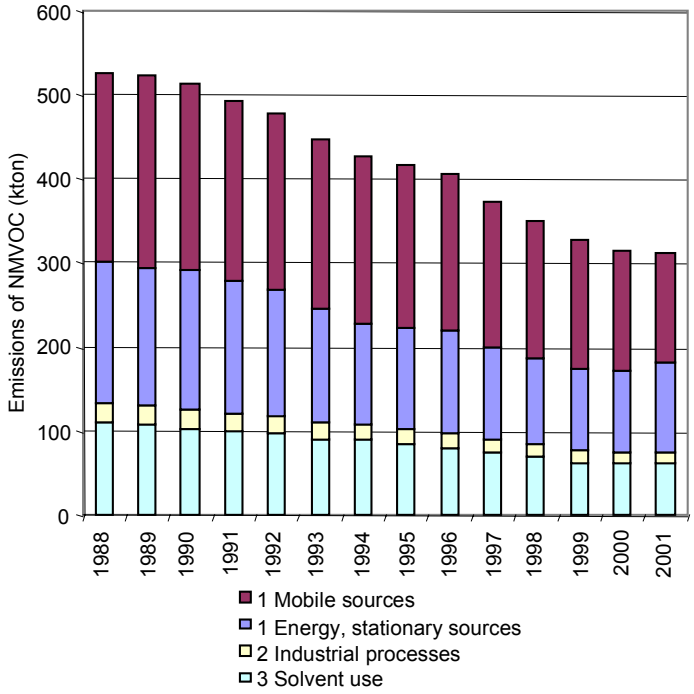
Report series SMED and SMED&SLU Nr 6 2004

Swedish Methodology for Environmental Data



Estimated emissions of NMVOC in Sweden 1988-2001

Karin Kindbom, Curt-Åke Boström, Tina Skårman,
IVL Swedish Environmental Research Institute

Tomas Gustafsson, Marja Talonpoika
Statistics Sweden, SCB

January 2004

Assignment for Swedish Environmental Protection Agency

Report title: Estimated emissions of NMVOC in Sweden 1988-2001
Authors: Karin Kindbom, Curt-Åke Boström and Tina Skårman, IVL, Tomas Gustafsson and Marja Talonpoika, SCB
Year of publication: 2004
Publication at: www.smed.se
Title: Report series for SMED
Publisher: SMHI Swedish Meteorological and Hydrological Institute
Address: Folkborgsvägen 1, 601 76 Norrköping, Sweden
Start Year: 2004
ISSN: 1652-4179

SMED är en förkortning för Svenska MiljöEmissionsData, och är ett samarbete mellan IVL Svenska Miljöinstitutet, SCB och SMHI. Samarbetet inom SMED inleddes under 2001 med syftet att långsiktigt samla och utveckla kompetensen inom emissionsstatistik kopplat till åtgärdsarbete inom olika områden, bland annat som ett svar på Naturvårdsverkets behov av upprätta ett svenskt datavärdskap för utsläpp till luft. Målsättningen med SMED-samarbetet är att utveckla och driva nationella emissionsdatabaser och att tillhandahålla olika tjänster relaterade till dessa. Kundbasen är tänkt att omfatta både nationella, regionala och lokala myndigheter samt luft- och vattenvårdsförbund och näringsliv. Dessa kan genom samarbetet inom SMED erbjudas en attraktiv återföring av resultat inom ett större område än tidigare. Konsulttjänster kommer att utvecklas både för nationella och internationella uppdrag.

SMED is an abbreviation for Swedish Methodology for Environmental Data which is based on a collaboration between IVL Swedish Environmental Research Institute, SCB Statistics Sweden and SMHI Swedish Meteorological and Hydrological Institute. The work co-operation within SMED commenced during 2001 with the long-term aim of acquiring and developing expertise within emission statistics. SMED fulfils the Swedish Environmental Protection Agency's requirements for a Swedish air emission data centre. In particular, the work focuses on following the introduction of abatement measures for different sectors. A central objective of the SMED collaboration is thus to develop and maintain national emission databases and offer related services. Potential clients include national, regional and local governmental authorities, air and water quality associations, and industrial representatives. In work-coperation with SMED, an implementation of results in a wider perspective is achieved. Consultant services will be developed for both national and international assigments.

