedish emissions by two per cent in two years. This will also demonstrate a will on the part of the Swedish people to reduce emissions and that the national reduction targets could be raised. The campaign makes use of adult education classes, lectures, radio, TV and the Internet.

The first step has been to train about 500 people internally at the participating organisations. Study materials are also being developed.

Some 500 – 1,000 "climate and lifestyle ambassadors" will be trained in the autumn of 2001.

These people will then lead adult education classes or provide information at workplaces.

A radio series will also be broadcast in the autumn. These activities are designed to encourage individuals or groups of people to commit to reducing their greenhouse gas emissions. The campaign website will be used to announce the commitments, to publicise identified obstacles in society standing in the way of a healthy climate and to encourage people to do more to influence decisions having a bearing on climate. The campaign will be regularly evaluated by the Swedish Institute for Ecological Sustainability.

8.5.2 "SparKraft" – Improving Energy Efficiency

The government created the Energy Supply Committee of Southern Sweden (DESS) in autumn 1997. Its task is to develop energy supply in the region.

A DESS initiative – "SparKraft" – Improving Energy Efficiency – began in 1999 as a four-year information project in cooperation with three regional energy offices. It is aimed at the industrial, property and household sectors. The idea is to support efficiency improvements and energy saving, and to limit the use of fossil fuels and electricity by changing over to energy from renewable sources. This is to be achieved by means of various pilot projects, public information and energy information.

Analyses are being performed at factories and in commercial and industrial premises.

Inventories are made and remedial measures proposed. Information is then distributed in various ways and the analyses serve as an example to others.

A nationwide campaign entitled "Släck efter dig!" ("Lights out before you leave!") is aimed at households in the region. The 2.2 million inhabitants of southern Sweden have received an information brochure and various adult education associations and municipal energy advisers are also involved. Special educational material for schools has also been produced. The aim is to create awareness of energy and environmental issues among the broad mass of people so as to ensure a long-term impact.

An initial evaluation a year into the campaign showed that 56 per cent of "the general public" had put one or more of the energy-saving tips in the "Släck efter dig" brochure into practice. The target of 15 per cent has been achieved with a vengeance.[4]

It is thought that the success of the campaign to date is due to the emphasis on simple and concrete energy-saving tips that do not cost much money.

8.6 Industry and the environment

Since the climate negotiations in Kyoto in 1997, the Confederation of Swedish Enterprise (formerly the Federation of Swedish Industries and the Swedish Employers' Confederation) has been distributing information to its member companies (chief executives and environmental directors), as well as to politicians, decision makers, journalists and schools.

"Klimatboken" ("the Climate Book"), which was published in 1999, describes the characteristic features of Swedish industry, the need for a "level playing field" and other aspects of its basic view of the climate issue. 15,000 copies of the book were distributed to these target groups. The Climate Book describes the scientific aspects of the climate issue and the international climate negotiations. It also describes the changeover from fossil fuels to other energy sources, the change from coal and oil to natural gas, and the reduction in energy use as three of the main ways of reducing emissions.

An easy-to-read climate brochure was also produced and distributed to all 7,000 or so member companies. The brochure gave a more general account of the scientific aspects of the climate issue and drew particular attention to the potential impact on companies of the international negotiations and various political decisions. A further publication has also been produced entitled "Klimatpolitik efter Kyoto" ("Climate policy after Kyoto"), in which the implications for Sweden of the Kyoto Protocol are described and analysed. The material has been used for a seminar for journalists and several thousand copies have also been distributed to decision makers and others.[7]

8.7 Municipalities

8.7.1 Agenda 21

Agenda 21 requires as many people as possible to participate to achieve the changes that will bring about sustainable development. For this reason, the local level has been given particular prominence in Agenda 21. The idea is that local people and municipalities should together produce a local action plan adapted to the needs and wishes in the area.

There has been a great response to Agenda 21 in Sweden. Efforts to formulate local Agenda 21 programmes have been, or are being, made on a broad front in most municipalities. In a study made in 1997, virtually all municipalities (97 per cent) said they were taking specific steps to involve local inhabitants. The most common methods of reaching the public include information material, exhibitions and marketing events, as well as advertising or articles in the local press. The emphasis has been placed on one-off activities, although regular campaigns are also common. Two out of three municipalities have also initiated educational and training activities in the form of courses and seminars, and have invited local inhabitants to attend public meetings. Adult education classes or environmental teams have been started in half the municipalities. Information and other activities relating to the greenhouse effect are a common feature of Agenda 21 projects.

8.7.2 The "Challenger Municipalities"

A project involving five "Challenger Municipalities" (Lund, Säffle, Uppsala, Växjö and Övertorneå) is running from 1998 to 2000 at the instigation of the Swedish Society for Nature Conservation. Five municipalities operating under differing conditions were selected from those applying to participate. The participants then set targets and drew up programmes to minimise their use of fossil fuels over time. Each municipality has set a target of a 50 per cent reduction in carbon dioxide emissions by 2020 or 25 per cent by 2010, with some variations. Local inhabitants have been informed of these commitments. The Challenger Municipalities wanted to show that it is possible to achieve a substantial reduction in fossil fuel use. There was also a joint advertising campaign in 2000, with full-page advertisements in Svenska Dagbladet and Dagens Nyheter, Sweden's two national daily newspapers. The campaign urged the Commission for Measures against Climate Change, which had been instructed by the government to review Swedish climate objectives, to set more far-reaching national targets along the lines of those set by the participating municipalities. The Challenger Municipalities project has received ample radio and TV coverage.

8.7.3 Local Investment Programmes (LIP)

Government funding for local investment programmes has two purposes: (i) to substantially increase the pace at which Sweden transforms into an ecologically sustainable society; and (ii) to increase employment. The programme gives municipalities and local companies and organisations the opportunity to make a joint application for investment grants to increase ecological sustainability. Grants are to be allocated to the municipalities whose investment programmes best contribute to the process of ecological adjustment.

Some of the SEK 7.2 billion that has been allocated for local investment programmes during the period 1998 – 2003 is being invested in supportive measures, including public information. Many projects focus on several environmental aspects, but projects often increase awareness of environmental issues.

8.7.4 A municipal project

The municipality of Vetlanda ran a project between 1997 and 2000 to reduce the environmental impact of road traffic. The project was run as a Community Intervention Program (CIP). The idea was that just over 100 "resource persons" would help people to become interested in the issue and accept a greater responsibility for the environment by discussing it with others in their daily lives. This is based on the belief that more is achieved when people are able to realise something they themselves have planned on the basis of their own thoughts and ideas.

As a result of the work carried out by the resource persons, in combination with other information activities, 70 per cent of municipal inhabitants knew about the project after three years, of whom 76 per cent considered it to be important. The motor car is still the commonest way of getting to work, but one positive effect of the project was to increase the amount of

---

[4] 28 per cent of people said that they had read the entire contents of the 52-page brochure distributed to Swedish households. As many as 80 per cent of those who had read the brochure said that it contained interesting information, and 56 per cent had saved it. The campaign also reached younger people (up to the age of 30). 79 per cent of them were aware of the brochure, and 83 per cent of these said that they had leafed through it or read some or all of it. The brochure was also sent to targeted categories, including the retail trade (mainly white goods). Here too, the campaign had a significant impact. 76 per cent of retailers said that they had noticed the brochure; 90 per cent of these had read or leafed through it and 67 per cent had saved it. 73 per cent of schools said that they intended to use the study materials produced for schools.

[5] The impact of the information campaigns has not been evaluated.

[6] In addition to the five municipalities, local branches of the Swedish Society for Nature Conservation participated in each municipality.

car-sharing. Similarly, more people have begun to walk and cycle to work.

On the other hand, the spare-time travel habits of the people of Vetlanda have deteriorated somewhat from an environmental viewpoint over the past year. Results show that 12 per cent of those who had begun car-sharing, cycling or walking in 1999 started to use their own car again in 2000.

The project has been continuously evaluated by researchers at Lund University.

8.8 Resource and information centres

Several central government agencies share responsibility for information on climate, often clearly linked to their own sector. A number of other organisations also play an important part in the climate issue and in efforts to disseminate information about the issue to their target groups and members. These are described in section 8.9.

8.8.1 The Swedish Environmental Protection Agency

The role of the Swedish EPA is to produce and disseminate information and knowledge about the environment, to take initiatives and to ensure that all actors assume responsibility for the environment. The Swedish EPA does not deal directly with the public. Its interface is mainly with sectoral authorities, regional and local authorities, and its role is to help formulate objectives, provide guidance and coordination and to monitor achievement of environmental objectives.

The EPA's conclusions are similar to those of the Commission for Measures against Climate Change with regard to information as in instrument of climate policy. The EPA considers that information alone is a weak instrument in relation to an environmental problem as complex as climate change. The agency is also of the view that information can cement and to some extent influence attitudes, but more powerful means are required to change behaviour. At the same time, the agency considers that information can help to change attitudes to the need for action, powerful instruments, and thereby also the need for political decisions.

The EPA is carrying out an information project on the climate issue during 2000 – 2002.

The primary targets of the project are municipalities, schools and trade and industry. The purpose of the project is to change attitudes about the need for measures and instruments and to make the public more receptive to information about what people can do to help reduce greenhouse gas emissions.

The EPA intends that the project should help

- to create the necessary conditions so that our actions increasingly take account of the impact on climate they cause;
- to attempt to create a positive perception of a sustainable Sweden in 50 years' time, with a better quality of life, a good standard of living and continuing Swedish competitiveness;
- to show that those who successfully manage to adjust to a sustainable society manufacture and use products that consume little fossil fuel;
- to develop information and education materials for the target groups.

Priority will be given to supporting municipalities that pursue the climate issue, developing various information material for exhibitions, developing the Swedish EPA website (www.environ.se), making an information pack on the third IPCC evaluation, identifying industry's climate information needs and producing teaching materials in the climate field for secondary and upper secondary schools. A number of seminars are also being arranged within the framework of the project, and a national climate conference is planned. The Swedish EPA conducts many other projects and activities in which the climate issue is very much a part and which involve the supply of various kinds of information. This applies to both the transport and the energy sector and more generally within the scope of sustainable development.

The Swedish Environmental Protection Agency is the public authority responsible for statistics on greenhouse gases and produces annual data for Sweden's communications under its UNFCCC and EU commitments. The statistics are available to the public at the EPA website and greenhouse gas emissions are also published by Statistics Sweden.

8.8.2 The Swedish Meteorological and Hydrological Institute

The task of the Swedish Meteorological and Hydrological Institute (SMHI) is to supply data for planning and decision making in activities dependent on the weather and climate.

SMHI is the expert body in the fields of meteorology, hydrology and oceanography, and is a resource in environmental protection.

Important SMHI products are its summaries and analyses of status, trends and extremes of climate variables. Information reports are published each month, annually and for longer periods. Standard climate reporting uses 30-year mean values. Special reports are produced in addition to these periodical reports. These may be in-depth analyses of specific variables of interest in relation to periods of heavy rain or drought. Information is made available in various publications and, increasingly, on the Internet (www.smhi.se).

SMHI is also under a duty to maintain and develop databases containing climate variables.

These are made available for research and commercial operations at SMHI and elsewhere.

In addition to its role as a public authority, SMHI performs special consultancy work/climate analyses on a commercial basis for individual customers. This may be for planning housing or industry, or for companies in the energy sector etc.

SMHI data is intended to help Sweden derive economic, environmental and safety benefits from the general and specific climate information it supplies. Properly managed planning and use of resources that is correct from various perspectives will enable us to influence factors impacting on climate and the environment and reduce our vulnerability.

SMHI is an important source of know-how and information on climate issues for the government, public authorities and society as a whole. It is clear in Sweden, Europe and around the world that the question of climate and climate change is growing in importance.

Consequently, SMHI has been instructed by the government to intensify its efforts in the climate field.

SWECLIM

The Swedish Regional Climate Modelling Programme (SWECLIM) is a project mainly funded by the Foundation for Strategic Environmental Research (MISTRA) and SMHI.

Its purpose is to increase our knowledge of the impact of climate change in Sweden and the Nordic region. The main aim is to supply decision makers, public authorities, trade and industry and other researchers with reliable assessments of future climate trends using the best possible methods. Information is also supplied to the public. SWECLIM works in close association with SMHI. The information they supply is largely coordinated.

The programme regularly reports on progress at SWECLIM in the form of articles and seminars of various kinds. The programme has also become a source of information for the public by responding to enquiries and requests for material made by various groups, and by participating in various seminars. SWECLIM's work has also attracted media coverage, which helps to increase public awareness. Some 40 lectures/presentations and a further 40 or so radio and TV interviews were given in the second half of 2000. SWECLIM's work was mentioned is approximately 100 newspaper and magazine articles during the same period.

8.8.3 The National Energy Administration

Within its terms of reference, the National Energy Administration runs information and communication projects about the energy system. These heighten public awareness of the impact of the energy system on climate. National Energy Administration information projects may be divided into five sub-areas, as described below.

General energy information

Information is distribution to broad target groups in the energy sector, such as energy producers, energy distributors, energy users, municipalities, energy experts, architects, installation firms, other public authorities and the media. Traditional information channels are the administration's website (www. stem.se) and periodicals, as well as the annual energy conference: "Energitinget". The administration disseminates information and know- how about the energy system, analyses and forecasts, as well as information and changes in the regulations governing the energy system. Particular emphasis is placed on the interrelationship between energy, economics and the environment.

Targeted information about improving energy efficiency and renewable energy sources

Targeted information is intended to provide specific information and a basis for decisions for one or more well-defined target groups. As well as technical information, it may be a question of information engendering acceptance and awareness. The information is largely based on know-how and information produced at the National Energy Administration and other agencies, as well as international experience.

A great deal of information has been distributed to consumers. It has included facts about different heating systems and different ways of saving energy. Brochures, publications and fact sheets are often produced in cooperation with the Swedish Consumer Agency.

Material is also targeted at architects, builders, consultants, installation firms and retailers.

Each year for the last three years, an exhibition has toured Sweden, with two trailers demonstrating alternative energy systems for home heating, eg, pellets, heat pumps and district heating. 200 – 300 people have visited the exhibition in each town it has stopped at. A "wind power tour" was undertaken in 2000, with a view to supplying local/regional authorities and municipal energy advisers with information about research, development and implementation of wind power in Sweden.

The National Energy Administration has developed guidelines for procurement of high-energy equipment, taking account of aspects such as quality requirements, occupational health and safety, operation and economics. Information has so far been produced for procurement of 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. The administration has distributed brochures and fact sheets to broad target groups as part of the technology procurement procedure, the purpose being to stimulate the market launch of the winning product.

Voluntary agreements with some ten Swedish municipalities were concluded in 2001. The agreements concern conversion of energy systems and improving energy efficiency so that carbon dioxide emissions are reduced to their 1990 levels.

Grants for information projects and municipal energy advisory services

The National Energy Administration gave grants for specific information and education projects between 1998 and 2000 in order to increase awareness of more efficient energy use. 69 projects received funding. Grants have mainly been given to regional energy offices, trade associations and other organisations. Grants during the period totalled just over SEK 10 million.

Government funding for municipal advisory services in the energy field was authorised for the first time between 1977 and 1986, and has been reinstated for the period 1998 – 2002.

The aim is to disseminate information about sustainable energy supply and improved energy efficiency via municipalities to the public, companies and local organisations. The grant can be used by municipalities to fund energy advisory services in their own municipality or for supply of these services in cooperation with other municipalities. The grant to each municipality is SEK 150,000 a year, plus a supplement related to the number of inhabitants in the municipality. 285 municipalities received this grant in 1999 and 2000.

Information about municipal energy planning and dissemination of information about the interrelationship between energy, economics and the environment

The National Energy Administration works to support municipal energy planning, which is supposed to help achieve local economically and ecologically sustainable energy systems.

This is done by commenting on draft municipal energy plans and by disseminating information and know-how about the interrelationship between energy, economics and the environment. A considerable number of publications have been produced jointly with the Swedish EPA. A book entitled "20 grader – men hur" ("20 degrees – but how?") was published in 1996 and compares factors such as the cost-effectiveness, environmental burden and energy efficiency of various heating systems for individual houses, apartment buildings, office buildings and schools. Practical examples are also given of settings for heating systems. The target group comprises property owners, building operators, heating, ventilation and sanitation engineers, officials at municipalities and energy companies, local Agenda 21 groups and educational institutions, including colleges, universities and those engaged in training heating, ventilation, sanitation and electrical engineers.

Several books along the same lines have followed. For example, "Ekonomi, energi och miljö på lokalnivå" (Economics, energy and environment at local level") deals with the links between these areas at local level using a new methodical approach. Examples are also given of measures or projects that are cost-effective and profitable, while reducing energy consumption and the burden borne by the environment. The target group consists of local and regional actors. "Lokala Uppvärmningsstrategier" ("Local Heating Strategies") gives ideas on converting heating systems, eg, strategies for new district heating and local heating. A publication entitled "Miljöanpassade lokala energiplaner – Exempel" ("Sustainable local energy plans – examples") complements this by giving good examples of sustainable municipal energy plans, eg, planning processes, objectives, strategies, environmental impact assessments and ideas for specific projects.

Information in connection with EU initiatives

During the period 1998 – 2001, the National Energy Administration ran a white goods campaign called "Stoppa elätarna – köp elsnålt" ("Stop the energy eaters – buy energy-efficient"), funded jointly by the industry. The aim was to persuade consumers to choose energy-efficient alternatives when they replace their white goods. The campaign complemented the EU energy labelling of refrigerators, freezers, dishwashers, washing machines and tumble driers.

Information activities are also conducted to encourage individual metering and charging of heating and hot water etc, which is governed by EC Directive EEC/93/76. OPET is a network of organisations in the EU, whose main task is to communicate research findings in the field of new technology. The National Energy Administration runs the office. Sweden has two offices: OPET Sweden and OPET Arctic, which began operating in 1997. Total funding in 2000 was SEK 2.5 million. The purpose of OPET is to promote energy technology by accelerating the market launch of new innovative energy technology.

Monitoring results

The aim of the above information activities is to improve public awareness and knowledge.

This will in turn result in action, which will help to improve energy efficiency and greater use of renewable energy sources. Monitoring focuses on determining the extent to which awareness has arisen among the target groups and the extent to which this has resulted in action. However, monitoring of this kind is costly, and has therefore been largely confined to major activities such as campaigns.

Monitoring of results has shown that over 23 per cent of consumers saw the white goods campaign during 1998 – 2000, and that 50 – 54 per cent of consumers think that energy efficiency is an important factor when buying a refrigerator, freezer, washing machine or tumble drier. A slight increase has been noted in the ability to interpret EU labelling among those planning to buy white goods. A comparison of sales statistics between 1997 and 2000 (ie, the campaign period) reveals a sharp move away from less energy-efficient appliances to energy-efficient class A and B devices. It is estimated that this may increase energy efficiency by just over 0.12 TWh.

Around 40 per cent of consumers were aware of the campaign for low-energy light bulbs.

Sales of these in 1998 – 1999 are estimated to have reduced energy consumption by about 5 GWh. According to participating installation firms, the "vatten-värmer-bättre" ("water warms better") touring exhibition had a great impact. They said that orders for waterborne heating systems had increased as a result of the tour. The effect to 2000 of the "Eko-energi-projektet" ("the eco-energy project") in industry (based on the companies reporting) is an energy saving of 33 GWh, including just over 10 GWh of electricity.

Information on procurement of new technology is considered to have made a major contribution to the introduction of the 17 products covered by technology procurement between 1998 and 2000. New heat pump technology has met with a particularly positive response; these pumps have replaced both oil-fired boilers and electric heating systems. A rough estimate of the effect of new heat pumps is that oil consumption has fallen by 0.4 TWh and that electricity consumption for heating has fallen by 0.13 TWh. However, it is not possible to distinguish between the effects of information distribution and the effect of the technology development projects. But if all types of energy efficiency project are taken together, energy consumption is estimated to have fallen by 0.4 TWh. This figure is based on sales statistics.

It is fairly hard to determine the effect of grants for municipal energy advisory services, and to measure the effects in terms of KWh or carbon dioxide emissions is virtually impossible.

However, 40 per cent of advisers feel that energy advice has raised public awareness of energy issues. Just over 200 consumers who had received energy advice were interviewed.

Their responses show that almost all recipients of advice are householders who either wanted some general advice on how to save energy or who wanted to ask questions about changing over to a different heating system, eg, to heat pumps or pellets. 86 per cent thought the information they had received was very or fairly useful. Following energy counselling, about half of them made an investment or changed their behaviour; the other half said that they planned to improve their energy efficiency in some way.

8.8.4 The National Road Administration

The National Road Administration, which is the sectoral agency for the road transport network, works to achieve two-way communication via a large number of activities.

At present, the administration has two major projects in progress at national level:

"Kvalitetssäkring av transporter" ("Transport Quality – TQ"), and "Sparsam körning - SPARK" ("Green Driving"). Local departments of the National Road Administration also run their own projects jointly with county councils, private enterprise and organisations.

The Transport Quality project is being run as a two-pronged traffic safety and environ- mental project. The aim is to create an effective market for safe and environmentally compatible transport. Both purchasers and sellers of transport are targeted by the project.

Trade and industry is also participating, mainly in the form of companies and trade associations in the retail, food, engineering, steel, mining, pulp and paper and transport sectors. The contribution made by the National Road Administration has been to provide a systematic approach, give examples of effective demands that can be made and of what the carrier can do.

The "Sparsam körning – SPARK" ("Green Driving") project is intended to make people more aware of how their approach to driving impacts on the environment. Important elements of the project are Eco-driving and Heavy Ecodriving (for truck drivers), which are practical and theoretical training courses on which people learn to drive in an environ- mentally compatible way. Some 3,400 people have completed the Ecodriving course.

The National Road Administration also conducts and/or supports and number of regional projects, in which information/communication are important elements. The Vetlanda project, described in greater detail in section 8.7.4, is one such project. The administration has also taken part in the "Challenger Municipalities" project, described in section 8.7.2.

The administration also publishes information about traffic and the environment at its website (www.vv.se). Examples are information about ways of driving, choice of car, energy- efficient engines and engine heaters.

8.8.5 The Swedish Consumer Agency

The Swedish Consumer Agency is the central government agency dealing with consumer affairs. Its main task is to help consumer to use time, money and other resources in the best way, and to strengthen their position in relation to sellers and manufacturers.
The agency also scrutinises marketing methods and participates in eco-labelling projects. Its primary objective in the environmental area is to ensure the development of patterns of production and consumption that reduce the burden on the environment and contribute to sustainable development. The agency distributes information via publications such as its "Råd&Rön" consumer product testing magazine, by training consumer advisory officers and via its website (www.konsumentverket.se).

Each year, the agency produces a brochure on the fuel consumption of new automobiles and their carbon dioxide emissions. The latest brochure had a print run of 175,000 copies.

It was distributed free to prospective purchasers at car showrooms. The information it contains is also available at the agency's website, where the figures can also be used to make cost calculations prior to purchase. Under EC Directive 1999/94/EC, all EU countries must provide information about fuel consumption and carbon dioxide emissions for new automobiles as from 2001.

The Swedish Consumer Agency also give advice on how to save energy in daily life and at home. The Råd&Rön consumer magazine provides information about eco-labelling of white goods, travel and cooking. The magazine currently has some 135,000 subscribers and is read by an average of 520,000 people.

The Swedish Consumer Agency considers that awareness of the negative impact of consumption on the environment has increased among consumers and in trade and industry. It is also considered that the agency's efforts have definitely made it easier for consumers to reduce the burden they place on the environment by regularly reminding them to consider environmental factors, by sending consistent messages, adopting an overall approach and giving specific advice.

8.8.6 The Swedish Institute for Ecological Sustainability

The Swedish Institute for Ecological Sustainability (IEH) is a national focal point for know-how, research findings, ideas and experience concerning the issue of ecological sustainability.