Table of contents

1. Introduction

Sweden has signed the protocols on long-range transboundary air pollutants (LRTAP), and as a consequence of this, emission estimates are to be reported annually to the Economic Commission for Europe (UN ECE), according to EB.AIR/GE.1/2002/7, Draft Guidelines for Estimating and Reporting Emissions Data (UNECE, 2002). Emissions of NMVOC are also reported to UNFCCC according to the Revised 1996 Guidelines for National Greenhouse Gas Inventories (IPCC, 1997) and under the NEC-directive (2001/81/EG). National emissions of NMVOC have been reported extensively in the past, but the data have not always been of an even, known or good enough quality.

In 2002 SMED, Swedish Methodology for Environmental Data, was given the task by the Swedish EPA to review and recalculate time series of emissions of NMVOC in Sweden, 1988-2001, to be included in the submission of national emissions to EU/NEC, UNECE/LRTAP, EU/MM and UNFCCC in 2003. Emission figures in the submission were, however, reported at a rather aggregated level, and details of the sources included and how the estimates were made were not provided in detail. The purpose of this report is to provide background information on the emissions estimation methodology, emission factors and the origin of the emission factors and activity data used in the estimates.

The base year for reporting NMVOC, according to the 1991 Geneva Protocol on the Control of Emissions of Volatile Organic Compounds, is 1988 for Sweden, which is the reason for choosing 1988 as the first year in the investigated time series presented in the report.

2. General methodology

The general method for calculating emissions from a certain source is to multiply relevant activity data with an emission factor, according to the equation:

$$E=AD*EF$$

Where E= emission, AD= activity data and EF= emission factor.

This kind of information is, however, not always available, thus a large range of different sources of information had to be used in order to derive the data needed to perform the calculations, unless emission data as such were readily available.

In order to compile time series of emissions of NMVOC in Sweden a wide range of background material and information sources was used. This consisted of national information, such as national official statistics, older reports of estimated emissions, information from trade associations and individual facilities, reports from emission measurements, research reports and information from and discussions with experts. In addition to the national information, other sources of information was the Joint

EMEP/CORINAIR Atmospheric Emission Inventory Guidebook (EEA, 2001), and relevant publications from other European countries.

For stationary combustion within the energy sector, emission factors were derived and used together with activity data from the official national energy statistics to calculate emissions.

Estimated emissions from road traffic are based on activity data in a national Swedish model (EMV), while for other mobile sources information on activity originates from various national administrative bodies (e.g. the Swedish Civil Aviation Administration, the National Administration of Shipping and Navigation) or were derived from national fuels statistics. Emission factors used were either nationally derived or as suggested in international literature.

For the sector industrial processes a large proportion of the information consists of emission estimates provided by trade associations, in companies' legal Environmental Reports or obtained in direct contact with facilities.

For the sector solvent and product use much information was provided from industrial facilities, but the larger proportion of information, especially for the earlier years in the time series, are literature data. In the late 1980´s and early 1990´s a lot of attention was directed towards NMVOC-emissions, and several reports from the Swedish EPA have been very useful in the inventory.

In this report NFR codes (Nomenclature for Reporting to UNECE/CLRTAP) and CRF (Common Reporting Format to UNFCCC) for each source are given, as defined in the respective guidelines for reporting (Draft Guidelines for Estimating and Reporting Emissions Data, UNECE, 2002 and in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, (IPCC 1997). This was done to facilitate the reading for those who are familiar with these guidelines. Other readers may just overlook this information.