The institute's main task is to support Swedish municipalities in their efforts to develop and implement local investment programmes by facilitating contact between municipalities, researchers, trade and industry, organisations and other actors. IEH should also inspire and inform by spreading information and experience from completed investment programmes.

The climate issue is part of this. Information is disseminated through newsletters, conferences, the website (www.ieh.se) and face-to-face contact.

8.8.7 The Swedish International Development Cooperation Agency (Sida)

Sida administers foreign aid given to developing countries. For example, Sida funds local Agenda 21 projects in a number of countries. It also provides environmental organisation and network support for individual organisations in developing countries via the Swedish Society for Nature Conservation. This support has made it possible to conduct information campaigns about patterns of consumption and lifestyle issues in industrialised nations that have an adverse impact on the environment. Sida also runs education and training projects and funds the periodical "Tiempo" and its accompanying website, which deals with the climate issue. More information about Sida's work in developing countries is given in Chapter 6 under "Financial support and technology transfer".

8.8.8 Ekocentrum

The Ekocentrum know-how and resources centre in Gothenburg runs a large permanent environment exhibition. Ekocentrum is an independent foundation originating from the green movement, and contributes to sustainable development by spreading knowledge and inspiration concerning environmental technology and successful environmental projects. Its activities consist of a permanent exhibition on various themes, with training courses and seminars. Some 70 per cent of visitors to the centre are from trade and industry and Swedish municipalities; 30 per cent come from the schools system. At present there is an exhibition entitled "Sustainable Energy and Transport". The exhibition demonstrates good examples from a global, national, regional and local perspective. The focal point of the transport exhibition is a detailed presentation of available environmentally compatible fuels, vehicle types, alternative solutions and the potential contribution of IT to sustainability. The climate issue is dealt with thoroughly as part of the transport exhibition. Some 15,000 people visit the exhibition each year.

8.9 Involvement of the public and non-governmental organisations

Most NGOs are involved in climate issues and take an active part in the public debate. They include established international non-profit organisations, as well as less formal networks and representatives of specific lobby groups in trade and industry and other sectors of society. Agenda 21 has involved a very large number of local organisations in the climate issue. These include farming associations, sports clubs, youth organisations, adult education associations etc. Several organisations have already been described above under other headings.

The Swedish Society for Nature Conservation is very actively involved in the climate issue. It instigated the "Challenger Municipalities" project described above. The society is one of the organisations involved in the Klimat.nu campaign, which has also been described above.

The society also distributes information to its members via newsletters, the magazine for members, seminars and its website. The society also plays an active role in public debate, participating in discussion programmes on TV and radio. The World Wildlife Fund conducts international campaigns, but also operates nationally in Sweden. Its Swedish activities include its magazine for members (WWF Eko), seminars and lectures. WWF activities in Sweden have attracted a certain amount of media coverage.

References

Läroplaner: Lpfö98, Lpo94 och Lpf94 (Swedish schools curricula)

Collier, U. & Löfstedt, R. (Eds.) Cases in Climate Change Policy: political reality in the European Union. Earthscan, London, 1997

Swedish Environmental Protection Agency. Förprojekt klimatinformation ("Preliminary project - climate information"). Swedish Environmental Protection Agency, 16 May 2000

SIFO Research & Consulting AB. Allmänheten om klimatförändringar (Market research report: "Public awareness of climate change"). Projektnummer 3806400. SIFO, Stockholm 2000.

National Agency for Higher Education. Miljöperspektiv i utbildningen, hur då? ("How to incorporate the environmental dimension in education"). National Agency for Higher Education, 2000.

Svenska Ekodemiker. Ekodemisk granskning 2000 ("Swedish Ecodemics – Ecodemic Report 2000"). Svenska Ekodemiker, 2000.

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

SWECLIM (Swedish Regional Climate Modelling Programme). Ökad säkerhet i klimatfrågan ("Greater certainty on the climate issue"), SWECLIM's Annual Report 2000. SWECLIM, 2001.

Swedish Environmental Protection Agency. Från ord till handling - Nationell kommunikationsstrategi för Agenda 21 ("From words to deeds – National transport and communications strategy for Agenda 21"), Report 5059. Swedish Environmental Protection Agency publications, Stockholm, 2000.

Förslag till svensk klimatstrategi. Slutbetänkande SOU 2000:23 av Klimatkommittén (Commission for Measures to Combat Climate Change: "Proposed Climate Strategy" Final Report SOU 2000:23). Fritzes offentliga publikationer . Stockholm, 2000.
Swedish Consumer Agency. Årsredovisning 2000 ("Annual Report 2000"). Swedish Consumer Agency, 2001.

Swedish Consumer Agency. Bilar, bränsleförbrukning och vår miljö ("Cars, fuel consumption and our environment") Swedish Consumer Agency brochure, 2000.

Government Communication 1997/98:13 om ekologisk hållbarhet ("Ecological sustainability").

Regeringens skrivelse 1998/99:5. Hållbara Sverige – uppföljning och fortsatta åtgärder för en ekologisk hållbar utveckling. ("Sustainable Sweden – determining the effectiveness of measures to achieve ecologically sustainable development, and further measures").

Ministry of the Environment, 1999

Swedish Government Official Report. Konsumenterna och miljön : betänkande SOU 1996:108 av utredningen om konsumenterna och miljön ("Report by the Commission on Consumers and the Environment"). SOU 1996:108. Fritzes offentliga publikationer. Stockholm, 1996.

Katarina Eckerberg och Pia Brundin. Lokal Agenda 21 – en studie av tio svenska kommuner ("Local Agenda 21 – a study of ten Swedish municipalities"). Ministry of the Environment and Swedish Association of Local Authorities, Stockholm, 2000.

Anders Berndtsson, Carl Odelberg, Lars Palm. Högre bensinskatt eller vänlig övertalning? – Att påverka fordonsförares miljötänkande och miljöbeteende ("High petrol tax or simple persuasion? – Influencing the environmental awareness and behaviour of motorists"). Vetlanda municipality.

National Road Administration. Årsredovisning 2000 ("Annual Report 2000"). National Road Administration, 2001.

National Road Administration. Transporter – också en fråga om miljö och säkerhet ("Transport – environment and safety issues"), 4 brochures, National Road Administration.

En enkätundersökning, svenska kommuners arbete med Agenda 21 ("Results from a questionnaire on Swedish municipalities and Agenda 21"), Kommentus förlag, 1999

Swedish Consumer Agency. Konsumentverkets svar på regeringsuppdrag om mål i konsumentpolitiken ("Report to the government on consumer policy objectives"), Dnr. 2000/4639 Ordn. Nr. 20

Eftergymnasial Miljöutbildning 2001 ("The environment in further education"), article in the periodical Kretslopp, No. 1/2000

Appendices

1. Tables of emissions and removals of greenhouse gases 1990 – 1999, revised in line with IPCC guidelines
2. Acronyms and abbreviations
3. Normal-year correction of greenhouse gas emissions, method description and results
4. Method description and background data for projected emissions of carbon dioxide from the energy sector
    - A. Method for scenario calculations
    - B. Statistics and scenarios
    - C. Tables – Underlying assumptions
5. Bilateral and regional funding related to implementation of the Climate Convention, 1997 – 2000

Appendix 1 – Tables of emissions and removals of greenhouse gases 1990 – 1999, revised in line with IPCC guidelines

Values revised in this submission (November 2001) are shown in italics.

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1990.**
Sheet 1 of 3. **Revised submission. November 2001.**

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	*55 994.37*	-20 291.96	*324.30*	*23.12*	0.00	1.12	0.00	440.05	0.00	0.00	*348.87*	*1 113.31*	*516.63*	*110.28*
1. Energy	*51 713.43*		*37.08*	*5.73*							*335.15*	*1 099.10*	*394.02*	*82.33*
A. Fuel Combustion Reference Approach[2]	53 290.17													
Sectoral Approach[2]	*51 438.74*		*37.08*	5.73							*334.86*	*1 099.00*	*368.69*	*77.98*
1. Energy Industries	10 170.40		1.10	1.34							16.44	7.20	10.23	19.06
2. Manufacturing Industries and Construction	*11 775.66*		*2.31*	*1.80*							*56.57*	*35.99*	*14.07*	*25.08*
3. Transport	18 736.19		23.16	1.46							220.71	905.16	202.36	16.34
4. Other Sectors	10 672.87		10.51	1.14							41.13	150.65	142.03	17.50
5. Other	83.63		IE	IE							IE	IE	IE	IE
B. Fugitive Emissions from Fuels	274.69		0.00	0.01							0.29	0.10	25.33	4.35
1. Solid Fuels	252.62		0.00	0.01							0.00	0.03	0.01	0.16
2. Oil and Natural Gas	22.07		NE	NE							0.29	0.07	25.33	4.19
2. Industrial Processes	***4 170.15***		**0.23**	***2.81***	**0.00**	**1.12**	**0.00**	**440.05**	**0.00**	**0.00**	**13.72**	**14.21**	**25.02**	**27.95**
A. Mineral Products	1 764.97		NE	*0.05*							0.14	0.00	0.51	4.25
B. Chemical Industry	NE		0.00	2.63	NO	NO	NO	NO	NO	NO	2.23	NE	6.00	6.04
C. Metal Production	*2 374.18*		NE	NE				440.05		0.00	0.90	2.24	0.11	4.85
D. Other Production[3]	0.00										10.46	11.96	18.40	12.82
E. Production of Halocarbons and SF_6						NO		NO		NO				
F. Consumption of Halocarbons and SF_6					NE	1.12	NE	0.00	NE	0.00				
G. Other	31.00		0.23	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

P=Potential emissions based on Tier 1 approach of the IPCC Guidelines.
A=Actual emissions based on Tier 2 approach of the IPCC Guidelines.
[1] *The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2[II] of this common reporting format.*
[2] *For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.*
[3] *Other Production includes Pulp and Paper and Food and Drink Production.*

Note: *The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1990.**
Sheet 2 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A (CO_2 equivalent (Gg))	PFCs[1] P (CO_2 equivalent (Gg))	PFCs[1] A (CO_2 equivalent (Gg))	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
3. Solvent and Other Product Use	**110.79**			**NE**									**97.59**	
4. Agriculture	**0.00**	**0.00**	**165.38**	**14.58**							**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation			153.30											
B. Manure Management			12.09	2.35									IE	
C. Rice Cultivation			NO										NO	
D. Agricultural Soils	[4]	[4]	IE	12.23									IE	
E. Prescribed Burning of Savannas			NO	NO							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			NO	NO							NO	NO	NO	
G. Other			NO	NO							NO	NO	NO	
5. Land-Use Change and Forestry	**[5]0.00**	**[5]-20 291.96**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	[5]0.00	[5]-24 100.00												
B. Forest and Grassland Conversion	[5]0.00		0.00	0.00							0.00	0.00		
C. Abandonment of Managed Lands	[5]0.00	[5]0.00												
D. CO_2 Emissions and Removals from Soil	[5]3 808.04	[5]0.00												
E. Other	[5]0.00	[5]0.00	0.00	0.00							0.00	0.00		
6. Waste	**0.00**		**121.61**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	[6]NO		121.61									IE	IE	
B. Wastewater Handling			NE	NE							NE	NE	NE	
C. Waste Incineration	[6]IE		IE	IE							0.00	0.00	0.00	0.00
D. Other	NE		NE	NE							NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

[4]According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO_2 emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables. 27) allows for reporting CO_2 emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table 8(a) (Recalculation – Recalculated data) and Table 10 (Emission trends).
[5]Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[6]Note that CO_2 from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 3 of 3.

Sweden 1990.
Submission 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Memo Items:[7]														
International Bunkers	**3 989.00**		**0.00**	**0.00**							**52.00**	**7.00**	**2.00**	**17.00**
Aviation	1 826.00		0.00	NE							4.00	4.00	1.00	0.00
Marine	2 163.00		NE	NE							48.00	3.00	1.00	17.00
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass	**11 360.76**													

[7] *Memo Items are not included in the national totals.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 1 of 3.

Sweden 1991.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
Total National Emissions and Removals	***56 660.34***	**-29 327.65**	**321.19**	***22.39***	**0.00**	**2.91**	**0.00**	**427.31**	**0.00**	**0.00**	***340.15***	***1 068.95***	**512.51**	***101.02***
1. Energy	***52 472.05***		***37.01***	***5.68***							***326.67***	***1 054.96***	**389.77**	***73.64***
A. Fuel Combustion Reference Approach[2]	52 965.13													
Sectoral Approach[2]	*52 207.04*		37.01	5.67							*326.14*	*1 054.87*	367.29	*69.50*
1. Energy Industries	11 280.19		1.27	1.37							14.94	8.15	12.14	14.76
2. Manufacturing Industries and Construction	*11 550.30*		*2.25*	*1.82*							*57.30*	30.79	11.21	*26.77*
3. Transport	18 806.68		22.96	1.36							213.04	865.17	201.66	11.34
4. Other Sectors	10 486.23		10.53	1.13							40.87	150.75	142.29	16.63
5. Other	83.65		IE	IE							IE	IE	IE	IE
B. Fugitive Emissions from Fuels	265.00		0.00	0.01							0.53	0.09	22.48	4.14
1. Solid Fuels	247.45		0.00	0.01							0.26	0.03	0.01	0.16
2. Oil and Natural Gas	17.55		NE	NE							0.26	0.07	22.48	3.98
2. Industrial Processes	***4 077.51***		**0.23**	***2.69***	**0.00**	**2.91**	**0.00**	**427.31**	**0.00**	**0.00**	**13.49**	**13.99**	**25.15**	**27.38**
A. Mineral Products	1 621.90		NE	*0.05*							0.14	0.00	0.51	4.00
B. Chemical Industry	NE		0.00	2.50	NO	NO	NO	NO	NO	NO	2.14	NE	6.00	4.98
C. Metal Production	*2 424.61*		NE	NE				426.51		0.00	0.84	1.86	0.09	5.34
D. Other Production[3]	0.00										10.38	12.13	18.55	13.06
E. Production of Halocarbons and SF_6						NO		NO		NO				
F. Consumption of Halocarbons and SF_6					NE	2.91	NE	0.80	NE	0.00				
G. Other	31.00		0.23	0.14	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE

P=Potential emissions based on Tier 1 approach of the IPCC Guidelines.
A=Actual emissions based on Tier 2 approach of the IPCC Guidelines.
[1] *The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2(II) of this common reporting format.*
[2] *For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.*
[3] *Other Production includes Pulp and Paper and Food and Drink Production.*

Note: *The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 2 of 3.

Sweden 1991.
Submission 2001.

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
3. Solvent and Other Product Use	**110.79**			**NE**									**97.59**	
4. Agriculture	**0.00**	**0.00**	**160.21**	**14.03**							**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation			148.47											
B. Manure Management			11.74	2.30									IE	
C. Rice Cultivation			NO										NO	
D. Agricultural Soils	[4]	[4]	IE	11.73									IE	
E. Prescribed Burning of Savannas			NO	NO							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			NO	NO							NO	NO	NO	
G. Other			NO	NO							NO	NO	NO	
5. Land-Use Change and Forestry	[5]**0.00**	[5]**-29 327.65**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	[5]0.00	[5]-33 100.00												
B. Forest and Grassland Conversion	[5]0.00		0.00	0.00							0.00	0.00		
C. Abandonment of Managed Lands	[5]0.00	[5]0.00												
D. CO_2 Emissions and Removals from Soil	[5]3 772.35	[5]0.00												
E. Other	[5]0.00	[5]0.00	0.00	0.00							0.00	0.00		
6. Waste	**0.00**		**123.74**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	[6]NO		123.74									IE	IE	
B. Wastewater Handling			NE	NE							NE	NE	NE	
C. Waste Incineration	[6]IE		IE	IE							0.00	0.00	0.00	0.00
D. Other	NE		NE	NE							NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	**0.00**	**0.00**

[4] According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO_2 emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables. 27) allows for reporting CO_2 emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table 8(a) (Recalculation – Recalculated data) and Table 10 (Emission trends).
[5] Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[6] Note that CO_2 from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1991.**
Sheet 3 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
Memo Items:[7]														
International Bunkers	**4 470.00**		**0.10**	**0.00**							**52.20**	**6.20**	**1.50**	**15.00**
Aviation	1 910.00		0.10	NE							4.20	3.70	0.50	0.00
Marine	2 560.00		NE	NE							48.00	2.50	1.00	15.00
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass	**11 759.70**													

[7] *Memo Items are not included in the national totals.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1992.**
Sheet 1 of 3. **Revised submission. November 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
Total National Emissions and Removals	***54 957.66***	**-23 353.08**	**327.52**	***21.89***	**0.00**	**4.49**	**0.00**	**413.77**	**0.00**	**0.00**	**328.42**	**1 065.10**	**490.06**	**88.55**
1. Energy	**50 648.76**		**36.00**	**5.53**							**315.41**	**1 051.02**	**368.23**	**62.68**
A. Fuel Combustion Reference Approach[2]	50 781.91													
Sectoral Approach[2]	50 434.21		36.00	5.53							314.94	1 050.92	348.54	58.67
1. Energy Industries	11 319.44		1.25	1.39							14.25	8.12	6.96	14.14
2. Manufacturing Industries and Construction	10 260.70		2.59	1.68							52.24	37.36	14.55	23.37
3. Transport	19 031.50		21.65	1.39							208.92	855.92	185.31	9.27
4. Other Sectors	9 738.94		10.50	1.08							39.53	149.51	141.72	11.89
5. Other	83.63		IE	IE							IE	IE	IE	IE
B. Fugitive Emissions from Fuels	214.56		0.00	0.00							0.46	0.11	19.69	4.02
1. Solid Fuels	194.40		0.00	0.00							0.14	0.02	0.00	0.16
2. Oil and Natural Gas	20.15		NE	NE							0.32	0.08	19.69	3.86
2. Industrial Processes	***4 198.10***		**0.23**	***2.68***	**0.00**	**4.49**	**0.00**	**413.77**	**0.00**	**0.00**	**13.01**	**14.08**	**24.24**	**25.87**
A. Mineral Products	1 521.51		NE	*0.05*							0.19	0.00	0.40	3.75
B. Chemical Industry	NE		0.00	2.50	NO	NO	NO	NO	NO	NO	2.00	NE	5.65	4.80
C. Metal Production	*2 645.60*		NE	NE				412.97		0.00	0.86	2.00	0.10	4.56
D. Other Production[3]	0.00										9.96	12.08	18.09	12.76
E. Production of Halocarbons and SF_6						NO		NO		NO				
F. Consumption of Halocarbons and SF_6					NE	4.49	NE	0.80	NE	0.00				
G. Other	31.00		0.23	0.13	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE

P=Potential emissions based on Tier 1 approach of the IPCC Guidelines.
A=Actual emissions based on Tier 2 approach of the IPCC Guidelines.
[1]The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2[II] of this common reporting format.
[2]For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.
[3]Other Production includes Pulp and Paper and Food and Drink Production.

Note: *The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1992.**
Sheet 2 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A (CO_2 equivalent (Gg))	PFCs[1] P (CO_2 equivalent (Gg))	PFCs[1] A (CO_2 equivalent (Gg))	SF_6 P (CO_2 equivalent (Gg))	SF_6 A (CO_2 equivalent (Gg))	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
3. Solvent and Other Product Use	**110.79**			**NE**									**97.59**	
4. Agriculture	**0.00**	**0.00**	**167.17**	**13.67**							**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation			154.11											
B. Manure Management			13.06	2.24									IE	
C. Rice Cultivation			NO										NO	
D. Agricultural Soils	[4]	[4]	IE	11.43									IE	
E. Prescribed Burning of Savannas			NO	NO							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			NO	NO							NO	NO	NO	
G. Other			NO	NO							NO	NO	NO	
5. Land-Use Change and Forestry	**[5]0.00**	**[5]-23 353.08**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	[5]0.00	[5]-27 100.00												
B. Forest and Grassland Conversion	[5]0.00		0.00	0.00							0.00	0.00		
C. Abandonment of Managed Lands	[5]0.00	[5]0.00												
D. CO2 Emissions and Removals from Soil	[5]3 808.04	[5]0.00												
E. Other	[5]0.00	[5]0.00	0.00	0.00							0.00	0.00		
6. Waste	**0.00**		**124.12**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	[6]NO		124.12									IE	IE	
B. Wastewater Handling			NE	NE							NE	NE	NE	
C. Waste Incineration	[6]IE		IE	IE							0.00	0.00	0.00	0.00
D. Other	NE		NE	NE							NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**

[4]According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO_2 emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables. 27) allows for reporting CO_2 emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table 8(a) (Recalculation – Recalculated data) and Table 10 (Emission trends).
[5]Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[6]Note that CO_2 from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1992.**
Sheet 3 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Memo Items:[7]														
International Bunkers	**5 053.00**		**0.05**	**0.00**							**54.00**	**6.20**	**1.43**	**15.00**
Aviation	2 133.00		0.05	NE							4.00	3.70	0.43	0.00
Marine	2 920.00		NE	NE							50.00	2.50	1.00	15.00
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass	**12 716.44**													

[7] *Memo Items are not included in the national totals.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 1 of 3.

Sweden 1993.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO₂ equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
Total National Emissions and Removals	**54 878.81**	**-29 332.10**	**325.19**	***22.43***	**0.00**	**17.06**	**0.00**	**402.13**	**0.00**	**0.00**	**319.19**	**1 024.77**	**480.58**	**79.45**
1. Energy	**50 533.12**		**35.67**	**5.68**							**305.91**	**1 010.22**	**358.26**	**53.91**
A. Fuel Combustion Reference Approach[2]	51 641.38													
Sectoral Approach[2]	50 280.80		35.67	5.67							305.48	1 010.11	341.45	50.19
1. Energy Industries	10 829.43		1.58	1.37							14.81	9.54	6.48	14.21
2. Manufacturing Industries and Construction	11 417.93		2.55	1.77							52.31	37.30	14.35	19.79
3. Transport	18 236.67		20.95	1.46							200.21	812.65	177.64	8.27
4. Other Sectors	9 712.87		10.60	1.08							38.15	150.61	142.98	7.92
5. Other	83.90		IE	IE							IE	IE	IE	IE
B. Fugitive Emissions from Fuels	252.32		0.00	0.00							0.43	0.11	16.80	3.72
1. Solid Fuels	235.38		0.00	0.00							0.15	0.02	0.00	0.06
2. Oil and Natural Gas	16.94		NE	NE							0.29	0.08	16.80	3.66
2. Industrial Processes	**4 234.90**		**0.24**	***2.69***	**0.00**	**17.06**	**0.00**	**402.13**	**0.00**	**0.00**	**13.28**	**14.55**	**24.74**	**25.54**
A. Mineral Products	1 536.79		NE	*0.05*							0.05	0.00	0.30	4.09
B. Chemical Industry	NE		0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	1.92	0.00	5.70	4.28
C. Metal Production	2 667.11		NE	NE				399.43		0.00	0.88	2.13	0.11	4.44
D. Other Production[3]	0.00										10.43	12.43	18.63	12.74
E. Production of Halocarbons and SF_6						NO		NO		NO				
F. Consumption of Halocarbons and SF_6					NE	17.06	NE	2.70	NE	0.00				
G. Other	31.00		0.23	0.14	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE

P=Potential emissions based on Tier 1 approach of the IPCC Guidelines.
A=Actual emissions based on Tier 2 approach of the IPCC Guidelines.
[1]The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2[II] of this common reporting format.
[2]For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.
[3]Other Production includes Pulp and Paper and Food and Drink Production.