3. NMVOC

NMVOC (Non Methane Volatile Organic Compounds) is a diverse mixture of substances that for international reporting purposes are added together. The definition of NMVOC, according to the Draft Guidelines for Estimating and Reporting Emissions Data (UNECE, 2002) is:

Non-methane volatile organic compounds (VOC) means any organic compound having at 293.15 K a vapour pressure of 0.01 kP or more, or having a corresponding volatility under the particular conditions of use.

NMVOC emissions arise from combustion processes and industrial processes but are also to a large extent emitted as fugitive emissions from industrial process areas, from storage and handling of e.g. oil products and from the use of solvent or solvent containing products.

3.1. Estimated national emissions of NMVOC

Emissions of NMVOC have been estimated from the energy sector, including mobile sources (CRF/NFR 1), from industrial processes (CRF/NFR 2) and from solvent and product use (CRF/NFR 3). The largest contribution to national NMVOC-emissions comes from the energy sector and from solvent and product use, while emissions from industrial processes contribute less (Figure 3.1) The total national emissions have decreased from more than 500 000 tons in 1988 to approximately 300 000 ton in 2001. Calculated emissions are presented in Appendix 1.

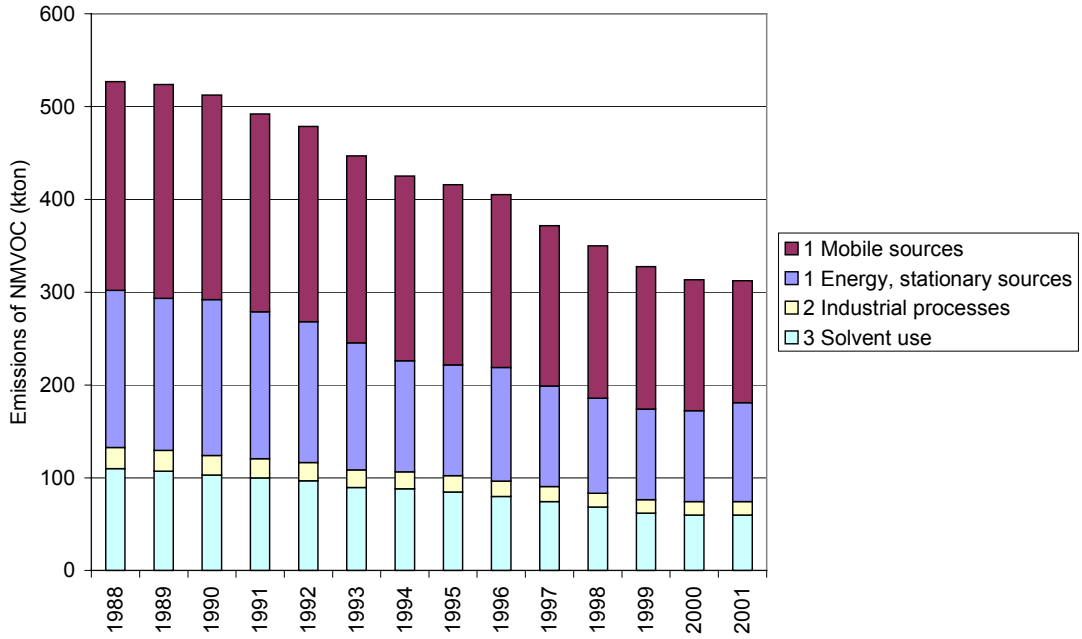


Figure 3.1 Estimated national emissions of NMVOC 1988-2001.

4. Stationary sources within the Energy sector (CRF/NFR 1)

4.1. Energy statistics

Since 1980 the Swedish energy system has changed substantially (Energimyndigheten, 2002). The dependence on fossil fuels (oil and coal), both for heating purposes and in industry has decreased during the last 20 years. During the period 1980-1990, the production of electricity from nuclear power plants increased from 26 TWh to 68 TWh. Due to surplus of electricity in Sweden during 1985-1995 (low price) conversion from oil and coal to electricity heating became common for residential heating. New built houses were also equipped with direct heating by electricity as standard. Another factor for this decrease in fossil fuel uses were the building of district heating systems in most cities. Many of the district heating plants use biofuels today (wood chips, bark). Incineration of municipal waste is also common in district heating plants (5 TWh in 2000). During the years 1990-2000 the district heating continued to increase. The use of heat pumps both in district heating plants and in residential houses has increased since 1985. In the manufacturing

industry the combustion of oil products has decreased from 1980 until 2000 and has to a large extent been replaced by biofuels.

The largest sectors in stationary combustion in Sweden today are district heating (50 TWh, Figure 4.1), combustion in manufacturing industry (96 TWh from combustion, Figure 4.2, presents total energy consumption in industry, including electricity and district heating) and combustion in the commercial and residential sector (35 TWh from combustion, Figure 4.3).

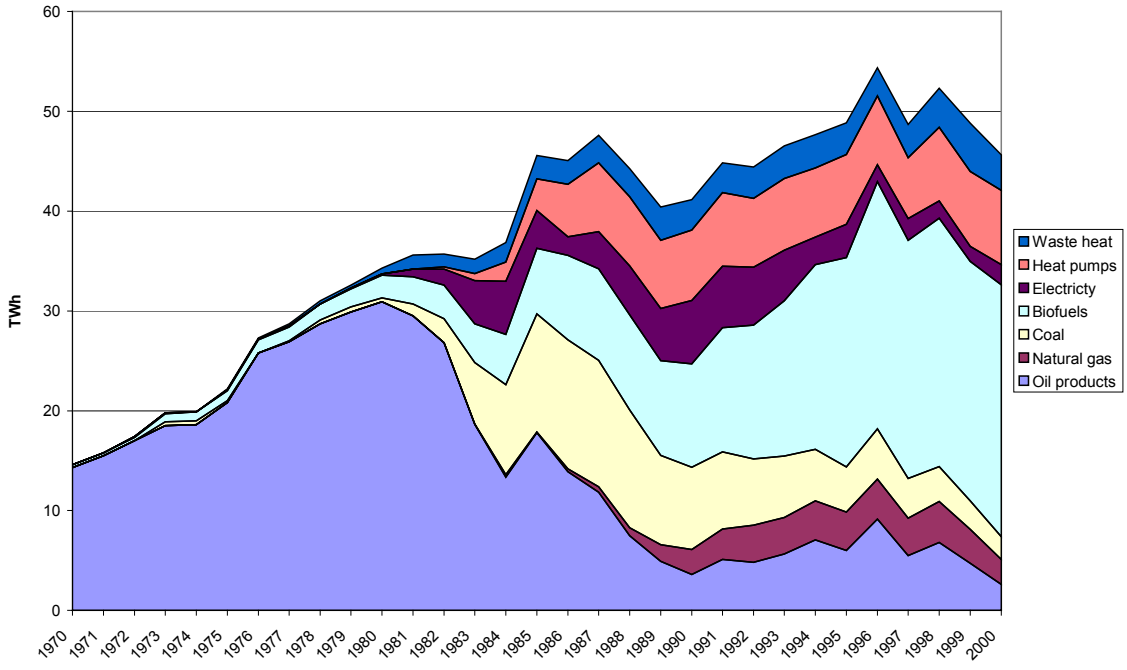


Figure 4.1 Energy supply to the Swedish district heating sector, 1970-2000.