Note: *The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1993.**
Sheet 2 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
3. Solvent and Other Product Use	**110.79**			**NE**									**97.59**	
4. Agriculture	**0.00**	**0.00**	**169.50**	**14.06**							**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation			155.43											
B. Manure Management			14.07	2.14									IE	
C. Rice Cultivation			NO										NO	
D. Agricultural Soils	[4]	[4]	IE	11.92									IE	
E. Prescribed Burning of Savannas			NO	NO							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			NO	NO							NO	NO	NO	
G. Other			NO	NO							NO	NO	NO	
5. Land-Use Change and Forestry	**[5]0.00**	**[5]-29 332.10**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	[5]0.00	[5]-33 100.00												
B. Forest and Grassland Conversion	[5]0.00		0.00	0.00							0.00	0.00		
C. Abandonment of Managed Lands	[5]0.00	[5]0.00												
D. CO2 Emissions and Removals from Soil	[5]3 767.90	[5]0.00												
E. Other	[5]0.00	[5]0.00	0.00	0.00							0.00	0.00		
6. Waste	**0.00**		**119.77**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	[6]NO		119.77									IE	IE	
B. Wastewater Handling			NE	NE							NE	NE	NE	
C. Waste Incineration	[6]IE		IE	IE							0.00	0.00	0.00	0.00
D. Other	NE		NE	NE							NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	**0.00**	**0.00**

[4] *According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO_2 emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables. 27) allows for reporting CO_2 emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table 8(a) (Recalculation – Recalculated data) and Table 10 (Emission trends).*

[5] *Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).*

[6] *Note that CO_2 from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1993.**
Sheet 3 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Memo Items:[7]														
International Bunkers	**4 752.00**		**0.05**	**0.00**							**54.00**	**6.20**	**1.43**	**15.00**
Aviation	1 820.00		0.05	NE							4.00	3.70	0.43	0.00
Marine	2 932.00		NE	NE							50.00	2.50	1.00	15.00
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass	**13 577.18**													

[7] *Memo Items are not included in the national totals.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1994.**
Sheet 1 of 3. **Revised submission. November 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
Total National Emissions and Removals	**59 232.82**	**-26 305.35**	**320.20**	***22.96***	**0.00**	**46.86**	**0.00**	**389.74**	**0.00**	**0.00**	**334.52**	**1 005.81**	**476.16**	**80.84**
1. Energy	**54 738.64**		**35.04**	**6.24**							**321.30**	**991.97**	**352.49**	**56.69**
A. Fuel Combustion Reference Approach[2]	54 271.13													
Sectoral Approach[2]	54 359.72		35.04	6.23							320.84	991.86	338.19	53.26
1. Energy Industries	13 119.17		1.87	1.60							16.26	11.24	14.95	14.54
2. Manufacturing Industries and Construction	12 861.03		2.77	1.97							61.69	27.26	12.42	23.09
3. Transport	18 561.03		20.42	1.53							200.23	812.61	176.95	8.23
4. Other Sectors	9 736.25		9.98	1.13							42.65	140.74	133.86	7.40
5. Other	82.25		IE	IE							IE	IE	IE	IE
B. Fugitive Emissions from Fuels	378.92		0.00	0.01							0.46	0.11	14.30	3.43
1. Solid Fuels	367.85		0.00	0.01							0.23	0.04	0.01	0.17
2. Oil and Natural Gas	11.06		NE	NE							0.23	0.07	14.30	3.26
2. Industrial Processes	**4 383.38**		**0.22**	***2.46***	**0.00**	**46.86**	**0.00**	**389.74**	**0.00**	**0.00**	**13.22**	**13.84**	**26.08**	**24.15**
A. Mineral Products	1 628.56		NE	*0.05*							0.04	0.00	0.35	4.42
B. Chemical Industry	NE		0.00	2.28	NO	NO	NO	NO	NO	NO	1.76	NE	5.50	4.29
C. Metal Production	2 723.82		NE	NE				385.89		0.00	0.91	2.32	0.11	4.03
D. Other Production[3]	0.00										10.52	11.53	20.13	11.42
E. Production of Halocarbons and SF_6					NO					NO	NO			
F. Consumption of Halocarbons and SF_6					NE	46.86	NE	3.85	NE	0.00				
G. Other	31.00		0.22	0.14	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE

P=Potential emissions based on Tier 1 approach of the IPCC Guidelines.
A=Actual emissions based on Tier 2 approach of the IPCC Guidelines.
[1]*The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2[II] of this common reporting format.*
[2]*For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.*
[3]*Other Production includes Pulp and Paper and Food and Drink Production.*

Note: *The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1994.**
Sheet 2 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO₂ equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
3. Solvent and Other Product Use	**110.79**			**NE**									**97.59**	
4. Agriculture	**0.00**	**0.00**	**170.38**	**14.26**							**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation			155.19											
B. Manure Management			15.19	2.16									IE	
C. Rice Cultivation			NO										NO	
D. Agricultural Soils	[4]	[4]	IE	12.10									IE	
E. Prescribed Burning of Savannas			NO	NO							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			NO	NO							NO	NO	NO	
G. Other			NO	NO							NO	NO	NO	
5. Land-Use Change and Forestry	[5]**0.00**	[5]**-26 305.35**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	[5]0.00	[5]-30 100.00												
B. Forest and Grassland Conversion	[5]0.00		0.00	0.00							0.00	0.00		
C. Abandonment of Managed Lands	[5]0.00	[5]0.00												
D. CO_2 Emissions and Removals from Soil	[5]3 794.65	[5]0.00												
E. Other	[5]0.00	[5]0.00	0.00	0.00							0.00	0.00		
6. Waste	**0.00**		**114.55**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	[6]NO		114.55									IE	IE	
B. Wastewater Handling			NE	NE							NE	NE	NE	
C. Waste Incineration	[6]IE		IE	IE							0.00	0.00	0.00	0.00
D. Other	NE		NE	NE							NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

[4] *According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO_2 emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables. 27) allows for reporting CO_2 emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table 8(a) (Recalculation – Recalculated data) and Table 10 (Emission trends).*

[5] *Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).*

[6] *Note that CO_2 from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1994.**
Sheet 3 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO₂ equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
Memo Items:[7]														
International Bunkers	**5 263.00**		**0.07**	**0.00**							**54.00**	**6.20**	**0.58**	**15.00**
Aviation	1 811.00		0.07	NE							4.00	3.70	0.58	0.00
Marine	3 452.00		NE	NE							50.00	2.50	NE	15.00
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass	**15 099.54**													

[7] *Memo Items are not included in the national totals.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1995.**

Sheet 1 of 3. **Revised submission. November 2001.**

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**58 521.35**	**-21 292.70**	**316.40**	***22.23***	**739.27**	**93.83**	**2.80**	**389.37**	**0.01**	**0.00**	**309.74**	**993.55**	**471.48**	**68.54**
1. Energy	**53 730.65**		**35.20**	**5.93**							**296.88**	**978.93**	**347.80**	**45.36**
A. Fuel Combustion Reference Approach[2]	57 168.87													
Sectoral Approach[2]	53 389.90		35.19	5.92							296.71	978.82	334.28	44.82
1. Energy Industries	11 575.80		2.11	1.52							15.23	12.28	13.14	14.30
2. Manufacturing Industries and Construction	13 370.06		2.62	1.85							54.78	24.72	11.36	21.26
3. Transport	18 992.77		19.80	1.56							192.00	794.79	167.07	2.59
4. Other Sectors	9 358.98		10.66	0.98							34.70	147.03	142.71	6.67
5. Other	92.30		IE	IE							IE	IE	IE	IE
B. Fugitive Emissions from Fuels	340.74		0.00	0.01							0.17	0.12	13.52	0.54
1. Solid Fuels	329.68		0.00	0.01							0.10	0.03	0.01	0.18
2. Oil and Natural Gas	11.06		NE	NE							0.07	0.08	13.52	0.36
2. Industrial Processes	**4 679.91**		**0.23**	***2.48***	**739.27**	**93.83**	**2.80**	**389.37**	**0.01**	**0.00**	**12.85**	**14.62**	**26.09**	**23.18**
A. Mineral Products	1 801.46		NE	*0.05*							0.04	0.00	0.35	5.62
B. Chemical Industry	NE		0.00	2.29	NO	NO	NO	NO	NO	NO	1.54	NE	5.35	4.19
C. Metal Production	2 847.45		NE	NE				380.47		0.00	0.84	2.39	0.12	3.36
D. Other Production[3]	0.00										10.43	12.23	20.28	10.01
E. Production of Halocarbons and SF_6						NO		NO		NO				
F. Consumption of Halocarbons and SF_6					739.27	93.83	2.80	8.90	0.01	0.00				
G. Other	31.00		0.23	0.14	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE

P=Potential emissions based on Tier 1 approach of the IPCC Guidelines.
A=Actual emissions based on Tier 2 approach of the IPCC Guidelines.
[1]*The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2[II] of this common reporting format.*
[2]*For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.*
[3]*Other Production includes Pulp and Paper and Food and Drink Production.*

Note: *The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 2 of 3.

Sweden 1995.
Submission 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
3. Solvent and Other Product Use	**110.79**			**NE**									**97.59**	
4. Agriculture	**0.00**	**0.00**	**166.72**	**13.83**							**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation			151.78											
B. Manure Management			14.95	1.93									IE	
C. Rice Cultivation			NO										NO	
D. Agricultural Soils	[4]	[4]	IE	11.90									IE	
E. Prescribed Burning of Savannas			NO	NO							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			NO	NO							NO	NO	NO	
G. Other			NO	NO							NO	NO	NO	
5. Land-Use Change and Forestry	**[5]0.00**	**[5]-21 292.70**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	[5]0.00	[5]-25 100.00												
B. Forest and Grassland Conversion	0.00		0.00	0.00							0.00	0.00		
C. Abandonment of Managed Lands	[5]0.00	[5]0.00												
D. CO2 Emissions and Removals from Soil	3 807.30	[5]0.00												
E. Other	0.00	[5]0.00	0.00	0.00							0.00	0.00		
6. Waste	**0.00**		**114.24**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	[6]NO		114.24									IE	IE	
B. Wastewater Handling			NE	NE							NE	NE	NE	
C. Waste Incineration	[6]IE		IE	IE							0.00	0.00	0.00	0.00
D. Other	NE		NE	NE							NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	**0.00**	**0.00**

[4]According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO2 emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables. 27) allows for reporting CO_2 emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table8 (a) (Recalculation – Recalculated data) and Table10 (Emission trends).

[5]Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

[6]Note that CO_2 from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 3 of 3.

Sweden 1995.
Submission 2001.

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO₂ equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
Memo Items:[7]														
International Bunkers	**5 243.00**		**0.07**	**0.08**							**23.81**	**3.43**	**0.51**	**21.92**
Aviation	1 849.00		0.07	NE							4.31	0.73	0.51	0.32
Marine	3 394.00		NE	0.08							19.50	2.70	NE	21.60
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass	**15 889.42**													

[7] *Memo Items are not included in the national totals.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 1 of 3.

Sweden 1996.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs [1] P	HFCs [1] A	PFCs [1] P	PFCs [1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**63 000.93**	**-22 269.05**	**315.83**	***22.91***	**539.60**	**140.72**	**10.50**	**343.34**	**0.01**	**0.00**	**309.43**	**966.19**	**471.01**	**74.34**
1. Energy	**58 107.49**		**35.87**	**6.61**							**296.88**	**951.65**	**347.38**	**50.88**
A. Fuel Combustion Reference Approach[2]	59 258.13													
Sectoral Approach[2]	57 791.18		35.86	6.60							296.72	951.59	331.58	50.04
1. Energy Industries	16 669.01		2.84	2.06							20.44	16.45	15.83	21.87
2. Manufacturing Industries and Construction	12 783.67		2.56	1.87							55.10	24.94	11.31	20.08
3. Transport	18 834.43		19.55	1.65							184.66	759.77	158.35	2.39
4. Other Sectors	9 421.92		10.91	1.02							36.51	150.43	146.09	5.69
5. Other	82.15		IE	IE							IE	IE	IE	IE
B. Fugitive Emissions from Fuels	316.31		0.00	0.01							0.16	0.06	15.80	0.84
1. Solid Fuels	290.73		0.00	0.01							0.09	0.03	0.01	0.18
2. Oil and Natural Gas	25.58		NE	NE							0.07	0.03	15.79	0.67
2. Industrial Processes	**4 782.65**		**0.23**	***2.39***	**539.60**	**140.72**	**10.50**	**343.34**	**0.01**	**0.00**	**12.55**	**14.54**	**26.05**	**23.46**
A. Mineral Products	1 709.11		NE	0.05							0.04	0.00	0.35	4.89
B. Chemical Industry	NE		0.00	2.19	NO	NO	NO	NO	NO	NO	1.41	NE	5.37	4.29
C. Metal Production	3 042.54		NE	NE				330.38		0.00	0.91	2.20	0.12	3.37
D. Other Production[3]	0.00										10.20	12.34	20.22	10.91
E. Production of Halocarbons and SF_6						NO		NO		NO				
F. Consumption of Halocarbons and SF_6					539.60	140.72	10.50	12.96	0.01	0.00				
G. Other	31.00		0.23	0.14	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE

P=Potential emissions based on Tier 1 approach of the IPCC Guidelines.
A=Actual emissions based on Tier 2 approach of the IPCC Guidelines.
[1] *The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2(II) of this common reporting format.*
[2] *For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.*
[3] *Other Production includes Pulp and Paper and Food and Drink Production.*

Note: *The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1996.**
Sheet 2 of 3. **Revised submission. November 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO₂ equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
3. Solvent and Other Product Use	**110.79**			**NE**									**97.59**	
4. Agriculture	**0.00**	**0.00**	**166.94**	**13.92**							**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation			151.98											
B. Manure Management			14.95	1.98									IE	
C. Rice Cultivation			NO										NO	
D. Agricultural Soils	[4]	[4]	IE	11.94									IE	
E. Prescribed Burning of Savannas			NO	NO							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			NO	NO							NO	NO	NO	
G. Other			NO	NO							NO	NO	NO	
5. Land-Use Change and Forestry	**[5]0.00**	**[5]-22 269.05**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	[5]0.00	[5]-26 100.00												
B. Forest and Grassland Conversion	0.00		0.00	0.00							0.00	0.00		
C. Abandonment of Managed Lands	[5]0.00	[5]0.00												
D. CO_2 Emissions and Removals from Soil	[5]3 830.95	[5]0.00												
E. Other	[5]0.00	[5]0.00	0.00	0.00							0.00	0.00		
6. Waste	**0.00**		**112.79**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	[6]NO		112.79									IE	IE	
B. Wastewater Handling			NE	NE							NE	NE	NE	
C. Waste Incineration	[6]IE		IE	IE							0.00	0.00	0.00	0.00
D. Other	NE		NE	NE							NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

[4]According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO_2 emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables. 27) allows for reporting CO_2 emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table 8(a) (Recalculation – Recalculated data) and Table 10 (Emission trends).

[5]Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

[6]Note that CO_2 from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 3 of 3.

Sweden 1996.
Submission 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Memo Items:[7]														
International Bunkers	**5 536.00**		**0.06**	**0.08**							**23.46**	**3.20**	**0.44**	**21.89**
Aviation	1 940.00		0.06	NE							3.96	0.50	0.44	0.29
Marine	3 596.00		NE	0.08							19.50	2.70	NE	21.60
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass	**17 712.58**													

[7] *Memo Items are not included in the national totals.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1997.**
Sheet 1 of 3. **Revised submission. November 2001.**

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Total National Emissions and Removals	**57 087.50**	**-27 287.61**	**310.80**	***22.82***	**849.88**	**239.22**	**12.50**	**315.91**	**0.01**	**0.01**	**291.92**	**883.22**	**442.40**	**65.62**
1. Energy	**52 374.93**		**32.51**	**6.13**							**279.10**	**867.56**	**317.48**	**42.00**
A. Fuel Combustion Reference Approach[2]	53 637.27													
Sectoral Approach[2]	52 114.39		32.51	6.13							278.96	867.51	302.67	41.24
1. Energy Industries	11 491.43		2.42	1.54							14.93	13.69	14.41	14.28
2. Manufacturing Industries and Construction	12 996.78		2.46	1.84							54.89	24.20	10.92	20.13
3. Transport	18 966.37		17.29	1.77							173.91	686.41	143.63	1.68
4. Other Sectors	8 617.39		10.34	0.98							35.24	143.21	133.72	5.15
5. Other	42.41		IE	IE							IE	IE	IE	IE
B. Fugitive Emissions from Fuels	260.54		0.00	0.00							0.14	0.05	14.81	0.76
1. Solid Fuels	233.60		0.00	0.00							0.07	0.02	0.00	0.16
2. Oil and Natural Gas	26.94		NE	NE							0.06	0.03	14.80	0.60
2. Industrial Processes	**4 601.77**		**0.25**	***2.37***	**849.88**	**239.22**	**12.50**	**315.91**	**0.01**	**0.01**	**12.83**	**15.66**	**27.33**	**23.62**
A. Mineral Products	1 642.20		NE	0.05							0.04	0.00	0.28	4.86
B. Chemical Industry	NE		0.00	2.17	NO	NO	NO	NO	NO	NO	1.22	NE	5.39	4.55
C. Metal Production	2 897.57		NE	NE				301.94		0.00	0.90	2.56	0.13	3.56
D. Other Production[3]	31.00										10.67	13.10	21.53	10.64
E. Production of Halocarbons and SF_6						NO		NO		NO				
F. Consumption of Halocarbons and SF_6					849.88	239.22	12.50	13.97	0.01	0.00				
G. Other	31.00		0.25	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

P=Potential emissions based on Tier 1 approach of the IPCC Guidelines.
A=Actual emissions based on Tier 2 approach of the IPCC Guidelines.
[1] *The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2[II] of this common reporting format.*
[2] *For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.*
[3] *Other Production includes Pulp and Paper and Food and Drink Production.*

Note: *The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1997.**
Sheet 2 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
3. Solvent and Other Product Use	**110.79**			**NE**									**97.59**	
4. Agriculture	**0.00**	**0.00**	**166.83**	**14.32**							**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation			152.26											
B. Manure Management			14.57	2.07									IE	
C. Rice Cultivation			NO										NO	
D. Agricultural Soils	[4]	[4]	IE	12.25									IE	
E. Prescribed Burning of Savannas			NO	NO							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			NO	NO							NO	NO	NO	
G. Other					NO		NO				NO	NO	NO	
5. Land-Use Change and Forestry	[5]**0.00**	[5]**-27 287.61**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	[5]0.00	[5]-31 100.00												
B. Forest and Grassland Conversion	0.00		0.00	0.00							0.00	0.00		
C. Abandonment of Managed Lands	[5]0.00	[5]0.00												
D. CO_2 Emissions and Removals from Soil	[5]3 812.39	[5]0.00												
E. Other	[5]0.00	[5]0.00	0.00	0.00							0.00	0.00		
6. Waste	**0.00**		**111.21**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	[6]NO		111.21									IE	IE	
B. Wastewater Handling			NE	NE							NE	NE	NE	
C. Waste Incineration	[6]IE		IE	IE							0.00	0.00	0.00	0.00
D. Other		NE	NE	NE							NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

[4]*According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO_2 emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables. 27) allows for reporting CO_2 emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table 8(a) (Recalculation – Recalculated data) and Table 10 (Emission trends).*

[5]*Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).*

[6]*Note that CO_2 from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 3 of 3.

Sweden 1997.
Submission 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1]		PFCs[1]		SF_6		NO_x	CO	NMVOC	SO_2
	(Gg)				P	A	P	A	P	A	(Gg)			
					CO_2 equivalent (Gg)									
Memo Items:[7]														
International Bunkers	**6 147.00**		**0.09**	**0.10**							**56.21**	**5.98**	**0.66**	**22.12**
Aviation	1 929.00		0.09	NE							7.31	3.28	0.66	0.52
Marine	4 218.00		NE	0.10							48.90	2.70	NE	21.60
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass	**16 264.40**													

[7] *Memo Items are not included in the national totals.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 1 of 3.

Sweden 1998.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
Total National Emissions and Removals	**58 142.10**	**-24 330.90**	**303.59**	***23.66***	**1 522.27**	**303.19**	**10.72**	**305.68**	**0.02**	**0.00**	**277.56**	**956.92**	**434.17**	**65.47**
1. Energy	**53 608.18**		**31.47**	**6.74**							**265.48**	**941.46**	**309.63**	**42.89**
A. Fuel Combustion Reference Approach[2]	52 149.43													
Sectoral Approach[2]	53 311.25		31.47	6.73							265.33	941.40	295.11	42.04
1. Energy Industries	12 671.11		2.56	1.67							16.17	14.60	14.56	15.91
2. Manufacturing Industries and Construction	12 659.82		2.55	2.11							55.38	32.68	12.52	19.77
3. Transport	19 481.27		16.24	1.71							156.78	738.79	136.14	1.56
4. Other Sectors	8 469.58		10.12	1.24							37.00	155.34	131.89	4.80
5. Other	29.47		IE	IE							IE	IE	IE	IE
B. Fugitive Emissions from Fuels	296.92		0.00	0.01							0.15	0.05	14.53	0.85
1. Solid Fuels	277.95		0.00	0.01							0.09	0.03	0.01	0.15
2. Oil and Natural Gas	18.97		NE	NE							0.07	0.02	14.52	0.70
2. Industrial Processes	**4 423.14**		**0.34**	***2.64***	**1 522.27**	**303.19**	**10.72**	**305.68**	**0.02**	**0.00**	**12.08**	**15.46**	**26.95**	**22.58**
A. Mineral Products	1 645.35		NE	*0.05*							0.05	0.00	0.20	6.38
B. Chemical Industry	NE		0.00	2.44	NO	NO	NO	NO	NO	NO	1.24	NE	5.28	4.33
C. Metal Production	2 746.79		NE	NE				292.46		0.00	0.94	2.53	0.10	3.36
D. Other Production[3]	0.00										9.85	12.94	21.37	8.51
E. Production of Halocarbons and SF_6						NO		NO		NO				
F. Consumption of Halocarbons and SF_6					1 522.27	303.19	10.72	13.22	0.02	0.00				
G. Other	31.00		0.33	0.15	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE

P=Potential emissions based on Tier 1 approach of the IPCC Guidelines.
A=Actual emissions based on Tier 2 approach of the IPCC Guidelines.
[1]*The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2(II) of this common reporting format.*
[2]*For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.*
[3]*Other Production includes Pulp and Paper and Food and Drink Production.*

Note: *The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1998.**
Sheet 2 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
3. Solvent and Other Product Use	**110.79**			**NE**									**97.59**	
4. Agriculture	**0.00**	**0.00**	**163.03**	**14.28**							**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation			148.58											
B. Manure Management			14.46	2.03									IE	
C. Rice Cultivation			NO										NO	
D. Agricultural Soils	[4]	[4]	IE	12.25									IE	
E. Prescribed Burning of Savannas			NO	NO							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			NO	NO							NO	NO	NO	
G. Other			NO	NO							NO	NO	NO	
5. Land-Use Change and Forestry	[5]**0.00**	[5]**-24 330.90**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	[5]0.00	[5]-28 100.00												
B. Forest and Grassland Conversion	0.00		0.00	0.00							0.00	0.00		
C. Abandonment of Managed Lands	[5]0.00	[5]0.00												
D. CO_2 Emissions and Removals from Soil	[5]3 769.10	[5]0.00												
E. Other	[5]0.00	[5]0.00	0.00	0.00							0.00	0.00		
6. Waste	**0.00**		**108.75**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	[6]NO		108.75									IE	IE	
B. Wastewater Handling			NE	NE							NE	NE	NE	
C. Waste Incineration	[6]IE		IE	IE							0.00	0.00	0.00	0.00
D. Other	NE		NE	NE							NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	**0.00**	**0.00**

[4] According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO_2 emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables. 27) allows for reporting CO_2 emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table 8(a) (Recalculation – Recalculated data) and Table 10 (Emission trends).
[5] Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[6] Note that CO_2 from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 3 of 3.

Sweden 1998.
Submission 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Memo Items:[7]														
International Bunkers	**6 958.00**		**0.09**	**0.37**							**40.40**	**15.89**	**0.68**	**17.10**
Aviation	2 103.00		0.09	NE							6.70	4.75	0.68	0.50
Marine	4 855.00		NE	0.37							33.70	11.14	NE	16.60
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass	**16 603.52**													

[7] *Memo Items are not included in the national totals.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1999.**

Sheet 1 of 3. **Revised submission. November 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
Total National Emissions and Removals	**56 458.18**	**-24 305.31**	**293.93**	***22.94***	**1 282.15**	**375.34**	**14.29**	**329.16**	**0.02**	**0.00**	**267.24**	**910.64**	**430.84**	**53.72**
1. Energy	**52 022.40**		**30.18**	**6.68**							**255.68**	**895.32**	**306.08**	**37.71**
A. Fuel Combustion Reference Approach[2]	53 520.28													
Sectoral Approach[2]	51 722.44		30.18	6.67							255.53	895.26	291.62	36.91
1. Energy Industries	11 129.40		2.62	1.56							13.86	14.52	16.99	12.37
2. Manufacturing Industries and Construction	11 990.87		2.40	2.04							52.70	31.82	12.19	18.06
3. Transport	19 886.05		14.44	1.84							151.58	603.91	107.95	1.54
4. Other Sectors	8 691.60		10.71	1.24							37.39	245.00	154.50	4.93
5. Other	24.53		IE	IE							IE	IE	IE	IE
B. Fugitive Emissions from Fuels	299.96		0.00	0.01							0.15	0.06	14.46	0.80
1. Solid Fuels	299.96		0.00	0.01							0.09	0.03	0.01	0.16
2. Oil and Natural Gas	NO		NE	NE							0.06	0.03	14.45	0.64
2. Industrial Processes	**4 324.99**		**0.41**	***2.66***	**1 282.15**	**375.34**	**14.29**	**329.16**	**0.02**	**0.00**	**11.56**	**15.32**	**27.17**	**16.01**
A. Mineral Products	1 589.77		NE	*0.07*							0.05	0.00	0.19	0.55
B. Chemical Industry	NE		0.00	2.44	NO	NO	NO	NO	NO	NO	0.56	NE	5.34	4.04
C. Metal Production	2 704.22		NE	NE				321.58		0.00	0.84	2.46	0.11	3.28
D. Other Production[3]	0.00										10.11	12.86	21.54	8.15
E. Production of Halocarbons and SF_6						NO		NO		NO				
F. Consumption of Halocarbons and SF_6					1 282.15	375.34	14.29	7.59	0.02	0.00				
G. Other	31.00		0.41	*0.15*	NO	NO	NO	NO	NO	NO	NE	NE	NE	NE

P=Potential emissions based on Tier 1 approach of the IPCC Guidelines.
A=Actual emissions based on Tier 2 approach of the IPCC Guidelines.
[1]The emissions of HFCs and PFCs are to be expressed as CO_2 equivalent emissions. Data on disaggregated emissions of HFCs and PFCs are to be provided in Table 2[II] of this common reporting format.
[2]For verification purposes, countries are asked to report the results of their calculations using the Reference approach and to explain any differences with the Sectoral approach. Where possible, the calculations using the Sectoral approach should be used for estimating national totals. Do not include the results of both the Reference approach and the Sectoral approach in national totals.
[3]Other Production includes Pulp and Paper and Food and Drink Production.

***Note:** The numbering of footnotes to all tables containing more than one sheet continue to the next sheet. Common footnotes are given only once at the first point of reference.*

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A). **Sweden 1999.**
Sheet 2 of 3. **Submission 2001.**

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	HFCs[1] P (CO_2 equivalent (Gg))	HFCs[1] A (CO_2 equivalent (Gg))	PFCs[1] P (CO_2 equivalent (Gg))	PFCs[1] A (CO_2 equivalent (Gg))	SF_6 P	SF_6 A	NO_x (Gg)	CO (Gg)	NMVOC (Gg)	SO_2 (Gg)
3. Solvent and Other Product Use	**110.79**			**NE**									**97.59**	
4. Agriculture	**0.00**	**0.00**	**161.08**	**13.60**							**0.00**	**0.00**	**0.00**	**0.00**
A. Enteric Fermentation			146.82											
B. Manure Management			14.25	1.94									IE	
C. Rice Cultivation			NO										NO	
D. Agricultural Soils	[4]	[4]	IE	11.66									IE	
E. Prescribed Burning of Savannas			NO	NO							0.00	0.00	0.00	
F. Field Burning of Agricultural Residues			NO	NO							NO	NO	NO	
G. Other			NO	NO							NO	NO	NO	
5. Land-Use Change and Forestry	[5]**0.00**	[5]**-24 305.31**	**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks	[5]0.00	[5]-28 100.00												
B. Forest and Grassland Conversion	[5]0.00		0.00	0.00							0.00	0.00		
C. Abandonment of Managed Lands	[5]0.00	[5]0.00												
D. CO_2 Emissions and Removals from Soil	[5]3 794.69	[5]0.00												
E. Other	[5]0.00	[5]0.00	0.00	0.00							0.00	0.00		
6. Waste	**0.00**		**102.26**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land	[6]NO		102.26									IE	IE	
B. Wastewater Handling			NE	NE							NE	NE	NE	
C. Waste Incineration	[6]IE		IE	IE							0.00	0.00	0.00	0.00
D. Other	NE		NE	NE							NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	**0.00**	**0.00**

[4]According to the IPCC Guidelines (Volume 3. Reference Manual, pp. 4.2, 4.87), CO_2 emissions from agricultural soils are to be included under Land-Use Change and Forestry (LUCF). At the same time, the Summary Report 7A (Volume 1. Reporting Instructions, Tables. 27) allows for reporting CO_2 emissions or removals from agricultural soils, either in the Agriculture sector, under D. Agricultural Soils or in the Land-Use Change and Forestry sector under D. Emissions and Removals from Soil. Parties may choose either way to report emissions or removals from this source in the common reporting format, but the way they have chosen to report should be clearly indicated, by inserting explanatory comments to the corresponding cells of Summary 1.A and Summary 1.B. Double-counting of these emissions or removals should be avoided. Parties should include these emissions or removals consistently in Table 8(a) (Recalculation – Recalculated data) and Table 10 (Emission trends).

[5]Please do not provide an estimate of both CO_2 emissions and CO_2 removals. "Net" emissions (emissions - removals) of CO_2 should be estimated and a single number placed in either the CO_2 emissions or CO_2 removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

[6]Note that CO_2 from Waste Disposal and Incineration source categories should only be included if it stems from non-biogenic or inorganic waste streams.

Summary 1 A. Summary report for national greenhouse gas inventories (IPCC table 7A).
Sheet 3 of 3.

Sweden 1999.
Submission 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	N_2O	HFCs[1] P	HFCs[1] A	PFCs[1] P	PFCs[1] A	SF_6 P	SF_6 A	NO_x	CO	NMVOC	SO_2
	(Gg)				CO_2 equivalent (Gg)						(Gg)			
Memo Items:[7]														
International Bunkers	**6 853.68**		**0.09**	**0.33**							**40.84**	**15.26**	**0.68**	**17.19**
Aviation	2 103.40		0.09	NE							7.14	4.65	0.68	0.59
Marine	4 750.27		NE	0.33							33.70	10.61	NE	16.60
Multilateral Operations	**0.00**		**0.00**	**0.00**							**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass	**16 708.90**													

[7] *Memo Items are not included in the national totals.*

Summary 2. Summary report for CO_2 equivalent emissions.

Sweden 1990.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)[(1)]	***35 702.41***	***6 810.37***	***7 167.04***	**1.12**	**440.05**	**81.26**	***50 202.25***
1. Energy	***51 713.43***	***778.66***	***1 777.45***				***54 269.54***
A. Fuel Combustion (Sectoral Approach)	*51 438.74*	*778.61*	*1 775.82*				*53 993.17*
1. Energy Industries	10 170.40	23.03	415.23				10 608.66
2. Manufacturing Industries and Construction	*11 775.66*	*48.48*	*557.22*				*12 381.35*
3. Transport	18 736.19	486.38	451.05				19 673.62
4. Other Sectors	10 672.87	220.72	352.32				11 245.91
5. Other	83.63	0.00	0.00				83.63
B. Fugitive Emissions from Fuels	274.69	0.06	1.63				276.37
1. Solid Fuels	252.62	0.06	1.63				254.31
2. Oil and Natural Gas	22.07	0.00	0.00				22.07
2. Industrial Processes	***4 170.15***	**4.81**	***870.70***	**1.12**	**440.05**	**81.26**	***5 568.09***
A. Mineral Products	1 764.97	0.00	*15.50*				1 780.47
B. Chemical Industry	NE	0.08	813.75	NO	NO	0.00	813.83
C. Metal Production	*2 374.18*	0.00	0.00		440.05	0.00	*2 814.23*
D. Other Production	0.00						0.00
E. Production of Halocarbons and SF_6				NO	NO	0.00	0.00
F. Consumption of Halocarbons and SF_6				1.12	0.00	81.26	82.38
G. Other	31.00	4.73	41.45	0.00	0.00	0.00	77.18
3. Solvent and Other Product Use	**110.79**		**0.00**				**110.79**
4. Agriculture	**0.00**	**3 473.04**	**4 518.89**				**7 991.93**
A. Enteric Fermentation		3 219.23					3 219.23
B. Manure Management		253.81	727.30				981.11
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils[(2)]		0.00	3 791.59				3 791.59
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[(1)]	**-20 291.96**	**0.00**	**0.00**				**-20 291.96**
6. Waste	**0.00**	**2 553.86**	**0.00**				**2 553.86**
A. Solid Waste Disposal on Land	NO	2 553.86					2 553.86
B. Wastewater Handling		0.00	0.00				0.00
C. Waste Incineration	IE	0.00	0.00				0.00
D. Other	NE	0.00	0.00				0.00
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:							
International Bunkers	**3 989.00**	**0.00**	**0.00**				**3 989.00**
Aviation	1 826.00	0.00	0.00				1 826.00
Marine	2 163.00	0.00	0.00				2 163.00
Multilateral Operations	**0.00**	**0.00**	**0.00**				**0.00**
CO_2 Emissions from Biomass	**11 360.76**						**11 360.76**

[(1)]For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+). [(2)]See footnote 4 to Summary 1.A of this common reporting format.

Summary 2. Summary report for CO_2 equivalent emissions – continued.

Sweden 1990.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-24 100.00	-24 100.00			-24 100.00
B. Forest and Grassland Conversion	0.00		0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	3 808.04	0.00	3 808.04			3 808.04
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	3 808.04	-24 100.00	-20 291.96	0.00	0.00	-20 291.96
	Total CO_2 Equivalent Emissions without Land-Use Change and Forestry[(a)]					*70 494.21*
	Total CO_2 Equivalent Emissions with Land-Use Change and Forestr[(a)]					*50 202.25*

[(a)]*The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.*

Summary 2. Summary report for CO_2 equivalent emissions.

Sweden 1991.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2[1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)[1]	*27 332.69*	*6 745.07*	*6 942.01*	2.91	427.31	82.22	*41 532.20*
1. Energy	*52 472.05*	*777.24*	*1 760.71*				*55 009.99*
A. Fuel Combustion (Sectoral Approach)	*52 207.04*	*777.19*	*1 759.09*				*54 743.31*
1. Energy Industries	11 280.19	26.66	424.49				11 731.34
2. Manufacturing Industries and Construction	*11 550.30*	*47.16*	*564.98*				*12 162.43*
3. Transport	18 806.68	482.18	420.05				19 708.91
4. Other Sectors	10 486.23	221.18	349.56				11 056.97
5. Other	83.65	0.00	0.00				83.65
B. Fugitive Emissions from Fuels	265.00	0.05	1.62				266.68
1. Solid Fuels	247.45	0.05	1.62				249.12
2. Oil and Natural Gas	17.55	0.00	0.00				17.55
2. Industrial Processes	*4 077.51*	4.87	*832.40*	2.91	427.31	82.22	*5 427.21*
A. Mineral Products	1 621.90	0.00	*15.50*				*1 637.40*
B. Chemical Industry	NE	0.08	775.00	NO	NO	0.00	775.08
C. Metal Production	*2 424.61*	0.00	0.00		426.51	0.00	*2 851.12*
D. Other Production	0.00						0.00
E. Production of Halocarbons and SF_6				NO	NO	0.00	0.00
F Consumption of Halocarbons and SF_6				2.91	0.80	82.22	85.92
G. Other	31.00	4.79	41.90	NO	NO	0.00	77.69
3. Solvent and Other Product Use	110.79		0.00				110.79
4. Agriculture	0.00	3 364.49	4 348.90				7 713.39
A. Enteric Fermentation		3 117.87					3 117.87
B. Manure Management		246.61	711.68				958.29
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils[s]		0.00	3 637.23				3 637.23
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[1]	-29 327.65	0.00	0.00				-29 327.65
6. Waste	0.00	2 598.47	0.00				2 598.47
A. Solid Waste Disposal on Land	NO	2 598.47					2 598.47
B. Wastewater Handling		0.00	0.00				0.00
C. Waste Incineration	IE	0.00	0.00				0.00
D. Other	NE	0.00	0.00				0.00
7. Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Memo Items:							
International Bunkers	4 470.00	2.10	0.00				4 472.10
Aviation	1 910.00	2.10	0.00				1 912.10
Marine	2 560.00	0.00	0.00				2 560.00
Multilateral Operations	0.00	0.00	0.00				0.00
CO_2 Emissions from Biomass	11 759.70						11 759.70

[1] *For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).* [2] *See footnote 4 to Summary 1.A of this common reporting format.*

Summary 2. Summary report for CO_2 equivalent emissions – continued.

Sweden 1991.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-33 100.00	-33 100.00			-33 100.00
B. Forest and Grassland Conversion	0.00		0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	3 772.35	0.00	3 772.35			3 772.35
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	3 772.35	-33 100.00	-29 327.65	0.00	0.00	-29 327.65
	Total CO_2 Equivalent Emissions without Land-Use Change and Forestry[a]					*70 859.85*
	Total CO_2 Equivalent Emissions with Land-Use Change and Forestry[a]					*41 532.20*

[a] *The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.*

Summary 2. Summary report for CO_2 equivalent emissions.

Sweden 1992.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)[(1)]	***31 604.58***	**6 877.99**	***6 785.08***	**4.49**	**413.77**	**81.74**	***45 767.64***
1. Energy	**50 648.76**	**756.03**	**1 715.65**				**53 120.43**
A. Fuel Combustion (Sectoral Approach)	50 434.21	755.98	1 714.35				52 904.54
1. Energy Industries	11 319.44	26.31	429.57				11 775.32
2. Manufacturing Industries and Construction	10 260.70	54.48	521.08				10 836.26
3. Transport	19 031.50	454.67	429.35				19 915.52
4. Other Sectors	9 738.94	220.52	334.35				10 293.80
5. Other	83.63	0.00	0.00				83.63
B. Fugitive Emissions from Fuels	214.56	0.04	1.30				215.90
1. Solid Fuels	194.40	0.04	1.30				195.74
2. Oil and Natural Gas	20.15	0.00	0.00				20.15
2. Industrial Processes	***4 198.10***	**4.86**	***832.32***	**4.49**	**413.77**	**81.74**	***5 535.28***
A. Mineral Products	1 521.51	0.00	*15.50*				*1 537.01*
B. Chemical Industry	NE	0.08	775.00	NO	NO	0.00	775.08
C. Metal Production	*2 645.60*	0.00	0.00		412.97	0.00	*3 058.57*
D. Other Production	0.00						0.00
E. Production of Halocarbons and SF_6				NO	NO	0.00	0.00
F. Consumption of Halocarbons and SF_6				4.49	0.80	81.74	87.02
G. Other	31.00	4.78	41.82	NO	NO	0.00	77.60
3. Solvent and Other Product Use	**110.79**		**0.00**				**110.79**
4. Agriculture	0.00	3 510.57	4 237.11				7 747.68
A. Enteric Fermentation		3 236.40					3 236.40
B. Manure Management		274.17	693.05				967.22
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils[(2)]		0.00	3 544.06				3 544.06
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[(1)]	**-23 353.08**	**0.00**	**0.00**				**-23 353.08**
6. Waste	0.00	2 606.53	0.00				2 606.53
A. Solid Waste Disposal on Land	NO	2 606.53					2 606.53
B. Wastewater Handling		0.00	0.00				0.00
C. Waste Incineration	IE	0.00	0.00				0.00
D. Other	NE	0.00	0.00				0.00
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:							
International Bunkers	5 053.00	1.05	0.00				5 054.05
Aviation	2 133.00	1.05	0.00				2 134.05
Marine	2 920.00	0.00	0.00				2 920.00
Multilateral Operations	**0.00**	**0.00**	**0.00**				**0.00**
CO_2 Emissions from Biomass	**12 716.44**						**12 716.44**

[(1)] *For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).* [(2)] *See footnote 4 to Summary 1.A of this common reporting format.*

Summary 2. Summary report for CO_2 equivalent emissions – continued.

Sweden 1992.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-27 100.00	-27 100.00			-27 100.00
B. Forest and Grassland Conversion	0.00		0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	3 746.92	0.00	3 746.92			3 746.92
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	3 746.92	-27 100.00	-23 353.08	0.00	0.00	-23 353.08
	Total CO_2 Equivalent Emissions without Land-Use Change and Forestry[(a)]					*69 120.71*
	Total CO_2 Equivalent Emissions with Land-Use Change and Forestry[(a)]					*45 767.64*

[(a)] *The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.*

Summary 2. Summary report for CO_2 equivalent emissions.

Sweden 1993.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2[1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)[1]	**25 546.71**	**6 828.89**	***6 952.75***	**17.06**	**402.13**	**88.43**	***39 835.97***
1. Energy	**50 533.12**	**749.15**	**1 759.49**				**53 041.76**
A. Fuel Combustion (Sectoral Approach)	50 280.80	749.10	1 757.99				52 787.89
1. Energy Industries	10 829.43	33.14	424.89				11 287.46
2. Manufacturing Industries and Construction	11 417.93	53.47	548.10				12 019.50
3. Transport	18 236.67	439.97	451.05				19 127.69
4. Other Sectors	9 712.87	222.51	333.95				10 269.34
5. Other	83.90	0.00	0.00				83.90
B. Fugitive Emissions from Fuels	252.32	0.05	1.50				253.87
1. Solid Fuels	235.38	0.05	1.50				236.93
2. Oil and Natural Gas	16.94	0.00	0.00				16.94
2. Industrial Processes	**4 234.90**	**5.00**	***833.58***	**17.06**	**402.13**	**88.43**	***5 581.09***
A. Mineral Products	1 536.79	0.00	*15.50*				*1 552.29*
B. Chemical Industry	NE	0.08	775.00	0.00	0.00	0.00	775.08
C. Metal Production	2 667.11	0.00	0.00		399.43	17.93	3 084.46
D. Other Production	0.00						0.00
E. Production of Halocarbons and SF_6				NO	NO	0.00	0.00
F. Consumption of Halocarbons and SF_6				17.06	2.70	70.51	90.26
G. Other	31.00	4.91	43.08	NO	NO	0.00	78.99
3. Solvent and Other Product Use	**110.79**		**0.00**				**110.79**
4. Agriculture	**0.00**	**3 559.50**	**4 359.69**				**7 919.19**
A. Enteric Fermentation		3 264.04					3 264.04
B. Manure Management		295.46	664.18				959.63
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils[2]		0.00	3 695.51				3 695.51
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[1]	**-29 332.10**	**0.00**	**0.00**				**-29 332.10**
6. Waste	**0.00**	**2 515.24**	**0.00**				**2 515.24**
A. Solid Waste Disposal on Land	NO	2 515.24					2 515.24
B. Wastewater Handling		0.00	0.00				0.00
C. Waste Incineration	IE	0.00	0.00				0.00
D. Other	NE	0.00	0.00				0.00
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:							
International Bunkers	**4 752.00**	**1.05**	**0.00**				**4 753.05**
Aviation	1 820.00	1.05	0.00				1 821.05
Marine	2 932.00	0.00	0.00				2 932.00
Multilateral Operations	**0.00**	**0.00**	**0.00**				**0.00**
CO_2 Emissions from Biomass	**13 577.18**						**13 577.18**

[1]For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+). [2]See footnote 4 to Summary 1.A of this common reporting format.

Summary 2. Summary report for CO_2 equivalent emissions – continued.

Sweden 1993.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-33 100.00	-33 100.00			-33 100.00
B. Forest and Grassland Conversion	0.00		0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	3 767.90	0.00	3 767.90			3 767.90
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	3 767.90	-33 100.00	-29 332.10	0.00	0.00	-29 332.10
	Total CO_2 Equivalent Emissions without Land-Use Change and Forestry[a]					*69 168.06*
	Total CO_2 Equivalent Emissions with Land-Use Change and Forestry[a]					*39 835.97*

[a] *The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.*

Summary 2. Summary report for CO_2 equivalent emissions.

Sweden 1994.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)[1]	**32 927.47**	**6 724.15**	***7 117.73***	**46.86**	**389.74**	**96.80**	***47 302.74***
1. Energy	**54 738.64**	**735.91**	**1 934.76**				**57 409.31**
A. Fuel Combustion (Sectoral Approach)	54 359.72	735.83	1 932.41				57 027.96
1. Energy Industries	13 119.17	39.21	497.41				13 655.79
2. Manufacturing Industries and Construction	12 861.03	58.09	610.96				13 530.08
3. Transport	18 561.03	428.86	473.68				19 463.57
4. Other Sectors	9 736.25	209.67	350.36				10 296.27
5. Other	82.25	0.00	0.00				82.25
B. Fugitive Emissions from Fuels	378.92	0.08	2.35				381.35
1. Solid Fuels	367.85	0.08	2.35				370.28
2. Oil and Natural Gas	11.06	0.00	0.00				11.06
2. Industrial Processes	**4 383.38**	**4.64**	***762.75***	**46.86**	**389.74**	**96.80**	***5 684.17***
A. Mineral Products	1 628.56	0.00	*15.50*				*1 644.06*
B. Chemical Industry	NE	0.08	705.25	NO	NO	0.00	705.33
C. Metal Production	2 723.82	0.00	0.00		385.89	26.29	3 136.00
D. Other Production	0.00						0.00
E. Production of Halocarbons and SF_6				NO	NO	0.00	0.00
F. Consumption of Halocarbons and SF_6				46.86	3.85	70.51	121.21
G. Other	31.00	4.56	42.00	NO	NO	0.00	77.56
3. Solvent and Other Product Use	**110.79**		**0.00**				**110.79**
4. Agriculture	**0.00**	**3 578.07**	**4 420.22**				**7 998.28**
A. Enteric Fermentation		3 259.06					3 259.06
B. Manure Management		319.01	669.53				988.54
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils[2]		0.00	3 750.68				3 750.68
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[1]	**-26 305.35**	**0.00**	**0.00**				**-26 305.35**
6. Waste	**0.00**	**2 405.54**	**0.00**				**2 405.54**
A. Solid Waste Disposal on Land	NO	2 405.54					2 405.54
B. Wastewater Handling		0.00	0.00				0.00
C. Waste Incineration	IE	0.00	0.00				0.00
D. Other	NE	0.00	0.00				0.00
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:							
International Bunkers	**5 263.00**	**1.47**	**0.00**				**5 264.47**
Aviation	**1 811.00**	**1.47**	**0.00**				**1 812.47**
Marine	3 452.00	0.00	0.00				3 452.00
Multilateral Operations	0.00	0.00	0.00				0.00
CO_2 Emissions from Biomass	**15 099.54**						**15 099.54**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+). [2] See footnote 4 to Summary 1.A of this common reporting format.

Summary 2. Summary report for CO_2 equivalent emissions – continued.

Sweden 1994.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-30 100.00	-30 100.00			-30 100.00
B. Forest and Grassland Conversion	0.00		0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	3 794.65	0.00	3 794.65			3 794.65
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	3 794.65	-30 100.00	-26 305.35	0.00	0.00	-26 305.35
	Total CO_2 Equivalent Emissions without Land-Use Change and Forestry[a]					*73 608.09*
	Total CO_2 Equivalent Emissions with Land-Use Change and Forestry[a]					*47 302.74*

[a] *The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.*

Summary 2. Summary report for CO_2 equivalent emissions.