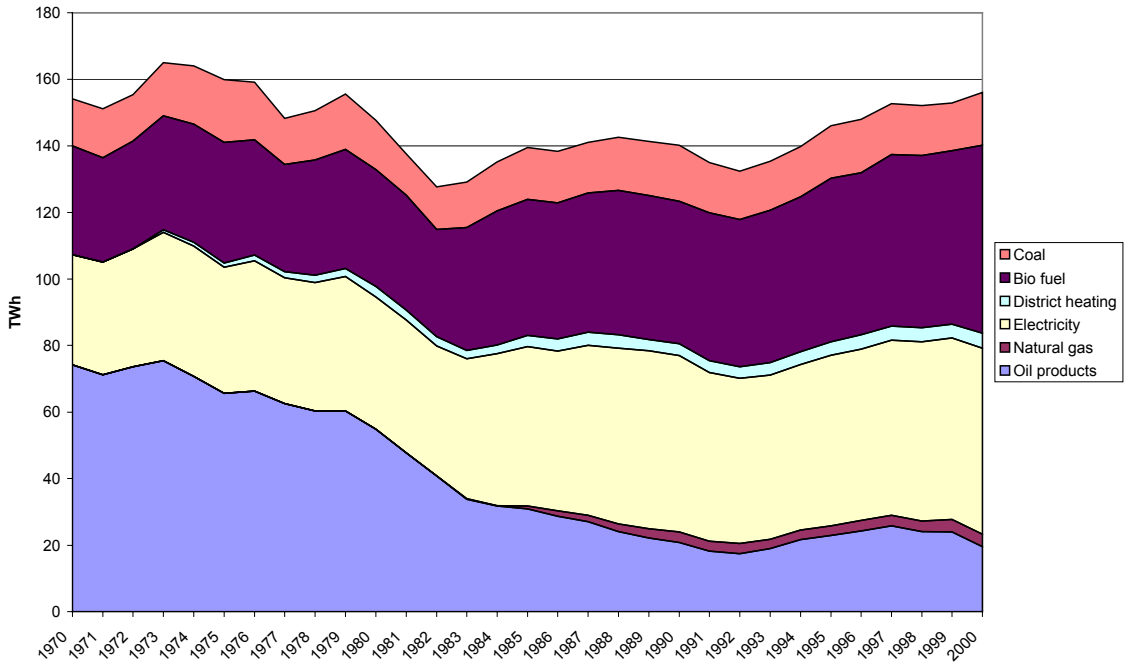


Figure 4.2 Energy consumption in Swedish industry, 1970-2000.

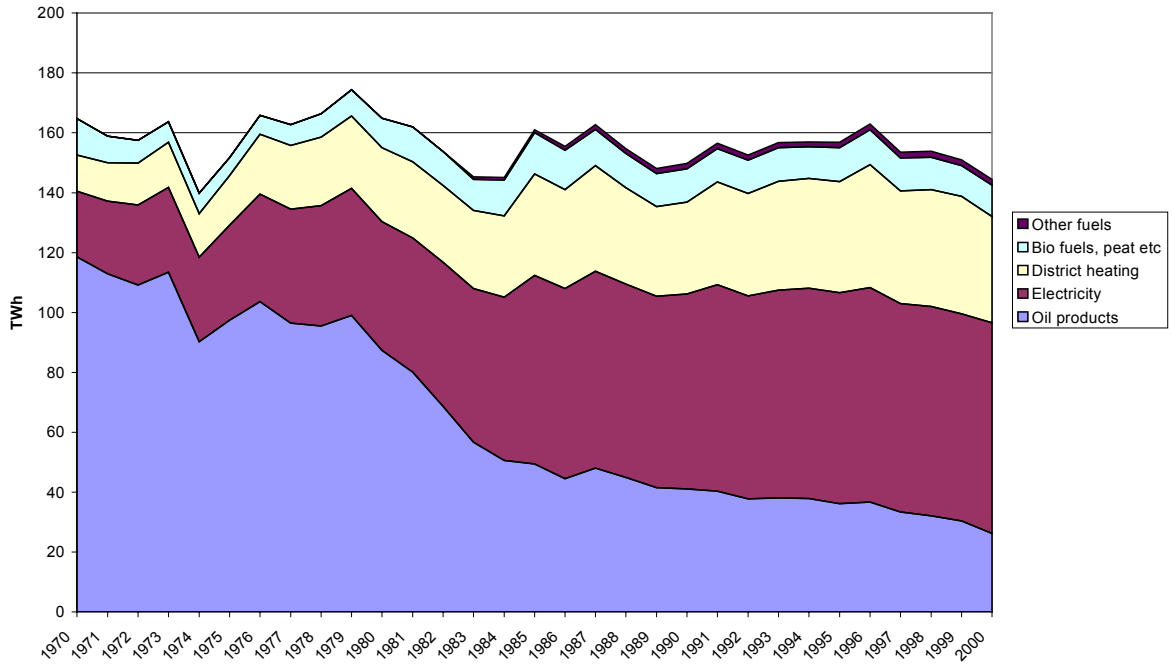


Figure 4.3 Energy consumption in commercial and residential buildings, 1970-2000.

4.2. Energy statistics as activity data for stationary combustion

4.2.1. Thermal values

Statistics Sweden has compiled thermal values for each fuel type based on information from the users. All thermal values refer to net calorific values. Most thermal values are calculated on the basis of chemical qualities and are considered to be of high quality. For some fuel types (coal, coke oven gas and blast furnace gas) the thermal value varies for different years, due to varying properties of the fuels. Hence the uncertainty of the thermal value for coal, coke oven gas and blast furnace gas is higher than for other fuels. No specific information on thermal values was available for the 80's and the thermal values for 1990 have therefore been used also for 1988 and 1989 in teh calculations.

4.2.2. Stationary combustion in Energy Industries, Manufacturing Industries and Construction (NFR 1A1a and 1A1b)

Emissions of NMVOC from stationary combustion in Energy Industries, Manufacturing Industries and Construction are estimated by using data on fuel consumption from Statistics Sweden, department of Energy Statistics, and emission factors presented in Appendix 2.

Both quarterly and yearly mail surveys are carried out to estimate the industrial fuel consumption. The methodology for these surveys has varied over the time period 1988-2001. To achieve total national estimates the quarterly statistics is adjusted. The changes in methods of collection of data that have occurred primarily influences the possibility of correctly allocating the fuels and fuel use to the different sub-categories, according to the requirements for international reporting of emissions. The national total estimates are however considered being of high quality. The changes in collection methods are briefly explained below, and summarised in Table 4.1.

Statistics on fuel consumption for electricity and heat producers (SNI 40, Swedish Standard Industrial Classification, i.e. NASE 40), e.g. heating plants and combined power and heating plants etc., were based on total surveys for all years 1988-2001, and is thus consistent for this time period.

Statistics on fuel consumption for industries (SNI 10-37) for the years 1988-1996 were based on total surveys to all companies with more than 4 employees in 1988-1989 and to all companies with more than 9 empolyees the years 1990-1996. All years 1988-1996 were reported by *working unit*[1]. Adjustments were also made using additional data from quarterly statistics of fuel consumption to achieve better national fuel type coverage.

Statistics on industrial fuel consumption for 1997-1999 were based on yearly surveys. The survey method was altered to include consumed fuels from all *economic activities*[2] in companies with at least 50 employees and a stratified sample of companies with 10-49 employees. The sample was stratified according to industry

[1] Factory, plant etc.
[2] Company level, can include several work units or parts of them.

sector and company size within each SNI-classification. Adjustments were made to yield yearly national estimates.

Statistics on industrial fuel consumption for the year 2000 was again based on a total survey on purchased fuels for all *working units* in companies within SNI 10-37 with more than 9 employees.

For the year 2001 the statistics on industry fuel consumption was based on the same type of survey sampling as for the years 1997-1999, i.e. companies with at least 50 employees and a stratified sample of companies with 10-49 employees. However, instead of *economic activities, working units* were surveyed. Adjustments were made to yield yearly national estimates.

Before 1996 the industry survey had focus on economy, not energy – only *purchased* fuel was included in the mail surveys. From 1997 focus has changed towards energy consumption, including also *own-produced* fuels. This should imply more accurate background data on energy use. On the other hand, between 1997 and 1999 the survey was a sample survey and thus sent to fewer companies than before. This could of course result in larger uncertainties in point estimates. However, the surveys for all years are considered to give high quality information on national total consumption, and possible mistakes, when the sample survey is adjusted, are marginal. Due to differences in survey methodology, time series relating to specific sub-sources are considered to be of lower quality.