Sweden 1995.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)[1]	**37 228.64**	**6 644.30**	***6 892.35***	**93.83**	**389.37**	**114.72**	***51 363.21***
1. Energy	**53 730.65**	**739.14**	**1 838.04**				**56 307.83**
A. Fuel Combustion (Sectoral Approach)	53 389.90	739.07	1 835.89				55 964.87
1. Energy Industries	11 575.80	44.34	472.31				12 092.45
2. Manufacturing Industries and Construction	13 370.06	55.12	574.60				13 999.78
3. Transport	18 992.77	415.82	483.79				19 892.38
4. Other Sectors	9 358.98	223.79	305.20				9 887.96
5. Other	92.30	0.00	0.00				92.30
B. Fugitive Emissions from Fuels	340.74	0.07	2.14				342.96
1. Solid Fuels	329.68	0.07	2.14				331.90
2. Oil and Natural Gas	11.06	0.00	0.00				11.06
2. Industrial Processes	**4 679.91**	**4.91**	***767.66***	**93.83**	**389.37**	**114.72**	***6 050.41***
A. Mineral Products	1 801.46	0.00	*15.50*				*1 816.96*
B. Chemical Industry	NE	0.08	708.35	NO	NO	0.00	708.43
C. Metal Production	2 847.45	0.00	0.00		380.47	19.12	3 247.04
D. Other Production	0.00						0.00
E. Production of Halocarbons and SF_6				NO	NO	0.00	0.00
F. Consumption of Halocarbons and SF_6				93.83	8.90	95.60	198.33
G. Other	31.00	4.83	43.81	NO	NO	0.00	79.64
3. Solvent and Other Product Use	**110.79**		**0.00**				**110.79**
4. Agriculture	**0.00**	**3 501.15**	**4 286.65**				**7 787.80**
A. Enteric Fermentation		3 187.30					3 187.30
B. Manure Management		313.86	598.15				912.00
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils[2]		0.00	3 688.50				3 688.50
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[1]	**-21 292.70**	**0.00**	**0.00**				**-21 292.70**
6. Waste	**0.00**	**2 399.09**	**0.00**				**2 399.09**
A. Solid Waste Disposal on Land	NO	2 399.09					2 399.09
B. Wastewater Handling		0.00	0.00				0.00
C. Waste Incineration	IE	0.00	0.00				0.00
D. Other	NE	0.00	0.00				0.00
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:							
International Bunkers	**5 243.00**	**1.37**	**24.80**				**5 269.17**
Aviation	1 849.00	1.37	0.00				1 850.37
Marine	3 394.00	0.00	24.80				3 418.80
Multilateral Operations	**0.00**	**0.00**	**0.00**				**0.00**
CO_2 Emissions from Biomass	**15 889.42**						**15 889.42**

[1]*For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).* [2]*See footnote 4 to Summary 1.A of this common reporting format.*

Summary 2. Summary report for CO_2 equivalent emissions – continued.

Sweden 1995.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	Total emissions
	CO₂ equivalent (Gg)					
Land-Use Change and Forestry						
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-25 100.00	-25 100.00			-25 100.00
B. Forest and Grassland Conversion	0.00		0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	3 807.30	0.00	3 807.30			3 807.30
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	3 807.30	-25 100.00	-21 292.70	0.00	0.00	-21 292.70
	Total CO_2 Equivalent Emissions without Land-Use Change and Forestry[a]					*72 655.91*
	Total CO_2 Equivalent Emissions with Land-Use Change and Forestry[a]					*51 363.21*

[a] *The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.*

Summary 2. Summary report for CO_2 equivalent emissions.

Sweden 1996.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2[1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)[1]	**40 731.88**	**6 632.51**	***7 103.05***	**140.72**	**343.34**	**103.01**	***55 054.50***
1. Energy	**58 107.49**	**753.22**	**2 048.94**				**60 909.65**
A. Fuel Combustion (Sectoral Approach)	57 791.18	753.16	2 047.04				60 591.38
1. Energy Industries	16 669.01	59.73	638.78				17 367.53
2. Manufacturing Industries and Construction	12 783.67	53.78	580.98				13 418.43
3. Transport	18 834.43	410.61	512.31				19 757.35
4. Other Sectors	9 421.92	229.03	314.98				9 965.92
5. Other	82.15	0.00	0.00				82.15
B. Fugitive Emissions from Fuels	316.31	0.06	1.90				318.27
1. Solid Fuels	290.73	0.06	1.90				292.69
2. Oil and Natural Gas	25.58	0.00	0.00				25.58
2. Industrial Processes	**4 782.65**	**4.93**	***739.49***	**140.72**	**343.34**	**103.01**	***6 114.13***
A. Mineral Products	1 709.11	0.00	*15.50*				*1 724.61*
B. Chemical Industry	NE	0.08	679.83	NO	NO	0.00	679.91
C. Metal Production	3 042.54	0.00	0.00		330.38	31.07	3 403.99
D. Other Production	0.00						0.00
E. Production of Halocarbons and SF_6				NO	NO	0.00	0.00
F. Consumption of Halocarbons and SF_6				140.72	12.96	71.94	225.61
G. Other	31.00	4.85	44.16	NO	NO	0.00	80.01
3. Solvent and Other Product Use	**110.79**		**0.00**				**110.79**
4. Agriculture	**0.00**	**3 505.66**	**4 314.62**				**7 820.28**
A. Enteric Fermentation		3 191.64					3 191.64
B. Manure Management		314.02	613.80				927.82
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils[2]		0.00	3 700.83				3 700.83
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[1]	**-22 269.05**	**0.00**	**0.00**				**-22 269.05**
6. Waste	**0.00**	**2 368.69**	**0.00**				**2 368.69**
A. Solid Waste Disposal on Land	NO	2 368.69					2 368.69
B. Wastewater Handling		0.00	0.00				0.00
C. Waste Incineration	IE	0.00	0.00				0.00
D. Other	NE	0.00	0.00				0.00
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:							
International Bunkers	**5 536.00**	**1.18**	**24.80**				**5 561.98**
Aviation	1 940.00	1.18	0.00				1 941.18
Marine	3 596.00	0.00	24.80				3 620.80
Multilateral Operations	**0.00**	**0.00**	**0.00**				**0.00**
CO_2 Emissions from Biomass	**17 712.58**						**17 712.58**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+). [2] See footnote 4 to Summary 1.A of this common reporting format.

Summary 2. Summary report for CO_2 equivalent emissions – continued.

Sweden 1996.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-26 100.00	-26 100.00			-26 100.00
B. Forest and Grassland Conversion	0.00		0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	3 830.95	0.00	3 830.95			3 830.95
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	3 830.95	-26 100.00	-22 269.05	0.00	0.00	-22 269.05
	Total CO_2 Equivalent Emissions without Land-Use Change and Forestry[(a)]					*77 323.55*
	Total CO_2 Equivalent Emissions with Land-Use Change and Forestr[(a)]					*55 054.50*

[(a)]*The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.*

Summary 2. Summary report for CO_2 equivalent emissions.

Sweden 1997.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)[(1)]	**29 799.89**	**6 526.75**	***7 074.53***	**239.22**	**315.91**	**146.03**	***44 102.32***
1. Energy	**52 374.93**	**682.70**	**1 900.75**				**54 958.39**
A. Fuel Combustion (Sectoral Approach)	52 114.39	682.65	1 899.22				54 696.26
1. Energy Industries	11 491.43	50.74	475.86				12 018.04
2. Manufacturing Industries and Construction	12 996.78	51.75	570.12				13 618.66
3. Transport	18 966.37	363.03	548.89				19 878.28
4. Other Sectors	8 617.39	217.14	304.35				9 138.88
5. Other	42.41	0.00	0.00				42.41
B. Fugitive Emissions from Fuels	260.54	0.05	1.53				262.12
1. Solid Fuels	233.60	0.05	1.53				235.18
2. Oil and Natural Gas	26.94	0.00	0.00				26.94
2. Industrial Processes	**4 601.77**	**5.24**	***734.69***	**239.22**	**315.91**	**146.03**	***6 042.86***
A. Mineral Products	1 642.20	0.00	*15.50*				*1 657.70*
B. Chemical Industry	NE	0.04	671.46	NO	NO	0.00	671.50
C. Metal Production	2 897.57	0.00	0.00		301.94	40.63	3 240.15
D. Other Production	31.00						31.00
E. Production of Halocarbons and SF_6				NO	NO	0.00	0.00
F. Consumption of Halocarbons and SF_6				239.22	13.97	105.40	358.58
G. Other	31.00	5.20	47.73	0.00	0.00	0.00	83.93
3. Solvent and Other Product Use	**110.79**		**0.00**				**110.79**
4. Agriculture	**0.00**	**3 503.42**	**4 439.09**				**7 942.51**
A. Enteric Fermentation		3 197.39					3 197.39
B. Manure Management		306.02	641.59				947.61
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils[(2)]		0.00	3 797.51				3 797.51
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[(1)]	**-27 287.61**	**0.00**	**0.00**				**-27 287.61**
6. Waste	**0.00**	**2 335.38**	**0.00**				**2 335.38**
A. Solid Waste Disposal on Land	NO	2 335.38					2 335.38
B. Wastewater Handling		0.00	0.00				0.00
C. Waste Incineration	IE	0.00	0.00				0.00
D. Other	NE	0.00	0.00				0.00
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:							
International Bunkers	**6 147.00**	**1.79**	**31.00**				**6 179.79**
Aviation	1 929.00	1.79	0.00				1 930.79
Marine	4 218.00	0.00	31.00				4 249.00
Multilateral Operations	**0.00**	**0.00**	**0.00**				**0.00**
CO_2 Emissions from Biomass	16 264.40						16 264.40

[(1)]For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+). [(2)]See footnote 4 to Summary 1.A of this common reporting format.

Summary 2. Summary report for CO_2 equivalent emissions – continued.

Sweden 1997.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-31 100.00	-31 100.00			-31 100.00
B. Forest and Grassland Conversion	0.00		0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	3 812.39	0.00	3 812.39			3 812.39
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	3 812.39	-31 100.00	-27 287.61	0.00	0.00	-27 287.61
	Total CO_2 Equivalent Emissions without Land-Use Change and Forestry[(a)]					*71 389.93*
	Total CO_2 Equivalent Emissions with Land-Use Change and Forestr[(a)]					*44 102.32*

[(a)] *The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.*

Summary 2. Summary report for CO_2 equivalent emissions.

Sweden 1998.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 [1] c	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Total (Net Emissions)[1]	**33 811.20**	**6 375.45**	***7 334.99***	**303.19**	**305.68**	**92.25**	***48 222.77***
1. Energy	**53 608.18**	**660.84**	**2 089.62**				**56 358.64**
A. Fuel Combustion (Sectoral Approach)	53 311.25	660.78	2 087.84				56 059.88
1. Energy Industries	12 671.11	53.80	517.32				13 242.24
2. Manufacturing Industries and Construction	12 659.82	53.61	654.30				13 367.73
3. Transport	19 481.27	340.94	530.68				20 352.88
4. Other Sectors	8 469.58	212.43	385.55				9 067.56
5. Other	29.47	0.00	0.00				29.47
B. Fugitive Emissions from Fuels	296.92	0.06	1.78				298.76
1. Solid Fuels	277.95	0.06	1.78				279.79
2. Oil and Natural Gas	18.97	0.00	0.00				18.97
2. Industrial Processes	**4 423.14**	**7.07**	***817.66***	**303.19**	**305.68**	**92.25**	***5 948.99***
A. Mineral Products	1 645.35	0.00	*15.19*				*1 660.54*
B. Chemical Industry	NE	0.04	756.40	NO	NO	0.00	756.44
C. Metal Production	2 746.79	0.00	0.00		292.46	31.07	3 070.32
D. Other Production	0.00						0.00
E. Production of Halocarbons and SF_6				NO	NO	0.00	0.00
F. Consumption of Halocarbons and SF_6				303.19	13.22	61.18	377.59
G. Other	31.00	7.03	46.07	NO	NO	0.00	84.10
3. Solvent and Other Product Use	**110.79**		**0.00**				**110.79**
4. Agriculture	**0.00**	**3 423.72**	**4 427.72**				**7 851.44**
A. Enteric Fermentation		3 120.10					3 120.10
B. Manure Management		303.62	629.01				932.64
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils[2]		0.00	3 798.70				3 798.70
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[1]	**-24 330.90**	**0.00**	**0.00**				**-24 330.90**
6. Waste	**0.00**	**2 283.81**	**0.00**				**2 283.81**
A. Solid Waste Disposal on Land	NO	2 283.81					2 283.81
B. Wastewater Handling		0.00	0.00				0.00
C. Waste Incineration	IE	0.00	0.00				0.00
D. Other	NE	0.00	0.00				0.00
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:							
International Bunkers	**6 958.00**	**1.83**	**115.63**				**7 075.46**
Aviation	2 103.00	1.83	0.00				2 104.83
Marine	4 855.00	0.00	115.63				4 970.63
Multilateral Operations	**0.00**	**0.00**	**0.00**				**0.00**
CO_2 Emissions from Biomass	**16 603.52**						**16 603.52**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+). [2] See footnote 4 to Summary 1.A of this common reporting format.

Summary 2. Summary report for CO_2 equivalent emissions – continued.

Sweden 1998.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-28 100.00	-28 100.00			-28 100.00
B. Forest and Grassland Conversion	0.00		0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	3 769.10	0.00	3 769.10			3 769.10
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	3 769.10	-28 100.00	-24 330.90	0.00	0.00	-24 330.90
	Total CO_2 Equivalent Emissions without Land-Use Change and Forestry[(a)]					*72 553.67*
	Total CO_2 Equivalent Emissions with Land-Use Change and Forestr[(a)]					*48 222.77*

[(a)] *The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.*

Summary 2. Summary report for CO_2 equivalent emissions.

Sweden 1999.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions)[1]	**32 152.87**	**6 172.59**	***7 111.88***	**375.34**	**329.16**	**96.32**	***46 238.17***
1. Energy	**52 022.40**	**633.83**	**2 071.02**				**54 727.25**
A. Fuel Combustion (Sectoral Approach)	51 722.44	633.77	2 069.10				54 425.31
1. Energy Industries	11 129.40	55.12	484.83				11 669.35
2. Manufacturing Industries and Construction	11 990.87	50.49	631.18				12 672.55
3. Transport	19 886.05	303.22	568.85				20 758.12
4. Other Sectors	8 691.60	224.93	384.23				9 300.76
5. Other	24.53	0.00	0.00				24.53
B. Fugitive Emissions from Fuels	299.96	0.07	1.93				301.95
1. Solid Fuels	299.96	0.07	1.93				301.95
2. Oil and Natural Gas	NO	0.00	0.00				0.00
2. Industrial Processes	**4 324.99**	**8.65**	***823.67***	**375.34**	**329.16**	**96.32**	***5 958.14***
A. Mineral Products	1 589.77	0.00	*20.77*				*1 610.54*
B. Chemical Industry	NE	0.04	756.40	NO	NO	0.00	756.44
C. Metal Production	2 704.22	0.00	0.00		321.58	31.07	3 056.86
D. Other Production	0.00						0.00
E. Production of Halocarbons and SF_6				NO	NO	0.00	0.00
F. Consumption of Halocarbons and SF_6				375.34	7.59	65.25	448.18
G. Other	31.00	8.61	*46.50*	NO	NO	0.00	*86.11*
3. Solvent and Other Product Use	**110.79**		**0.00**				**110.79**
4. Agriculture	**0.00**	**3 382.67**	**4 217.19**				**7 599.86**
A. Enteric Fermentation		3 083.32					3 083.32
B. Manure Management		299.35	601.85				901.20
C. Rice Cultivation		0.00					0.00
D. Agricultural Soils[2]		0.00	3 615.34				3 615.34
E. Prescribed Burning of Savannas		0.00	0.00				0.00
F. Field Burning of Agricultural Residues		0.00	0.00				0.00
G. Other		0.00	0.00				0.00
5. Land-Use Change and Forestry[1]	**-24 305.31**	**0.00**	**0.00**				**-24 305.31**
6. Waste	**0.00**	**2 147.43**	**0.00**				**2 147.43**
A. Solid Waste Disposal on Land	NO	2 147.43					2 147.43
B. Wastewater Handling		0.00	0.00				0.00
C. Waste Incineration	IE	0.00	0.00				0.00
D. Other	NE	0.00	0.00				0.00
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:							
International Bunkers	**6 853.68**	**1.83**	**102.30**				**6 957.80**
Aviation	2 103.40	1.83	0.00				2 105.23
Marine	4 750.27	0.00	102.30				4 852.57
Multilateral Operations	**0.00**	**0.00**	**0.00**				**0.00**
CO_2 Emissions from Biomass	**16 708.90**						**16 708.90**

[1] For CO_2 emissions from Land-Use Change and Forestry the net emissions are to be reported. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+). [2] See footnote 4 to Summary 1.A of this common reporting format.

Summary 2. Summary report for CO_2 equivalent emissions – continued.

Sweden 1999.
Revised submission. November 2001.

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	Net CO_2 emissions/ removals	CH_4	N_2O	Total emissions
Land-Use Change and Forestry	CO_2 equivalent (Gg)					
A. Changes in Forest and Other Woody Biomass Stocks	0.00	-28 100.00	-28 100.00			-28 100.00
B. Forest and Grassland Conversion	0.00		0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands	0.00	0.00	0.00			0.00
D. CO_2 Emissions and Removals from Soil	3 794.69	0.00	3 794.69			3 794.69
E. Other	0.00	0.00	0.00	0.00	0.00	0.00
Total CO_2 Equivalent Emissions from Land-Use Change and Forestry	3 794.69	-28 100.00	-24 305.31	0.00	0.00	-24 305.31
	Total CO_2 Equivalent Emissions without Land-Use Change and Forestry[a]					*70 543.48*
	Total CO_2 Equivalent Emissions with Land-Use Change and Forestr[a]					*46 238.17*

[a] *The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report emissions and removals from Land-Use Change and Forestry.*

Next page:
[1] *Fill in the base year adopted by the Party under the Convention, if different from 1990.*
[2] *See footnote 4 to Summary 1.A of this common reporting format.*
[3] *Take the net emissions as reported in Summary 1.A of this common reporting format. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).*
[4] *The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report CO_2 emissions and removals from Land-Use Change and Forestry.*

Table 10. Emissions trends (CO_2). **Sweden 1999.**
Sheet 1 of 5. *See footnote on previous page.* **Revised submission. November 2001.**

Greenhouse gas source and sink categories	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
						(Gg)					
1. Energy	0.00	*51 713.43*	*52 472.05*	50 648.76	50 533.12	54 738.64	53 730.65	58 107.49	52 374.93	53 608.18	52 022.40
A. Fuel Combustion (Sectoral Approach)	0.00	*51 438.74*	*52 207.04*	50 434.21	50 280.80	54 359.72	53 389.90	57 791.18	52 114.39	53 311.25	51 722.44
1. Energy Industries		10 170.40	11 280.19	11 319.44	10 829.43	13 119.17	11 575.80	16 669.01	11 491.43	12 671.11	11 129.40
2. Manufacturing Industries and Construction		*11 775.66*	*11 550.30*	10 260.70	11 417.93	12 861.03	13 370.06	12 783.67	12 996.78	12 659.82	11 990.87
3. Transport		18 736.19	18 806.68	19 031.50	18 236.67	18 561.03	18 992.77	18 834.43	18 966.37	19 481.27	19 886.05
4. Other Sectors		10 672.87	10 486.23	9 738.94	9 712.87	9 736.25	9 358.98	9 421.92	8 617.39	8 469.58	8 691.60
5. Other		83.63	83.65	83.63	83.90	82.25	92.30	82.15	42.41	29.47	24.53
B. Fugitive Emissions from Fuels	0.00	274.69	265.00	214.56	252.32	378.92	340.74	316.31	260.54	296.92	299.96
1. Solid Fuels		252.62	247.45	194.40	235.38	367.85	329.68	290.73	233.60	277.95	299.96
2. Oil and Natural Gas		22.07	17.55	20.15	16.94	11.06	11.06	25.58	26.94	18.97	NO
2. Industrial Processes	0.00	*4 170.15*	*4 077.51*	*4 198.10*	4 234.90	4 383.38	4 679.91	4 782.65	4 601.77	4 423.14	4 324.99
A. Mineral Products		1 764.97	1 621.90	1 521.51	1 536.79	1 628.56	1 801.46	1 709.11	1 642.20	1 645.35	1 589.77
B. Chemical Industry		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Metal Production		*2 374.18*	*2 424.61*	*2 645.60*	2 667.11	2 723.82	2 847.45	3 042.54	2 897.57	2 746.79	2 704.22
D. Other Production		0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.00	0.00	0.00
E. Production of Halocarbons and SF_6											
F. Consumption of Halocarbons and SF_6											
G. Other		31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00	31.00
3. Solvent and Other Product Use		110.79	110.79	110.79	110.79	110.79	110.79	110.79	110.79	110.79	110.79
4. Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A. Enteric Fermentation											
B. Manure Management											
C. Rice Cultivation											
D. Agricultural Soils[2]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
E. Prescribed Burning of Savannas											
F. Field Burning of Agricultural Residues											
G. Other											
5. Land-Use Change and Forestry[1]	0.00	-20 291.96	-29 327.65	-23 353.08	-29 332.10	-26 305.35	-21 292.70	-22 269.05	-27 287.61	-24 330.90	-24 305.31
A. Changes in Forest and Other Woody Biomass Stocks		-24 100.00	-33 100.00	-27 100.00	-33 100.00	-30 100.00	-25 100.00	-26 100.00	-31 100.00	-28 100.00	-28 100.00
B. Forest and Grassland Conversion									0.00	0.00	0.00
C. Abandonment of Managed Lands									0.00	0.00	0.00
D. CO_2 Emissions and Removals from Soil		3 808.04	3 772.35	3 746.92	3 767.90	3 794.65	3 807.30	3 830.95	3 812.39	3 769.10	3 794.69
E. Other									0.00	0.00	0.00
6. Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A. Solid Waste Disposal on Land		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Wastewater Handling											
C. Waste Incineration		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
D. Other		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
7. Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Emissions/Removals with LUCF[4]	0.00	*35 702.41*	*27 332.69*	*31 604.58*	25 546.71	32 927.47	37 228.65	40 731.88	29 799.89	33 811.20	32 152.87
Total Emissions without LUCF[4]	0.00	*55 994.37*	*56 660.34*	*54 957.66*	54 878.81	59 232.82	58 521.35	63 000.93	57 087.50	58 142.10	56 458.18
Memo Items:											
International Bunkers	0.00	3 989.00	4 470.00	5 053.00	4 752.00	5 263.00	5 243.00	5 536.00	6 147.00	6 958.00	6 853.68
Aviation		1 826.00	1 910.00	2 133.00	1 820.00	1 811.00	1 849.00	1 940.00	1 929.00	2 103.00	2 103.40
Marine		2 163.00	2 560.00	2 920.00	2 932.00	3 452.00	3 394.00	3 596.00	4 218.00	4 855.00	4 750.27
Multilateral Operations		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 10. Emissions trends (CH_4).
Sheet 2 of 5.

Sweden 1999.
Revised submission. November 2001.

Greenhouse gas source and sink categories	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
						(Gg)					
Total Emissions	0.00	*324.30*	*321.19*	327.52	325.19	320.20	316.40	315.83	310.80	303.59	293.93
1. Energy	**0.00**	***37.08***	**37.01**	**36.00**	**35.67**	**35.04**	**35.20**	**35.87**	**32.51**	**31.47**	**30.18**
A. Fuel Combustion (Sectoral Approach)	0.00	*37.08*	37.01	36.00	35.67	35.04	35.19	35.86	32.51	31.47	30.18
1. Energy Industries		1.10	1.27	1.25	1.58	1.87	2.11	2.84	2.42	2.56	2.62
2. Manufacturing Industries and Construction		*2.31*	*2.25*	2.59	2.55	2.77	2.62	2.56	2.46	2.55	2.40
3. Transport		23.16	22.96	21.65	20.95	20.42	19.80	19.55	17.29	16.24	14.44
4. Other Sectors		10.51	10.53	10.50	10.60	9.98	10.66	10.91	10.34	10.12	10.71
5. Other		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
B. Fugitive Emissions from Fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid Fuels		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Oil and Natural Gas		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2. Industrial Processes	**0.00**	**0.23**	**0.23**	**0.23**	**0.24**	**0.22**	**0.23**	**0.23**	**0.25**	**0.34**	**0.41**
A. Mineral Products		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
B. Chemical Industry		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. Metal Production		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Other Production											
E. Production of Halocarbons and SF_6											
F. Consumption of Halocarbons and SF_6											
G. Other		0.23	0.23	0.23	0.23	0.22	0.23	0.23	0.25	0.33	0.41
3. Solvent and Other Product Use											
4. Agriculture	**0.00**	**165.38**	**160.21**	**167.17**	**169.50**	**170.38**	**166.72**	**166.94**	**166.83**	**163.03**	**161.08**
A. Enteric Fermentation		153.30	148.47	154.11	155.43	155.19	151.78	151.98	152.26	148.58	146.82
B. Manure Management		12.09	11.74	13.06	14.07	15.19	14.95	14.95	14.57	14.46	14.25
C. Rice Cultivation		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Agricultural Soils[2]		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
E. Prescribed Burning of Savannas		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry[1]	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks											
B. Forest and Grassland Conversion											
C. Abandonment of Managed Lands											
D. CO_2 Emissions and Removals from Soil											
E. Other											
6. Waste	**0.00**	**121.61**	**123.74**	**124.12**	**119.77**	**114.55**	**114.24**	**112.79**	**111.21**	**108.75**	**102.26**
A. Solid Waste Disposal on Land		121.61	123.74	124.12	119.77	114.55	114.24	112.79	111.21	108.75	102.26
B. Wastewater Handling		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Waste Incineration		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
D. Other		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:											
International Bunkers	**0.00**	**0.00**	**0.10**	**0.05**	**0.05**	**0.07**	**0.07**	**0.06**	**0.09**	**0.09**	**0.09**
Aviation		0.00	0.10	0.05	0.05	0.07	0.07	0.06	0.09	0.09	0.09
Marine		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Multilateral Operaations		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO_2 Emissions from Biomass											

Table 10. Emissions trends (N_2O). **Sweden 1999.**
Sheet 3 of 5. **Revised submission. November 2001.**

Greenhouse gas source and sink categories	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
						(Gg)					
Total Emissions	0.00	23.12	22.39	21.89	22.43	22.96	22.23	22.91	22.82	23.66	22.94
1. Energy	**0.00**	**5.73**	**5.68**	**5.53**	**5.68**	**6.24**	**5.93**	**6.61**	**6.13**	**6.74**	**6.68**
A. Fuel Combustion (Sectoral Approach)	0.00	5.73	5.67	5.53	5.67	6.23	5.92	6.60	6.13	6.73	6.67
1. Energy Industries		1.34	1.37	1.39	1.37	1.60	1.52	2.06	1.54	1.67	1.56
2. Manufacturing Industries and Construction		1.80	1.82	1.68	1.77	1.97	1.85	1.87	1.84	2.11	2.04
3. Transport		1.46	1.36	1.39	1.46	1.53	1.56	1.65	1.77	1.71	1.84
4. Other Sectors		1.14	1.13	1.08	1.08	1.13	0.98	1.02	0.98	1.24	1.24
5. Other		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
B. Fugitive Emissions from Fuels	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01
1. Solid Fuels		0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01
2. Oil and Natural Gas		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2. Industrial Processes	**0.00**	**2.81**	**2.69**	**2.68**	**2.69**	**2.46**	**2.48**	**2.39**	**2.37**	**2.64**	**2.66**
A. Mineral Products		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07
B. Chemical Industry		2.63	2.50	2.50	2.50	2.28	2.29	2.19	2.17	2.44	2.44
C. Metal Production		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
D. Other Production											
E. Production of Halocarbons and SF_6											
F. Consumption of Halocarbons and SF_6											
G. Other		0.13	0.14	0.13	0.14	0.14	0.14	0.14	0.15	0.15	0.15
3. Solvent and Other Product Use		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4. Agriculture	**0.00**	**14.58**	**14.03**	**13.67**	**14.06**	**14.26**	**13.83**	**13.92**	**14.32**	**14.28**	**13.60**
A. Enteric Fermentation											
B. Manure Management		2.346	2.296	2.236	2.143	2.160	1.930	1.98	2.07	2.03	1.94
C. Rice Cultivation											
D. Agricultural Soils(2)		12.231	11.733	11.432	11.921	12.099	11.898	11.94	12.25	12.3	11.66
E. Prescribed Burning of Savannas		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
F. Field Burning of Agricultural Residues		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
G. Other		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5. Land-Use Change and Forestry(1)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
A. Changes in Forest and Other Woody Biomass Stocks											
B. Forest and Grassland Conversion		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C. Abandonment of Managed Lands											
D. CO_2 Emissions and Removals from Soil											
E. Other		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Waste	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
A. Solid Waste Disposal on Land											
B. Wastewater Handling		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
C. Waste Incineration		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
D. Other		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
7. Other (please specify)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Memo Items:											
International Bunkers	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.08**	**0.10**	**0.37**	**0.33**
Aviation		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Marine		NE	IE	NE	NE	NE	IE	0.08	0.10	0.37	0.33
Multilateral Operations		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
CO_2 Emissions from Biomass											

Table 10. Emission trends (HFCs, PFCs and SF_6).
Sheet 4 of 5.

Sweden 1999.
Submission 2001.

Greenhouse gas source and sink categories	Base year(1)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
						(Gg)					
Emissions of HFCs[5]– CO2 equivalent (Gg)	**0.00**	**1.12**	**2.91**	**4.49**	**17.06**	**46.86**	**93.83**	**140.72**	**239.22**	**303.19**	**375.34**
HFC-23		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-32		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-41		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-43-10mee		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-125		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-134a		0.00	0.00	0.00	0.01	0.03	0.07	0.10	0.16	0.20	0.25
HFC-152a		0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.14	0.14	0.13
HFC-143		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-143a		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-227ea		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-236fa		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFC-245ca		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emissions of PFCs[5]–CO_2 equivalent (Gg)	**0.00**	**440.05**	**427.31**	**413.77**	**402.13**	**389.74**	**389.37**	**343.34**	**315.91**	**305.68**	**329.16**
CF_4		0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04
C_2F_6		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C_3F_8		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_4F_{10}		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
c-C_4F_8		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_5F_{12}		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C_6F_{14}		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emissions of SF6[5]–CO_2 equivalent (Gg)	**0.00**	**81.26**	**82.22**	**81.74**	**88.43**	**96.80**	**114.72**	**103.01**	**146.03**	**92.25**	**96.32**
SF_6		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00

[5] *Enter information on the actual emissions. Where estimates are only available for the potential emissions, specify this in a comment to the corresponding cell. Only in this row the emissions are expressed as CO2 equivalent emissions in order to facilitate data flow among spreadsheets.*

Table 10. Emission trends (Summary). **Sweden 1999.**
Sheet 5 of 5. **Revised submission. November 2001.**

Greenhouse gas emissions	**Base year[1]**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)										
Net CO_2 emissions/removals	0.00	*35 702.41*	*27 332.69*	*31 604.58*	25 546.71	32 927.47	37 228.65	40 731.88	29 799.89	33 811.20	32 152.87
CO_2 emissions (without LUCF)[6]	0.00	*55 994.37*	*56 660.34*	*54 957.66*	54 878.81	59 232.82	58 521.35	63 000.93	57 087.50	58 142.10	56 458.18
CH_4	0.00	*6 810.37*	*6 745.07*	6 877.99	6 828.89	6 724.15	6 644.30	6 632.51	6 526.75	6 375.45	6 172.59
N_2O	0.00	*7 167.04*	*6 942.01*	*6 785.08*	*6 952.75*	*7 117.73*	*6 892.35*	*7 103.05*	*7 074.53*	*7 334.99*	*7 111.88*
HFCs	0.00	1.12	2.91	4.49	17.06	46.86	93.83	140.72	239.22	303.19	375.34
PFCs	0.00	440.05	427.31	413.77	402.13	389.74	389.37	343.34	315.91	305.68	329.16
SF_6	0.00	81.26	82.22	81.74	88.43	96.80	114.72	103.01	146.03	92.25	96.32
Total (with net CO_2 emissions/removals)	**0.00**	***50 202.25***	***41 532.20***	***45 767.63***	***39 835.96***	***47 302.74***	***51 363.21***	***55 054.50***	***44 102.32***	***48 222.77***	***46 238.17***
Total (without CO_2 from LUCF)[6]	**0.00**	***70 494.21***	***70 859.85***	***69 120.71***	***69 168.06***	***73 608.09***	***72 655.91***	***77 323.55***	***71 389.93***	***72 553.67***	***70 543.48***

Table 10. Emission trends (Summary). **Sweden 1999.**
Sheet 5 of 5. **Revised submission. November 2001.**

Greenhouse gas source and sink Categories	**Base year[1]**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)										
1. Energy	0.00	*54 269.54*	*55 009.99*	53 120.43	53 041.76	57 409.31	56 307.83	60 909.65	54 958.39	56 358.64	54 727.25
2. Industrial Processes	0.00	*5 568.09*	*5 427.21*	*5 535.28*	*5 581.09*	*5 684.17*	*6 050.41*	*6 114.13*	*6 042.86*	*5 948.99*	*5 958.14*
3. Solvent and Other Product Use	0.00	110.79	110.79	110.79	110.79	110.79	110.79	110.79	110.79	110.79	110.79
4. Agriculture	0.00	7 991.93	7 713.39	7 747.68	7 919.19	7 998.28	7 787.80	7 820.28	7 942.51	7 851.44	7 599.86
5. Land-Use Change and Forestry[7]	0.00	-20 291.96	-29 327.65	-23 353.08	-29 332.10	-26 305.35	-21 292.70	-22 269.05	-27 287.61	-24 330.90	-24 305.31
6. Waste	0.00	2 553.86	2 598.47	2 606.53	2 515.24	2 405.54	2 399.09	2 368.69	2 335.38	2 283.81	2 147.43
7. Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[6] *The information in these rows is requested to facilitate comparison of data, since Parties differ in the way they report CO2 emissions and removals from Land-Use Change and Forestry.*
[7] *Net emissions.*

Appendix 2

Acronyms and abbreviations, in alphabetical order

ACEA	Association des Constructions Européene d'Automobiles
AFREPREN	African Energy Policy Network
AIJ	Activities Implemented Jointly
ARRPEEC	Asian Regional Research Programme in Energy/Environment and Climate
CEC	Commission of the European Community
CFC	chlorofluorocarbons
CGIAR	Consultative Group for International Agricultural Research
CH_4	methane
CHP	Combined heating and power
CO_2	carbon dioxide
CSE	Centre for Science and Environment
DESS	The Energy Supply Committee of Southern Sweden
E	Economic instruments
EEPSEA	Economy and Environment Program for Southeast Asia
EU	European Union
FORMAS	Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning
G	giga (10^9, billion)
GEF	Global Environment Fund
GIS	Geographic Information System
GIWA	Global International Water Assessment
GNI	Gross National Income
GWh	Gigawatt hour
GWP	Global Water Partnership
GWP	Global Warming Potential
HCFC	hydrochlorofluorocarbons
HFC	hydrofluorocarbons
IIED	International Institute for Environment and Development
Info	Information instruments
IPCC	Intergovernmental Panel of Climate Change
ISO	International Standards Organisation.
ISO 14 001	Standard for environmental management systems
IT	Information Technology

IUCN	International Union for the Conservation of Nature
IVL	Swedish Environmental Research Institute
J	Joule (J) unit of energy
JI	Joint Implementation
kW	kilowatt (unit of power)
kWh	kilowatt hour (unit energy)
LCA	Life-Cycle Analysis
LIP	Local Investment Programme
M	mega (10^6, million)
m	milli (10^{-3}, one thousandth)
micro	one millionth (10^{-6})
MISTRA	Foundation for Swedish Environmental Research
MWh	Megawatt hour (unit of energy; 1 MWh = 3600 MJ)
N_2O	nitrous oxide
NC	Not calculated
NIU	Measure not in use at the time
NOx	nitrogen oxides
NUTEK	Swedish National Board for Industrial and Technical Development
OECD	Organisation for Economic Co-operation and Development
OPET	Organisation for Promotion of Energy Technology
P	peta (10^{15}, one thousand trillion)
PAIB	Protección Ambiental en la Industria Boliviana
PFC	perfluorocarbons
ppm	Parts per million
PPP	Polluter Pays Principle
R&D	Research and Development
RETsAsia	Renewable Energy Technologies in Asia
SAVE	Specific Actions for Vigorous Energy Efficiency
SCB	Statistics Sweden
SEI	Stockholm Environment Institute
SEK	Swedish kronor
SF_6	sulphur hexafluoride
Sida	Swedish International Development Cooperation Agency
SIKA	Swedish Institute for Transport and Communication Analysis
SMHI	Swedish Meteorological and Hydrological Institute
SO_2	sulphur dioxide
SOU	Swedish Government Official Report

Swedish EPA	Swedish Environmental Protection Agency
T	tera (10^{12}, one trillion)
TWh	Terawatt hour (unit of energy)
UN	United Nations
UNCED	United Nation Conference on Environment and Development
UNDP	United Nation Development Program
UNEP	United Nation Environmental Program
UNFCCC	UN Framework Convention on Climate Change
USD	US dollars
VINNOVA	Swedish Agency for Innovation Systems
V	Voluntary commitment
WCRP	World Climate Research Programme
WHO	World Health Organisation
WMO	World Meteorological Organisation
WRI	World Resources Institute
WTO	World Trade Organisation

Appendix 3 – Normal-year correction of greenhouse gas emissions, method description and results

The Swedish climate varies a great deal from year to year. The variables are temperature, wind conditions, radiation and precipitation. Temperature, radiation and wind influence the amount of energy needed to heat buildings to maintain normal indoor temperatures.

Precipitation affects the quantity of water flowing in watercourses and hence the potential for generating electric energy using hydropower. Normal-year correction allows relevant comparisons between the years.

When preparing its two previous national communications, and also in the interim, Sweden has calculated what its emissions would have been in the years in question under normal conditions. A new normal-year correction model has been used for the Third National Communication. This model differs in terms of calculation method and results. Normal-year correction involves estimating emissions a normal year from the heating of buildings and from electricity generation. These two areas are described below.

Correction of carbon dioxide emissions from heating

The Swedish Meteorological and Hydrological Institute (SMHI) has developed a method of calculating variations in Swedish carbon dioxide emissions from heating, which are due to deviations from normal weather conditions. Calculations have been made for each of the years 1990 – 1999, and for a 30-year normal period 1965 – 95. The overall impact of weather on building heating requirements has been calculated month by month for a number of locations in Sweden using the ENLOSS model, developed by SMHI (see, inter alia, Taesler (1986) and CADET Energy Efficiency (1999). This is a model employing detailed calculation of energy consumption for heating of buildings, taking account of temperature, wind, cloud cover, the sun's elevation and air turbidity (affects radiation).

ENLOSS calculates an "equivalent temperature" taking account of the weather parameters and their interaction with the position, characteristics and use of the building. This equivalent temperature is then used as a basis for calculating an Energy Index, which is a measure of the quantity of energy required to heat a specific building to normal room temperature (21°C) in relation to the requirement during the same period under normal weather conditions. These days, the Energy Index calculated using the ENLOSS model is also used commercially in Sweden for optimum financial savings, function and comfort in relation to the energy and power requirements of buildings.

All calculations of normal-year correction have been made for a "standard building" possessing the following characteristics:

- Represents mixed building development
- Mechanical ventilation
- Heating requirement for hot water NOT included
- Heat from lighting, people in the building, electrical equipment and the like have been eliminated from the heating requirement using a standard formula
- 24-hour time constant for description of heat storage in the building

Using ENLOSS calculations of the heating requirement at up to 87 meteorological stations as a basis, a geographical distribution of the heating requirement over Sweden has been determined with the help of optimal interpolation. This has been done for each month and the figures have then been added together to give annual values, weighted to take account of the population distribution in each county. This information in turn provides a basis for determining a county-specific Energy Index for each year. These standardised values for the heating requirement in each county, together with Statistics Sweden figures on actual heating of buildings in each county using various fuels and electric energy (summarised in Table 1 below) have then formed the basis for estimated normal-year corrections of carbon dioxide emissions for each year during the period 1990 – 1999. Statistics Sweden's figures are based on the "regional energy balances", which, been collated for all counties, comprise Statistics Sweden's annual energy balances. Emissions are calculated using the same emission factors as those used in the national communications under the Climate Convention and in other reports. Emissions from electricity use are calculated using an emission factor that is the quotient of carbon dioxide emissions from fossil fuel combustion for electricity production in Sweden divided by total net production of electric energy in Sweden. Oil has been assumed to be the marginal fuel for heating.

Table 1
Industries and sectors in energy balances for which fuels and electric energy have been added together for use in the calculation

Balance number	Heat producer	Fuels
3.6.1	CHP production. district heating	All
3.7.	Separate heating plants	All
9.1	Agriculture, forestry, fisheries	fuel oils
9.4.	Public sector	fuel oils
9.6	Other services	fuel oils
9.7	Household fuel oils.	wood fuels and 53% of electricity

Source: National Energy Administration

Table 1 Industries and sectors in energy balances for which fuels and electric energy have been added together for use in the calculation

Summarised normal-year-corrected carbon dioxide emissions from heating are greater than the actual emissions each year of the 1990s, except for 1996. The difference between actual and normal-year-corrected emissions was greatest in 1990.

Correction of carbon dioxide emissions depending on variations in hydropower supply

Most electricity in Sweden is generated using hydropower and nuclear power. A small proportion is produced using combined heat and power. That portion varied between 7 and 15 per cent in the 1990s. The balance between electricity supply and demand in Sweden in the 1990s was also adjusted by export and import of electricity. In an average year, hydropower accounts for 64.2 TWh of electric energy. But the figure varies a great deal. Some years production may be considerably higher; others it may be much lower. These variations are due to precipitation. Hydropower may be regarded as the basic source of electricity generation in Sweden, ie, the source of first choice, depending on factors such as the electricity price. A deficit of electric energy as compared with the "normal" year must be replaced by electricity from other sources, ie, nuclear power, combined heat and power or import. Thus, since some of the electricity that is to replace a shortfall in hydropower is generated by burning fossil fuels, carbon dioxide emissions will occur. These depend on the degree of deviation from the normal year. The opposite occurs in years when hydropower produces a surplus as compared with the normal year.

Carbon dioxide emissions have been estimated by calculating the surplus/deficit of hydropower, ie, the quantity of electricity generation minus normal year production, and multiplying this by an emission factor for carbon dioxide emissions. This emission factor has been calculated by dividing an average emission of carbon dioxide from electricity generated using combined heat and power by the sum of electricity generated using nuclear power, combined heat and power and import minus export, ie, total net production of electricity not including electricity generated using hydropower. This has been done for each year of the 1990s. Statistics from Statistics Sweden and the National Energy Administration have been used for this purpose. This calculation differs from the previous model in that a varying emission factor is used. The previous model used a standard assumption that 7 per cent of electricity was generated using fossil fuels.

For all years in the 1990s except 1991, 1994 and 1996, the calculation produces a positive normal-year

Table 2
Overall normal-year correction, expressed as carbon dioxide, thousand tonnes:

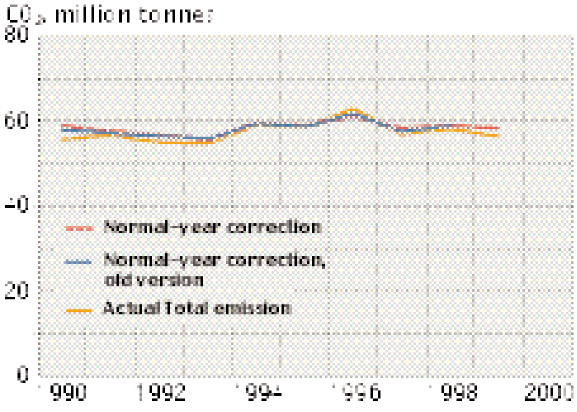
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hydropower	159	-40	349	410	-239	140	-911	182	389	274
Heating	3,008	1,040	1,631	291	655	393	-936	1,134	391	1,647
Normal-year correction	3,167	1,000	1,980	701	416	533	-1,847	1,316	780	1,921
Previous model	2,117	642	1,491	1,037	207	297	-1,185	518	903	-

Source: Statistics Sweden and Swedish Environmental Protection Agency correction, ie, a higher figure than the actual national emission.

As may be seen from the table, the calculation differs somewhat from the previous model (for which no calculation has been made for 1999).

Normal-year correction is added to the actual figure. As the diagram below shows, the normal-year correction evens out the curve showing carbon dioxide emissions. The new calculation model produces a result well in line with the previous model. The fact that the curve nonetheless varies is mainly a result of variations in the economic cycle, although it cannot be ruled out that there are factors that should be represented in some other way in the calculation. For example, the question of the choice of marginal fuel should be further examined, as should the choice of emission factor for estimating emissions from hydropower.

Table 1
Industries and sectors in energy balances for which fuels and electric energy have been added together for use in the calculation



Source: Swedish Environmental Protection Agency and Statistics Sweden

Appendix 4 – Method description and background data for projected emissions of carbon dioxide from the energy sector

A. Method for scenario calculations

The scenarios for carbon dioxide emissions from the energy sector are based on calculations and assessments of future developments in the energy system. The energy system includes energy use as well as supply. Scenarios are produced for various sub-sectors of the energy system. These are then compiled to form an energy balance. Energy use should balance energy supply. In addition to end use in the industrial, housing, service and transport sectors, the user side includes conversion and distribution losses and international shipping. The supply side comprises total fuel supply and hydropower production, nuclear power production, wind power and net import of electricity.

Different calculation methods are used for each sector. These are described below. The methods and analyses used are based on a socio-economic perspective. One basic premise is that total energy consumption and the relative amounts of each kind of energy are adjusted in line with expected energy prices, the economic climate and technological developments. Account is also taken of the impact of international developments on the Swedish energy system. Work in this field is based on existing governmental and parliamentary decisions within the scope of current energy and environment policy.

Calculations using the MARKAL model have been used as a basis for the scenarios for the Third National Communication (NC3). The model is outlined briefly below.

Method for the industrial sector

The scenarios for industrial energy use to 2010 and 2020 are based partly on results from the National Institute of Economic Research EMEC model and, to some extent, also on the MARKAL model. The EMEC model provides the economic conditions for a number of industries and for the manufacturing industry as a whole. Estimates have been made for the industries not specified by the EMEC model. However, these must fall within the scope of the total growth rate for manufacturing industry. In other words, no industry can be estimated to have a growth rate causing the overall EMEC growth rate for manufacturing industry to be exceeded.

A scenario for industrial energy use has been pro duced on the basis of the assumptions as to economic conditions and assumed energy prices. This has involved in-depth discussions with the various industrial trade organisations and associations, as well as the National Energy Administration's own experts in certain fields. The EMEC model results have been discussed, as have the prospects for various products in a given industry and likely investments during the period. Production trends for various products are a central factor, since the total demand for energy and its components are dependent on these trends. The technology that may be put to use during the period is naturally also of great importance.

All materials and all know-how generated during this process are examined and placed in relation to each other to arrive at the scenarios.

The scenarios for industrial energy demand have also served as an input in the MARKAL model calculations. The results from the MARKAL model have been carefully examined and cross-checked with other calculation results.