Table 4.1 Methodology for fuel consumption survey of industry (SNI 10-37) for the years 1980-2001.

Year	Survey sampling	Included areas	Adjustments	Quality
1988-2001	Quarterly sample survey to all consumers of more than 325 toe.	Working unit: All fuel use.	Adjusted to reach yearly national estimates.	Good survey quality. Changes in coding during the 80's complicated the data processing.
1988-1989	Yearly total surveys to all companies with more than 4 employees.	Working unit: only purchased fuels, quantity and economical value.	Using additional data from the quarterly survey.	Good.
1990-1996	Yearly total surveys to all companies with more than 9 employees.	Working unit: only purchased fuels, quantity and economical value.	Using additional data from the quarterly survey.	Good quality for economical value. Less good quality of quantity.
1997-1999	Yearly surveys to companies with at least 50 employees and a stratified sample of companies with 10-49 employees.	Economic activity: purchased + own-produced fuels.	Adjusted to reach yearly national estimates.	Good for national estimates, less good for sub sources.
2000	Yearly total survey to all companies with more than 9 employees.	Working unit: purchased + own-produced fuels.	No adjustments needed.	Excellent.
2001	Yearly survey to companies with at least 50 employees and a stratified sample of companies with 10-49 employees.	Working unit: purchased + own-produced fuels.	Adjusted to reach yearly national estimates.	Good.

As a result of the changes in methods of compiling the national energy statistics, especially the data for the 1980´s are uncertain when trying to allocate them to the code systems required for the international reporting of emissions.

For refineries (included in code 1A1) as well as for primary iron- and steel plants (included in code 1A2) the data in the energy statistics are sometimes not consistent between years. Fuels, e.g. oil in refineries and coal or coke in primary iron and steel processes, can be used both as fuel for the purpose of energy production, but can also be considered as raw material for the process. Possible causes for a non-consistent reporting of energy consumption from these industries are different definitions of the fuel use when answering questionnaires to the statistical offices. Additionally, the definitions may in turn be different when it comes to emission calculations according to the Guidelines for reporting. In the Guidelines the main issue is that care has to be taken not to double count or omit any emissions calculated from these fuels. The international reporting permits emissions either to be allocated as emissions from

combustion in the energy sector (CRF/NFR 1), or as process emission in the industrial processes sector (CRF/NFR 2).

Due to additional information from refineries concerning fuel consumption in later surveys, the results for 2000 and 2001 are not comparable to earlier years.

In the primary iron and steel industry, inconsistencies in reporting the use of coal and coke as an energy source or as raw material for the process have resulted in comparatively lower estimates from combustion in the energy sector from this source in 1997-1999.

The inconsitencies due to varying methodology in collecting energy statistics for stationary combustion can be seen in Figure 4.4, where estimated emissions of NMVOC are presented. The contribution of 10-20 kton NMVOC from stationary combustion in code 1A1 (energy industries) and 1A2 (Manufacturing industries) is however small compared to the emissions from residantial combustion, which are estimated to be in the order of 75-120 kton (see chapter 4.4).