Method for the housing and service sector

Much of the energy consumed in the housing and service sector goes on heating homes and commercial/industrial premises. Economic growth and population growth determine the extent of new production, renovation, modernisation of housing and commercial/industrial premises. This in turn influences the need for heating.

The energy used for heating depends on the outdoor temperature. Energy consumption is temperature-corrected to take account of this. Temperature-corrected energy consumption tells us how much energy would have been used a given year if temperatures that year had been normal. Temperature correction is carried out to allow comparison of energy consumption from year to year and to see how it is influenced by other factors. The calculations disregard the effect of temperature by assuming that a forecast year will be normal in terms of temperature (part of the "normal-year correction"). Temperature correction is based on daily temperature statistics from the Swedish Meteorological and Hydrological Institute (SMHI).

As well as heating, electric energy is used to operate commercial and industrial premises and appliances in the home. Energy consumption is also calculated for the sub-sectors agriculture, forestry and fisheries, second homes and other services.

The heating sector

In the short term, energy consumption for heating purposes is largely determined by the type of heating systems installed in buildings. The exceptions to this are houses fitted with combination boilers. These are capable of switching instantly from electric power to oil. Heating systems are usually replaced when an existing system wears out.

The heating requirement has been estimated with the help of a model (the "DoS model").

The following input data is required to make a forecast for the heating sector using thismodel:

- Energy consumption broken down into heating systems and types of building (individual houses, apartment buildings/commercial premises)
- Forecast new production and demolition
- Average improvements in energy efficiency during the period
- Average lifespan of the respective heating systems (which determines the need for replacement during the forecast period)
- The cost of investing in various energy systems, cost of capital and depreciation period
- Energy prices (not power prices, since DoS forecasts all power prices)
- Conversion efficiency of the various heating systems and estimated improvements in this
- Maximum potential of various heating systems.

Since the model assumes that consumers will choose the most economical alternative when replacing an existing system, the user of the DoS model must insert a number of limitations. Even though heat pumps are the most economical alternative, not all people will choose them; perhaps 20 per cent will.

On the basis of these premises, the model calculates the consumption of various types of energy at different electricity prices. The model also optimises the operation of combination systems.

The MARKAL model has also been used to estimate heating requirements for housing and commercial/industrial premises (see separate description). DoS results and MARKAL results have been compared. The final results have then been obtained following an assessment of the reasonableness of the results produced by the two models.

Household electricity and operating electricity

Household electricity and operating electricity in commercial/industrial premises is estimated using a growth factor based on assumptions made as to economic growth.

Consumer spending and public spending are important factors.

Energy use throughout the sector

Energy consumption in housing and commercial/industrial premises is obtained by adding household electricity and operating electricity to heating. These together represent just over 85 per cent of total energy use in the sector. Additional to this is energy consumption in agriculture, forestry and fisheries, second homes and other services (electricity, gas, water supply and sewage, street lighting etc). Use in these minor sub-sectors is usually estimated fairly roughly, often on the basis of the stated economic conditions in each sector.

Method for the transport sector

The scenarios for emissions from the transport sector have been produced in two stages: (i) scenarios for total transport (person/tonne kilometres); and (ii) scenarios for energy consumption (broken down into various types of energy).

Total transport (tonnes/person kilometres)

The scenarios for transport in this communication have been produced using model systems developed jointly by the Swedish Institute of Transport and Communication Analysis (SIKA), the transport authorities and the Swedish Agency for Innovation Systems (Vinnova) (formerly the Swedish Transport and Communications Research Board).

Passenger transport

Information on actual travel, the range of transport available, population structure etc has been gathered as a basis for developing the SAMPERS modelling system for passenger transport. Information on actual travel comes from the national travel survey: "Riks-RVU" (now RES). Some 30,000 interviews during the period 1994 – 1997 have been taken from the survey. Statistics on travel habits, available range of transport and demography have then been used to formulate models for passenger transport demand. Travel frequency is one parameter that is modelled, ie, the number of journeys per person and day, choice of destination and mode of transport chosen. This is known as the "logit model".[1] Choice of route is also modelled with the help of the Canadian net analysis system Emme/2.

Forecasting requires input data in the form of assumptions as to economic growth, demographic changes and changes in the transport system. The system is suitable for analysing the impact of, for example, changes in the range of transport available, price changes or demographic changes. SAMPERS comprises five regional models for short journeys, a nationwide model for long domestic journeys, and a model for foreign travel.

Analyses can be made and results presented at regional, national and international level.

Goods transport

The Swedish national modelling system for goods transport (SAMGODS) may best be described as a collection of separate models, to some extent developed for quite different purposes than analyses of national goods demand, but which have been linked together to serve as a fairly effective and consistent method. The system primarily consists of two parts:

one with models dealing with demand for transport, and a model dealing with the transport network and transport market. Geographical disaggregated matrices for goods demand in Sweden and between Swedish and foreign regions are obtained from the demand models. This demand is then broken down by the network models into various modes of transport and transport routes. The modelling system uses a cost-minimising algorithm to allow forecasts of transport streams for various types of transport and to analyse transport chains and the impact on the transport system of transport policy measures or changes in the infrastructure.

Fuel use

Petrol consumption accounts for almost 60 per cent of the energy used for domestictransport. A "top-down" demand model is used to estimate petrol consumption trends.

Petrol demand is based on assumptions as to changes in the petrol price and disposable incomes2, as well as estimated elasticities. Price elasticity is assumed to be -0.7 and income elasticity 0.6.3 Also included are assumptions as to technological developments (rate of efficiency improvements). The model is limited in the sense that it does not have a built-in adjustment mechanism, which, among other things, means that it cannot tell us when a petrol price rise will have the greatest impact on petrol demand.

Diesel consumption accounts for just over 30 per cent of the energy used for domestic transport. Here too, a "top-down" demand model has been used to estimate diesel consumption trends. The model is based on assumptions about future growth in various industries. The industries that have been found to have the greatest impact on diesel consumption are the pulp and paper industry, the petrochemicals industry and the engineering industry. The model also takes into account estimates of diesel price trends (price elasticity -0.2) and technological developments.

Aviation fuel for domestic air traffic accounts for approximately 4 per cent of energy consumption in the transport sector. Estimates of aviation fuel consumption are based on Civil Aviation forecasts of the number of landings at Swedish airports. This forecast is in turn derived from forecast passenger numbers. The number of landings is obtained from assumptions about the aircraft models in use and cabin factor trends (average number of seats available). Passenger forecasts have been produced using a demand function, which uses the correlation between the demand for air travel and economic growth, together with the price of air travel.

Electricity use represents 4 per cent of energy consumption in the transport sector.

Estimates of electricity consumption trends are mainly based on decided investments in expansion rail transport.

Fuel oils for domestic shipping account for 2 per cent of energy consumption in the transport sector. Changes in the use of Fuel oil 1 and Fuel oils 2 – 5 are mainly a result of traffic between the island of Gotland and the mainland. Estimates of the consumption of fuel oils in international shipping ("bunkers") are based on assumptions about future import and export trends.

Estimates of future use of alternative fuels are based on information about technical developments in relation

[1] The "conditioned logit model" (D McFadden, 1974) may be described as follows. We assume that the individual can choose between a number (say J) of options. Let X represent the characteristics of the options and Z the characteristics of the individuals the scientist can observe in his data. In one study, the options may be car, bus or underground train; X may include details of journey costs and time, while Z could include details of age, income and educational background. However, in addition to X and Z, there are a number of other characteristics of individuals and options that determine the choice they make to achieve maximum benefit, but which the scientist cannot observe. These are summarised in a "random term". Models of this kind are regularly used in studies of individual's choice of mode of travel, but have also been used in a number of other areas, such as studies of choice of housing, place of residence and education. (Source: Royal Swedish Academy of Sciences, Populärvetenskaplig information, Swedish Riksbank Nobel prize in economics 2000).

[2] Forecasts of consumer spending are used as a measure of future income trends.

[3] "Bensinskatteförändringars effekter" (Effects of Changes in Petrol Taxation"). Expert Group for Studies in Public Sector Economics, government report Ds 1994:55

to the various fuels, and also on political decisions. Technologies now exist allowing operation using a series of alternative fuels. The reason these are not widely used at present is that fuel and vehicle costs are higher than those for petrol and diesel. The limited number of distribution outlets and service stations also inhibits the introduction and use of alternative fuels. There is currently considerable uncertainty about future taxation of alternative fuels, which also impacts on estimates about their future use.

Electricity and heat production

Estimated trends for electricity and heat production in the scenarios are based on an iterative process. A test is made to see whether the production system balances demand, and an assessment is also made as to whether the energy system as a whole is adequate.

However, electricity and district heating production are given on the basis of demand in the user sectors.

Economic conditions and fuel prices represent input data both for the user sectors and for supply, ie, for electricity and district heating production. Derived fuel prices and tax and subsidy systems are input data for calculating electricity production costs for new power and for calculating variable production costs for existing power.

Some account is taken of improvements in production technologies for electric energy and district heating. Account is also taken of increased production capacity for some types of power as a result of various forms of subsidy.

The current electricity production systems have been fairly well surveyed. Information is available about existing capacity for producing various kinds of power and about the limitations of the overall production system. Where applicable, special studies are also made of costs in the electricity production system.

Estimates for combined power and heating are based on data on current power and heating systems. In the calculations regarding a future system, district heating productionis also given by the use within the housing and service sectors and in industry. The basic approach is to optimise the cost-effectiveness of each district heating system individually.

In other words, the cheapest boilers or heat pumps are used at any given time. Moreover, combined power and heating must be optimised in relation to the electricity prices prevailing over a year.

Estimates of changes in the power balance are based on the principle that types of energy are used in order of cost. That is, the cheapest form of energy is used first. Marginal cost pricing means that the price reflects the cost of producing an additional kilowatt hour of electricity. The short-term marginal cost for one year is defined as a time-weighted mean figure for the variable cost of the most expensive form of power used at different times plus a "scarcity cost" component. The scarcity cost is intended to reflect the production system's capacity to supply. When there is overcapacity, the scarcity cost is low; but it rises when demand rises within the framework of a given system.

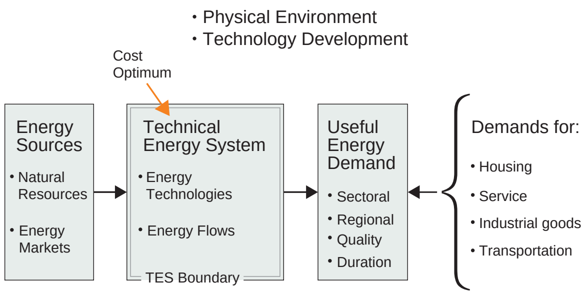
Outline of MARKAL and its use

MARKAL is a dynamic linear programming model developed in the mid-1970s by IEA-ETSAP for analysis of the technical energy system. The model has been continuously improved and is widely used throughout the world. Briefly, an extrinsically specified demand for various energy services in a number of sectors of society drives the MARKAL model. The model attempts to achieve the specified demand at the lowest possible cost.

The model specifies a large number of technologies, present and future. These cover everything from large-scale power production to small-scale energy conversion technologies used by the end user, as well as measures taken to improve energy efficiency. There are also a large number of boundary conditions such as environmental requirements and technical performance. The time horizon is normally 10 – 25 years.

MARKAL is usually used for scenario analyses, in which the scenarios are formed (selected) on the basis of different forecast trends for factors surrounding the energy system. The flow chart shown below describes the technical energy system and its surroundings, in which outside factors are gathered under four headings: energy markets, energy demand, technological developments and environmental requirements.

Figure 2
MARKAL's theoretical construction in relation to the technical energy system (TES) and the four external factors. The arrow pointing diagonally towards TES represents the objective of



the model, usually to minimise system costs under the stated boundary conditions.

MARKAL optimises development of the technical energy system during the period studied on the basis of:

- a predetermined objective;
- forecast trends for the four external factors; and
- set boundary conditions (system limitations).

The commonest objective in MARKAL is to minimise costs on the basis of socio-economic criteria. The model results then comprise the most cost-effective development of the energy system, given the assumptions made about trends for the external factors and given the boundary conditions.

The models also offer the possibility of choosing objectives other than economic ones. For example, the aim in MARKAL may be to minimise greenhouse gas emissions.

The boundary conditions may comprise a long series of limitations. For example: capacity restrictions (for developing given technologies or for transfer between countries), potentials (eg, limitations in available quantities of waste fuels), emission limitations (eg, of greenhouse gases under the Kyoto Protocol) etc.

B. Statistics and scenarios

Table 3
Energy supply, actual trend 1990, 1997, 1999 and scenarios for 1997–2010, TWh

	1990	1997 base yr	1999	2005	2010	2020 Scen. 1 %	2020 Scen. 2 %	Trend 1997–2020 Scen. 1 %	Trend 1997–2020 Scen. 2 %
Use									
End use	365	382	384	400	415	435	432	14	13
comprising:									
Industry	140	153	153	162	172	183	178	20	17
Transport	75	76	80	84	86	91	91	19	19
Housing, services etc	150	153	151	154	157	161	162	5	6
International shipping	15	23	26	29	32	38	38	65	65
Non-energy purposes	29	22	18	20	22	27	27	24	24
Distribution and conversion losses	175	189	198	183	184	188	144	-1	-24
including losses in nuclear power	139	145	152	138	138	138	89	-5	-38
Total use	**583**	**616**	**625**	**632**	**653**	**688**	**641**	**12**	**4**
Supply									
Total fuel supply	298	327	326	345	363	398	417	22	27
comprising:									
Oil products	195	201	199	207	213	232	234	15	16
Natural gas och city gas	7	9	10	8	9	9	24	4	171
Coal och coke	30	27	26	27	27	27	27	2	0
Biomass fuels, peat etc	67	90	91	102	114	129	132	42	46
Waste heat. boiler heat	8	9	10	9	9	9	7	2.0	-18
Hydropower, gross	73	70	72	68	70	71	72	1	3
Nuclear power, gross	206	213	224	203	203	203	132	-5.0	-38
Wind power, gross	0.0	0.2	0.4	1.4	3.9	4.2	10.5	21 times[*]	52 times[*]
Import-export electricity	-2	-3	-7	7	4	4	4		
Total supply	**583**	**616**	**625**	**632**	**653**	**688**	**641**	**12**	**4**

[1] Energy after the reactor according to UN/ECE

[2] Not including input electricity

Source: Statistics Sweden and National Energy Administration

[*] Not expressed as a percentage but as the number of times over production is expected to increase.

Table 4
Electricity balance, TWh

	1990	1997 base yr	1999	2005	2010	2020 Scen. 1	2020 Scen. 2	Percentage change 1997–2020 Scen. 1	Percentage change 1997–2020 Scen. 2
Use									
Total use, net	139.9	142.6	143.3	148.4	152.0	158.4	153.6	11	8
comprising:									
Industry	53.0	52.7	54.5	56.7	58.6	62.0	59.2	18	12
Transport	2.5	3.0	3.0	3.1	3.2	3.2	3.2	7	7
Housing, services etc	65.0	69.6	68.9	71.8	74.2	76.9	75.9	10	9
Supply									
Net production	141.7	145.3	150.8	141.8	147.9	154.3	149.6	6	3
comprising:									
Hydropower	71.4	68.2	70.9	66.2	68.6	69.2	70.1	1	3
Wind power	0.0	0.2	0.4	1.4	3.9	4.2	10.5	21 times*)	52 times*)
Nuclear power	65.2	66.9	70.2	63.6	63.6	63.6	41.3	-5	-38
CPH in industry	2.6	4.2	3.9	4.5	4.9	5.6	6.4	33	52
CPH in district heating systems	2.2	5.3	5.2	6.0	6.8	11.7	13.5	121	156
Condensing fossil fuels	0.2	0.4	0.2	0.1	0.1	0.0	7.9	-100	20 times*)
Gas turbines	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Import-export	-1.8	-2.7	-7.5	6.6	4.2	4.0	4.0		
Total supply, net	**139.9**	**142.6**	**143.3**	**148.4**	**152.0**	**158.4**	**153.6**	**11**	**8**

*) Not expressed as a percentage but as the number of times over production is expected to increase.

Table 5
Fuel input for electricity generation, TWh

	1990	1997 base year	1999	2005	2010	2020 Scen. 1	2020 Scen. 2	Trend 1997–2020 Scen. 1, %	Trend 1997–2020 Scen. 2, %
Fuel input:	7.1	13.9	13.2	14.2	15.7	22.5	38.8	62	179
Oils (inc.LP-gas)	1.8	5.6	5.0	5.1	4.5	4.0	4.4	-29	-22
Natural gas	0.5	0.7	0.6	0.5	0.7	1.0	15.7	40	22 times[*]
Biomass fuels, peat etc	2.5	3.9	3.6	4.6	7.3	14.8	15.5	272	291
Coal (inc. foundry gas)	2.4	3.7	4.0	3.9	3.2	2.8	3.2	-24	-12

[*] Not expressed as a percentage but as the number of times over production is expected to increase.

Source: Statistics Sweden and National Energy Administration

Table 6
District heating balance, 1990,1997,1999 and scenarios for 2010 och 2020, TWh

	1990	1997	1999	2005	2010	2020 (1)	2020 (2)	Percentage change 1997–2020 (1) %	Percentage change 1997–2020 (2) %
Use									
Total end use	34.3	41.9	43.3	45.9	48.0	49.9	49.8	19	19
comprising:									
Industry	3.6	4.3	4.0	4.6	5.0	5.9	5.8	38	36
Housing, services etc	30.7	37.6	39.3	41.3	43.0	44.0	44.0	17	17
Distrib. and conv. losses	6.8	7.9	7.0	6.8	6.7	6.9	7.1	-12	-11
Total use	41.1	49.8	50.3	52.7	54.8	56.8	56.9	14	14
Supply									
Fuel input:									
Oils including LP-gas	4.1	6.1	5.1	4.3	3.6	2.4	2.6	-61	-57
Biomass fuels	10.4	23.9	24.8	30.3	34.9	39.9	41.9	67	75
Coal, inc. foundry gas	8.2	4.0	3.3	2.8	2.3	1.4	1.5	-65	-62
Natural gas	2.0	3.1	3.2	3.0	2.8	2.5	2.6	-21	-17
Other supply:									
Electric boilers	6.3	1.8	1.5	0.9	0.0	0.0	0.0	-100	-100
Heat pumps	7.1	7.0	7.5	7.2	6.9	6.3	4.0	-10	-43
Waste heat1	3.0	3.8	4.8	4.3	4.3	4.3	4.3	13	13
Total supply	41.1	49.8	50.3	52.7	54.8	56.8	56.9	14	14

Scenario 1:
Nuclear power remains in operation for as long as it is profitable.
An assessment of necessary reinvestments has been made.

Scenario 2: Nuclear power is phased out at the end of its 40-year lifespan

[1] Heat received from industry and the housing and services sector.

Note: As a result of rounding up or down, the individual figures do not always add up to the total.

Source: Statistics Sweden and National Energy Administration

Table 7
Industrial energy use in 1990, 1997 and 1999 and scenarios for 2010 och 2020, TWh

Type of energy	1990	1999	1997 base yr	2010	2020 Scen. 1	2020 Scen. 2	1997–2010 %	2010–2020 (1) %	2010–2020 (2) %
Energy coal	7.1	4.9	5.3	6.1	6.8	6.3	15	11	3
Coke [1)]	9.7	9.9	10.6	11.4	12.0	11.5	8	4	0
Biomass fuels, peat etc [2)]	42.8	52.2	51.5	60.4	61.6	61.6	17	2	2
Natural gas	2.8	3.7	3.1	3.5	3.7	3.6	13	6	3
Diesel oil	0.3	0.2	0.2	0.2	0.2	0.2	0	0	0
Fuel oil 1	4.6	3.6	4.9	5.2	6.4	6.2	6	23	19
Fuel oil 2-5	11.6	13.6	14.5	14.9	17.7	17.5	3	19	17
LP-gas	4.1	5.9	5.5	6.1	6.5	6.3	11	7	3
city gas 3)	0.1	0	0	0	0	0	0	0	0
District heating	3.6	4.0	4.3	5.0	5.9	5.8	16	18	16
Electricity	53.0	54.5	52.7	58.6	62.0	59.2	11	6	1
Total	140	153	153	172	183	178	12	6	3
Production value, SEK bn	828	1,116	1,011	1,360	1,667	1,646	34.5	22.6	21.0
Specific energy use, kWh/SEK prod. value	0.169	0.137	0.151	0.126	0.110	0.108	16	15	14
Specific energy use, kWh/SEK prod. value	0.064	0.049	0.052	0.043	0.037	0.037	17	14	14

Scenario 1:
Nuclear power remains in operation for as long as it is profitable.
An assessment of necessary reinvestments has been made.

Scenario 2:
Nuclear power is phased out at the end of its 40-year lifespan

1) Coke includes coke gas and blast furnace gas.

2) Biomass fuels include spent liquor in the pulp and paper industry.

3) City gas is reported together with natural gas for the forecast years.

Note: As a result of rounding up or down, the individual figures do not always add up to the total.

Source: Statistics Sweden and National Energy Administration

Table 8
Energy use in various industries 1990, 1997 och 1999 and scenarios for 2010 och 2020, TWh

	1990	1999	1997 base yr	2010	2020 Scen. 1		1997–2010 %		2010–2020 %
Energy coal	7.1	4.9	5.3	6.1	6.8	6.3	15	11	3
Coke [1]	9.7	9.9	10.6	11.4	12.0	11.5	8	4	0
Biomass fuels, peat etc [2]	42.8	52.2	51.5	60.4	61.6	61.6	17	2	2
Natural gas	2.8	3.7	3.1	3.5	3.7	3.6	13	6	3
Diesel oil	0.3	0.2	0.2	0.2	0.2	0.2	0	0	0
Fuel oil 1	4.6	3.6	4.9	5.2	6.4	6.2	6	23	19
Fuel oil 2-5	11.6	13.6	14.5	14.9	17.7	17.5	3	19	17
LP-gas	4.1	5.9	5.5	6.1	6.5	6.3	11	7	3
city gas [3]	0.1	0	0	0	0	0	0	0	0
District heating	3.6	4.0	4.3	5.0	5.9	5.8	16	18	16
Electricity	53.0	54.5	52.7	58.6	62.0	59.2	11	6	1
Total	140	153	153	172	183	178	12	6	3
Production value, SEK bn	828	1,116	1,011	1,360	1,667	1,646	34.5	22.6	21.0
Specific energy use, kWh/SEK prod. value	0.169	0.137	0.151	0.126	0.110	0.108	16	15	14
Specific energy use, kWh/SEK prod. value	0.064	0.049	0.052	0.043	0.037	0.037	17	14	14

Scenario 1:
Nuclear power remains in operation for as long as it is profitable.
An assessment of necessary reinvestments has been made.

Scenario 2:
Nuclear power is phased out at the end of its 40-year lifespan

1) Coke includes coke gas and blast furnace gas.

2) Biomass fuels include spent liquor in the pulp and paper industry.

3) City gas is reported together with natural gas for the forecast years.

Note: As a result of rounding up or down, the individual figures do not always add up to the total.

Source: Statistics Sweden and National Energy Administration

Table 9
Temperature-corrected energy use in housing, services etc, broken down into energy type, 1990, 1997 och 1999, with estimated values for 2010 och 2020, TWh.

	1990	1999	1997 base yr	2010	2020 Scen. 1	2020 Scen. 2	1997–2010 %	2010–2020 (1) %	2010–2020 (2) %
Total energy use	162.3	156.6	156.3	157.2	161.2	162.2	0.6	2.5	3.2
Electricity, total	68.2	70.3	70.3	74.2	76.9	75.9	5.5	3.6	2.3
Electric heating	29.0	22.8	26.8	27.6	26.0	25.0	3.0	-5.8	-9.4
Household electricity	17.9	19.2	18.7	21.1	23.2	23.2	12.8	10.0	10.0
Operating electricity in commercial/industrial premises	15.8	19.2	18.0	18.5	20.8	20.8	2.8	12.4	12.4
Electricity used in agriculture, forestry and fisheries	1.5	1.4	1.6	1.5	1.4	1.4	-6.3	-6.7	-6.7
Electricity used for other services	4.0	7.7	5.2	5.5	5.5	5.5	5.8	0.0	0.0
District heating, total	34.5	41.7	38.6	43.0	44.0	44.0	11.4	2.3	2.3
Oils, total	45.1	31.6	34.1	26.8	26.0	27.8	-21.4	-3.0	3.7
Wood fuels	12.5	10.8	11.3	11.2	12.4	12.6	-0.9	10.7	12.5
Coal	0.5	0.0	0.1	0.0	0.0	0.0	-100.0	0.0	0.0

Scenario 1:
Nuclear power remains in operation for as long as it is profitable.
An assessment of necessary reinvestments has been made.

Scenario 2:
Nuclear power is phased out at the end of its 40-year lifespan

Note: Oils include LP-gas. Gas comprises city gas and natural gas.

Source: Statistics Sweden "Annual balances" och "Energy statistics for individual houses, apartment buildings and commercial and industrial premises". Also: scenario calculations by the National Energy Administration.

Table 10
Passenger and goods transport to 2020

Traffic and transport	1990	1997	1999	2010	2020	1997–2010	2010–2020
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%
Heavy trucks	1.8	2.3	2.3	3.2	4.2	41%	28%
Light commercial vehicles	5.3	5.0	5.7	7.0	9.0	41%	28%
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%
Railway	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%
Transport, tonne kilometres, billions							
Heavy trucks	27.5	34.4	34.0	47.4	54.0	38%	26%
Railway	18.4	18.4	18.2	20.3	21.1	10%	7%
Shipping	25.6	29.0	27.9	34.8	37.5	20%	14%

Source: Swedish Institute for Transport and Communication Analysis

Table 11
Energy use in the transport sector 1990-2020

Fuel	Unit	1990	1999	1997 base yr	2010	2020	1997–2010 %	2010–2020 %
Domestic transport								
Petrol	1,000 m3	5,589	5,453	5,576	5,770	5,990	4	4
Diesel	1,000 m3	2,052	2,565	2,097	2,940	3,180	40	8
Fuel oil 1	1,000 m3	96	115	74	100	130	35	30
Fuel oil 2-5	1,000 m3	64	41	33	30	25	-9	-17
Aviation fuel	1,000 m3	235	299	298	223	274	-25	23
Electricity	GWh	2,475	3,024	2,954	3,150	3,150	7	0
Total	TWh	75.4	80.5	76.4	86.1	91.1	13	6
International transport								
Diesel/fuel oil 1	1,000 m3	179	257	291	372	440	28	18
Fuel oil 2-5	1,000 m3	568	1,371	1,174	1,556	1,830	32	18
Aviation fuel	1,000 m3	706	851	767	1,170	1,436	52	23
Total	TWh	14.7	25.5	22.9	31.7	36.9	39	16
Total	TWh	90.1	106.0	99.3	117.7	129.0	18	10

Note: Domestic and international aviation fuel use is broken down in line with Civil Aviation Administration estimates. According to the administration, domestic air traffic had a share of 25 per cent in 1990 and 28 per cent in 1997. It is expected to account for 16 per cent by 2010 and 2020. International shipping and air traffic is not included in the estimates of Swedish carbon dioxide emissions.

C. Tables – Underlying assumptions

Table 12
Actual and forecast growth in GNI and industrial production, annual percentage change.

	GNI	Industrial production
Actual growth		
1960-1970	4.6	5.8
1970-1980	2.0	1.2
1980-1990	2.2	1.8
1990-1999	1.5 [1)]	3.4 [2)]
Forecast		
1997-2010	1.9	2.3
2010-2020	1.1	2.1

Note: Statistics Sweden has reported GNI using a revised method since 1980
[1)] 1990-1993: –1.6%.1993-1999: 3.1%
[2)] 1990-1993: – 3.5%. 1993-1999: 7.0%.

Source: Statistics Sweden and National Institute of Economic Research

Table 13
Actual and forecast growth in consumer spending and public spending, annual percentage change.

	Consumer spending	Public spending
Actual growth		
1960-–1970	3.8	5.7
1970–1980	1.6	3.2
1980–1990	1.7	1.7
1990–1999	1.0	0.7
Forecast		
1997–2010	2.4	1.2
2010–2020	1.9	0.8

Source: Statistics Sweden and National Institute of Economic Research

Table 14
Fuel prices for large heating plants, heat distribution stations, large and small factories, SEK/kWh, including energy and environmental taxes.

	1997[1]	1999[2]	2010[3]	2020[3]
Large heating plants				
Fuel oil 1	0.312 (0.173)	0.308 (0.181)	0.349 (0.224)	0.372 (0.224)
Fuel oil 5	0.256 (0.167)	0.266 (0.175)	0.292 (0.215)	0.327 (0.215)
Coal	0.222 (0.177)	0.227 (0.186)	0.282 (0.240)	0.293 (0.240)
Heat distribution stations				
Fuel oil 1	0.341 (0.181)	0.329 (0.181)	0.369 (0.224)	0.393 (0.224)
Fuel oil 5	0.275 (0.175)	0.278 (0.175)	0.304 (0.214)	0.336 (0.214)
Coal	0.232 (0.177)	0.234 (0.182)	0.286 (0.234)	0.297 (0.234)
Large factories				
Fuel oil 1	0.193 (0.054)	0.018 (0.053)	0.179 (0.054)	0.202 (0.054)
Fuel oil 5	0.148 (0.059)	0.150 (0.058)	0.136 (0.059)	0.172 (0.06)
Coal	0.126 (0.081)	0.123 (0.082)	0.123 (0.081)	0.137 (0.084)
Natural gas	0.153 (0.037)	0.150 (0.04)	0.157 (0.041)	0.203 (0.041)
Small factories				
Fuel oil 1	0.213 (0.053)	0.201 (0.053)	0.2 (0.054)	0.223 (0.054)
Fuel oil 5	0.159 (0.059)	0.161 (0.058)	0.149 (0.059)	0.181 (0.059)
Coal	0.136 (0.081)	0.132 (0.080)	0.133 (0.081)	0.144 (0.081)

Note: The tax is shown in brackets.

[1] The price includes the average tax in 1997. The tax was altered on 1 July 1997.

[2] The price for 1999 includes the tax from 1 January 1999.

[3] The price for 2010 and 2020 includes the latest tax in force from 1 January 2001.

Source: Swedish Tax Administration and National Energy Administration

Table 15
Fuel prices for commercial premises and individual houses, SEK/kWh, including taxes and VAT.

	1997[1]	1999[2]	2010[3]	2020[3]
Commercial premises				
Fuel oil 1	0.421 (0.261)	0.411 (0.263)	0.4638 (0.317)	0.491 (0.322)
Fuel oil 5	0.340 (0.240)	0.348 (0.245)	0.381 (0.291)	0.421 (0.299)
Coal	0.290 (0.235)	0.293 (0.241)	0.358 (0.306)	0.371 (0.308)
Individual houses				
Fuel oil 1	0.448 (0.267)	0.439 (0.269)	0.49 (0.322)	0.516 (0.327)
Natural gas	0.396 (0.173)	0.409 (0.187)	0.464 (0.234)	0.558 (0.253)

Note: Tax including VAT is shown in brackets.

[1] The price includes 25 per cent VAT and the average tax in 1997. The tax was altered on 1 July 1997.

[2] The price for 1999 includes 25 per cent VAT and the tax from 1 January 1999.

[3] The price for 2010 and 2020 includes 25 per cent VAT and the latest tax in force from 1 January 2001.

Source: Swedish Tax Administration and National Energy Administration

Table 16
Electricity prices och distribution charges for various types of customer, including selective purchase taxes and VAT, SEK/kWh

	Electricity-intensive industry	Medium-sized factory	Electric heating	Household electricity
1997				
Electricity price	0.234	0.244	0.276	0.292
Distribution charge	0.057	0.093	0.216	0.411
Selective purchase tax	0.0	0.0	0.126	0.126
Total price inc. purchase tax och VAT	0.291	0.337	0.772	1.036
1999				
Electricity price	0.197	0.196	0.214	0.218
Distribution charge	0.057	0.093	0.206	0.398
Selective purchase tax	0.0	0.0	12.8	0.128
Total price inc. purchase tax and VAT	0.254	0.289	0.685	0.93
2010				
Electricity price	0.23	0.235	0.245	0.25
Distribution charge	0.05	0.082	0.19	0.362
Selective purchase tax	0.0	0.0	0.181	0.181
Total price inc. purchase tax and VAT	0.28	0.317	0.77	0.991
2020 reinvest. in nuc. power				
Electricity price	0.24	0.245	0.255	0.26
Distribution charge	0.047	0.077	0.179	0.34
Selective purchase tax			0.181	0.181
Total price inc. purchase tax and VAT	0.287	0.322	0.768	0.976
2020 nuclear power 40 years				
Electricity price	0.31	0.315	0.3.5	0.33
Distribution charge	0.047	0.077	0.179	0.34
Selective purchase tax			18.1	18.1
Total price inc. purchase tax and VAT	0.357	0.392	0.856	1.064

Source: National Energy Administration

Table 17
Energy and environmental taxes from 1 January 2001, not including VAT

	Energy tax	CO_2 tax	Sulphur tax	Total tax	Tax SEK/kWh
Fuels[1)]					
Fuel oil 1, SEK/m³ (< 0.1% sulphur)	688	1,527	-	2,215	0.224
Fuel oil 5, SEK/m³ (0.4% sulphur)	688	1,527	108	2,323	0.215
Coal, SEK/tonne (0.5% sulphur)	293	1,329	150	1,772	0.234
LP-gas, SEK/tonne	134	1,606	-	1,740	0.136
Natural gas/methane, SEK/1,000 m³	223	1,144	-	1,367	0.141
Raw tall oil, SEK/m³	2,215	-	-	2,215	0.221
Peat, SEK/tonne, 45% moisture content (0.24% sulphur)	-	-	40	40	0.015
Motor fuels[2)]					
Petrol, environmental class 1, SEK/l	3.26	1.24	-	4.5	0.516
Petrol, environmental class 2, SEK/l	3.29	1.24	-	4.5	0.519
Other petrol, SEK/l	3.92	1.24	-	5.16	0.592
Diesel, environmental class 1, SEK/l	1.51	1.53	-	3.04	0.311
Diesel, environmental class 2, SEK/l	1.79	1.53	-	3.27	0.334
Diesel, environmental class 3 or other, SEK/l	2.04	1.53	-	3.57	0.358
Natural gas/methane, SEK/m³	0	1.04		1.04	0.107
LP-gas, SEK/kg	0	1.26		1.26	0.106
Electricity use					
Elec. N Sweden, SEK/kWh Elec.	0.125	-	-	0.125	0.125
Other Sweden SEK/kWh	0.181	-	-	0.181	0.181
Electricity, gas, heating or water supply, SEK/kWh					
N Sweden,	0.125	-	-	0.125	0.125
Other Sweden	0.158	-	-	0.158	0.158
Electric boilers, output > 2 MW, 1/11-31/3, SEK/kWh					
N Sweden,	0.148	-	-	0.148	0.148
Other Sweden	0.181	-	-	0.181	0.181

Note: VAT at a rate of 25 per cent is payable in addition to other taxes, although not by industry. An environmental charge of SEK 40/kg is payable for emissions of nitrogen oxides from boilers, gas turbines and stationary combustion plants having a power output of at least 25 GWh. The charge is refunded in proportion to the energy production and emissions of each plant. Nuclear power is subject to a tax based on the thermal output of the reactors. Under certain operating conditions, the output tax is SEK 0.027/kWh. A tax of SEK 0.015/kWh is also levied under the "Studsvik Act", and a further SEK 0.01/kWh is levied under the Funding of Future Costs for Spent Nuclear Fuels Act.

Fuels used for electricity generation are exempt from the energy and carbon dioxide taxes but are subject to the sulphur tax. Fossil fuels used for heat production at combined power and heating plants are subject to half-rate energy tax, as well as full carbon dioxide and sulphur tax.

[2)] Aviation fuel is not specifically taxed. However, domestic air traffic pays tax via the Civil Aviation Administration landing and passenger charges.

Source: Swedish Tax Administration and National Energy Administration

Table 18
Energy and environmental taxes for industry, agriculture, forestry and aquaculture from 1 January 2001, not including VAT

	Energy tax	CO_2 tax	sulphur tax	Total tax	Tax SEK/kWh
Fuel oil 1, SEK/m^3	0	534	-	534	0.054
Fuel oil 5, SEK/m^3	0	534	108	642	0.059
Coal, SEK/tonne	0	465	150	615	0.081
LP-gas, SEK/tonne	0	562	-	562	0.044
Natural gas, SEK/1,000 m^3	0	400	-	400	0.041
Raw tall oil, SEK/m3	534	-	-	534	0.053
Peat, SEK/tonne, 45% moisture content (0.24% sulphur)	-	-	40	40	0.015

Note: When purchasing energy, industry may receive a refund of 65 per cent of the carbon dioxide tax on fuels used to generate heat.

Source: Swedish Tax Administration and National Energy Administration

Appendix 5 – Bilateral and regional funding related to implementation of the Climate Convention 1997 – 2000

Table 19
Bilateral and regional funding related to implementation of the Climate Convention, 1997 (millions SEK)

Recipient country/ region	Measures to reduce emissions and increase removals of greenhouse gases							Adjustment			Other-
	Energy	Transport	Forestry	Agriculture	Waste	Industry management	Air pollution/ other	Capacity developm./ research	Adm. Coastal areas	Other vulnerability reduction	
Non-Annex 1 countries											
1. Tanzania	25.03		2.07	3.43				5.10	0.23	34.27	0.20
2. India	41.44		5.03	0.85		2.02	3.52		1.00	0.01	
3. Uganda	46.72										
4. Mozambique	18.17	0.08		5.57				2.39		7.00	5.76
5. Thailand	21.00		0.70				1.23				
6. Kenya			0.04	18.51				0.23		3.22	
7. Laos			14.01					3.30			
8. Zambia	1.62			13.47						0.15	
9. Costa Rica			9.56			1.23				0.70	
10. Bolivia			10.01								
11. China	5.92			0.12							1.04
12. Lesotho								1.37		5.13	
13. Vietnam			0.46	0.15	0.60	1.69			0.12		1.38
14. Ethiopia			2.78							0.42	
15. Chile					0.26	1.91					
16. Philippines						1.19	0.95				
17. Africa regional	9.50	1.83		10.64			2.30	4.95		6.97	
18. Asia regional	3.00							1.30			
19. Latin America reg.							2.37				
20. Global progr.	17.21	4.08	15.09	4.20	0.99		14.71	4.60		30.90	
21. Other	1.40	0.30	0.49	1.12	2.05	0.73	1.00	0.11	1.44	0.68	-
Sub-total	**191.02**	**6.29**	**60.23**	**58.06**	**3.90**	**11.14**	**23.70**	**23.35**	**2.79**	**89.44**	**8.37**
Other countries											
22. Latvia	3.78	1.27				0.57					
23. Poland	1.36						3.96				
24. Estonia	1.28					1.03					
25. Other	1.30	-	-	0.20	0.57	-	-	-	-	-	-
Sub-total	**7.72**	**1.27**	**-**	**0.20**	**0.57**	**1.60**	**3.96**	**-**	**-**	**-**	**-**
TOTAL:	**198.74**	**7.56**	**60.23**	**58.26**	**4.47**	**12.74**	**27.66**	**23.35**	**2.79**	**89.44**	**8.37**
Including credits:	72.42	-	-	-	-	2.37	-	-	-	-	-

Source: Sida

Table 20
Bilateral and regional funding related to implementation of the Climate Convention, 1998, (millions SEK)

Recipient country/ region	Measures to reduce emissions and increase removals of greenhouse gases							Adjustment			Other-
	Energy	Transport	Forestry	Agriculture	Waste	Industry management	Air pollution/ other	Capacity developm./ research	Adm. Coastal areas	Other vulnerability reduction	
Non-Annex 1 countries											
1. Tanzania	86.67	1.83						27.20	2.07	35.14	0.04
2. Vietnam	35.59				0.21	1.03	1.71	13.22	2.32		
3. Kenya					0.96			2.94		43.97	
4. Bangladesh										41.78	
5. Mozam-bique	9.13	0.32						27.86		2.74	
6. India	2.54		0.28	17.17	1.00	3.19		5.32			
7. Laos			12.10					0.85			
8. Bolivia			0.49			3.63		8.41			
9. Ethiopia								12.53			
10. Ecuador	4.71					7.18					
11. Nicaragua	3.89							5.70		0.30	
12. Zambia	6.93	1.19									
13. Zimbabwe		1.86						2.32			3.93
14. Philippines			0.39		0.40	4.38	0.85	1.59			
15. Guatemala								0.03		6.05	
16. Chile		0.84				2.75	0.04	0.57			
17. Africa regional	9.50			19.97		1.43		16.80	17.70	3.77	1.31
18. Asia regional	4.47							10.47	2.00	1.60	
19. Latin America reg.								0.90	3.48	1.80	
20. Global programmes	14.55	4.90	7.97	9.71	2.80	10.66	5.42	135.54	7.59	16.96	0.79
21. Other	2.31	0.94	0.44	1.10	1.63	3.81	1.19	6.07	0.95	2.17	1.44
Sub-total	**180.29**	**10.06**	**23.49**	**48.91**	**6.03**	**38.05**	**10.10**	**280.92**	**34.43**	**154.48**	**7.51**
Other countries											
22. Poland	1.48	7.60	0.07		3.31		7.70				0.59
23. Latvia	11.54	0.40	0.03		0.55						
24. Russia	3.32	3.62	1.59	0.28			2.48				
25. C/E Europe regional	11.36	1.30		3.58	0.71		4.00		0.94		
26. Other	0.87	4.50	0.65	0.60	-	-	0.34	3.53	-	1.61	-
Sub-total	**28.56**	**17.43**	**2.33**	**4.46**	**4.57**	**-**	**14.52**	**3.53**	**0.94**	**1.61**	**0.59**
TOTAL:	**208.8**	**27.5**	**25.8**	**53.4**	**10.6**	**38.1**	**24.6**	**284.4**	**35.4**	**156.1**	**8.1**
including credits:	17.32	-	-	-	-	-	-	-	-	-	-

Source: Sida

Table 21
Bilateral and regional funding related to implementation of the Climate Convention, 1999, (millions SEK)

Recipient country/ region	Measures to reduce emissions and increase removals of greenhouse gases							Adjustment			Other-
	Energy	Transport	Forestry	Agriculture	Waste	Industry management	Air pollution/ other	Capacity developm./ research	Adm. Coastal areas	Other vulnerability reduction	
Non-Annex 1 countries											
1. Tanzania	69.50		2.41					37.42	3.20	35.09	0.03
2. Bangladesh										76.82	
3. Vietnam	39.14					2.24	0.24	13.24	0.00		
4. Mozam- bique	36.95		0.02					13.32		1.52	
5. Kenya								1.56		33.14	
6. Zambia	9.14	0.80		6.55				12.13		0.19	
7. India	5.94	0.21	2.28	6.11		2.79	0.29				
8. Bolivia						7.14		7.14			
9. Honduras								0.09		12.32	
10. Zimbabwe		1.84			0.97			4.25			2.57
11. Tunisia		2.05			0.93					6.18	
12. Eritrea	8.33										
13. Nicaragua								8.09			0.21
14. Laos			8.00								
15. Guatemala				2.00		0.30				5.52	
16. Africa regional	6.50			30.35		2.22		18.53	15.91	11.79	0.10
17. Asia regional	14.93					0.19	1.61	15.50	16.27	16.20	
18. Latin Amer. reg., Carib						0.71	0.90	17.37	4.25	1.70	
19. Global programmes	15.56	7.34	7.31	13.17	3.19	14.10	10.46	108.54	15.91	10.92	1.43
20. Other	1.14	1.58	0.28	5.34	2.49	12.91	1.97	6.08	0.97	4.06	-
Sub-total	**207.13**	**13.83**	**20.29**	**63.52**	**7.58**	**42.59**	**15.48**	**263.27**	**56.52**	**215.47**	**4.33**
Other countries											
21. Russia	14.71	0.62	0.56	0.67		0.35	1.86				0.57
22. Latvia	5.76		1.44		4.63						0.61
23. Poland	0.29	0.70	0.86				7.74				0.18
24. Kosovo	30.78	0.74									
25. C./E.. Europe reg	0.41			3.00	1.47		4.00		0.28	7.36	
26. Other	6.13	6.60	2.53	2.70	-	-	0.87	2.78	-	7.08	-
Sub-total	**58.08**	**8.65**	**5.39**	**6.37**	**6.10**	**0.35**	**14.47**	**2.78**	**0.28**	**14.44**	**1.36**
TOTAL	**265.2**	**22.5**	**25.7**	**69.9**	**13.7**	**42.9**	**29.9**	**266.0**	**56.8**	**229.9**	**5.7**
including credits:	-	-	-	-	-	-	-	-	-	-	-

Source: Sida

Table 22
Bilateral and regional funding related to implementation of the Climate Convention, 2000, (millions SEK)

Recipient country/ region	Measures to reduce emissions and increase removals of greenhouse gases							Adjustment			Other-
	Energy	Transport	Forestry	Agriculture	Waste	Industry management	Air pollution/ other	Capacity developm./ research	Adm. Coastal areas	Other vulnerability reduction	
Non-Annex 1 countries											
1. Tanzania	71.99		2.08	1.00				35.68	3.87	31.62	0.09
2. Vietnam	63.91					4.90	0.56	12.64			
3. Bangladesh										74.43	
4. Kenya				0.37				13.95		29.74	
5. Sri Lanka						32.14					
6. Zambia	7.27			7.09				15.02		0.41	
7. Mozam-bique	9.76		0.01					19.28			
8. Uganda	20.00										
9. Ghana	19.50										
10. Honduras							0.11	5.18		12.06	
11. Laos			14.77					1.31			
12. Zimbabwe		0.93						9.66			1.57
13. North Korea			12.00								
14. India	1.01		0.35	1.15	1.00	1.94	0.54	5.52			
15. Nicaragua								10.74			0.08
16. Africa regional	15.18		0.00	23.08		0.78		35.01	4.39	7.07	0.01
17. Asia regional	13.95						5.12	11.22		9.29	
18. Latin Am. reg., Carib.	2.50						0.90	11.72	1.58	7.40	
19. Global programmes	20.96	3.86	3.28	13.45	2.36	14.95	6.67	160.45	17.39	10.50	4.68
20. Other	11.94	4.18	0.18	14.94	2.31	9.74	4.35	0.70	3.94	9.71	3.92
Sub-total	**257.95**	**8.96**	**20.69**	**73.07**	**5.67**	**64.46**	**18.24**	**348.08**	**31.17**	**192.24**	**10.35**
Other countries											
21. Kosovo	46.43	4.27			5.00						
22. Russia	19.22	2.64		0.70		2.75	0.44				0.44
23. Bosnia-Herzegovina		0.53		12.72							
24. Ukraine	4.29		2.65					1.63		2.69	
25. C/E. Europe reg	1.98		0.23	13.00	0.86		4.30		0.02	12.94	0.70
26. Other	4.42	2.37	1.19	4.80	1.77	-	5.93	0.26	-	5.01	0.81
Sub-total	**76.35**	**9.81**	**4.07**	**31.23**	**7.63**	**2.75**	**10.68**	**1.89**	**0.02**	**20.64**	**1.94**
TOTAL	**334.3**	**18.8**	**24.8**	**104.3**	**13.3**	**67.2**	**28.9**	**350.0**	**31.2**	**212.9**	**12.3**
including credits:	73.90	-	-	-	-	-	-	-	-	-	-

Source: Sida