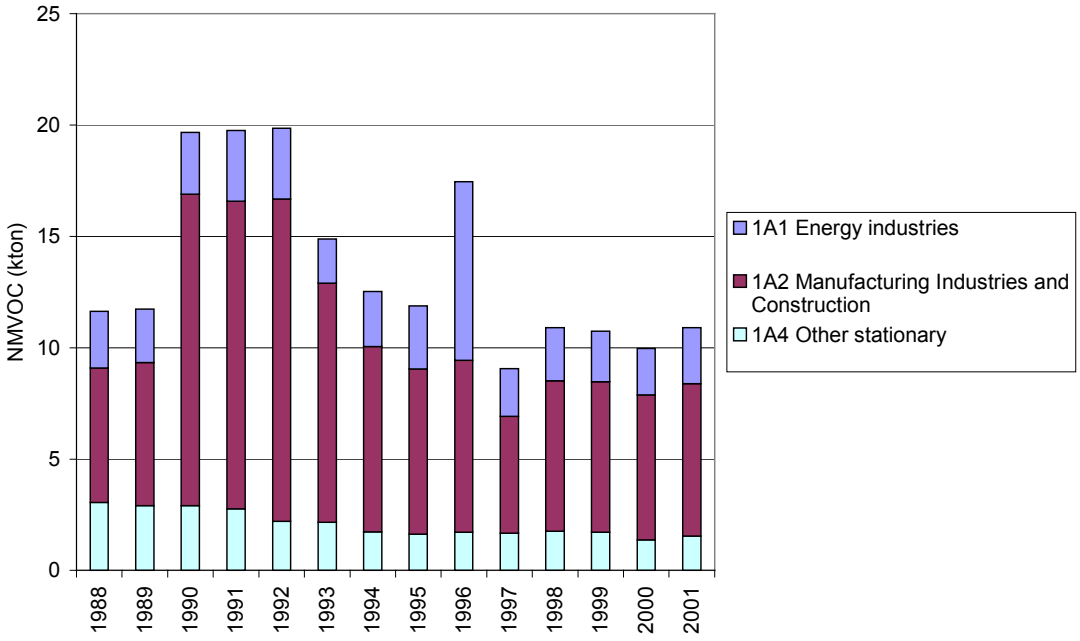


Figure 4.4 Estimated emissions of NMVOC from stationary combustion 1988-2001 (except residential combustion).

4.3. Emission factors for stationary combustion

The emission factors developed for calculation of emissions of NMVOC from stationary combustion are based on information from many different sources. Historically the focus in Sweden, as in many other countries, was to estimate the emissions of sulfur and nitrogen oxides. Emissions and emission factors for other substances have only been studied, estimated and updated sporadically in national inventories.

In the beginning of the 1980´s a large research project concerning many aspects of combustion of coal for power generation started in Sweden, known as "Kol Hälsa Miljö" (Coal Health Environment). During that project a lot of information was compiled regarding emissions of different substances from coal combustion, but also from combustion of other fuels. Other national research programs also started during that time period, concerning combustion of municipal waste (Energi ur Avfall, Energy from Waste), the use of peat (Torv Hälsa Miljö, Peat Health Environment) and natural gas (Naturgas Hälsa Miljö, Natural Gas Health Environment). Emission factors used in the present compilation of time series of emissions, for the period 1988–1990, are to a some extent based on results from these research programs.

From approximately 1990 until present date, the specific emissons have decreased for most of the stationary combustion sources. The cause for this is the technical development of the combustion technique and abatement measures in combination with regulations and requirements from authorities. Combustion of MSW (municipal solid waste) also became strictly regulated in the sense of oxidation efficiency. In the district heating sector installation of flue gas condensation equipment has become common since the beginning of the 1990´s. The reasons for implementing this technique is to increase the heat output, but it also reduces the emission to air of many substances.

The emission factors developed for conditions during 1990-2001 are based on knowledge on the technical development and the general effects of that, as mentioned above. The known effects of this general development has been combined with information from companies legal Environmental Reports, where actual emission factors can be derived, and information from trade associations where experts have contributed their specific knowledge on the different sectors where combustion occurs. Since the energy statistics used for calculation of national emissions is only split into a few areas of use, e.g. combustion in energy industries, combustion in manufacturing industries, and "other", the available information had to be generalized to be used in the emission calculations. From the different information sources general emission factors were thus developed for combustion of individual fuels, split into only a few areas of use. The emission factors used are presented in Appendix 2.

The published information sources that were used to develop emission factors for stationary combustion are collected as a special reference list at the end of this report.

4.4. Emissions from combustion, stationary sources

Estimated emissions of NMVOC from combustion of fuels in stationary sources have decreased from approximately 130-140 kton in late 1980´s and early 1990´s, to about 80-90 ktons in 2000-2001. The dominant source is residential combustion, where the combustion of wood contributes most to the estimated emissions of NMVOC (Figure 4.5).

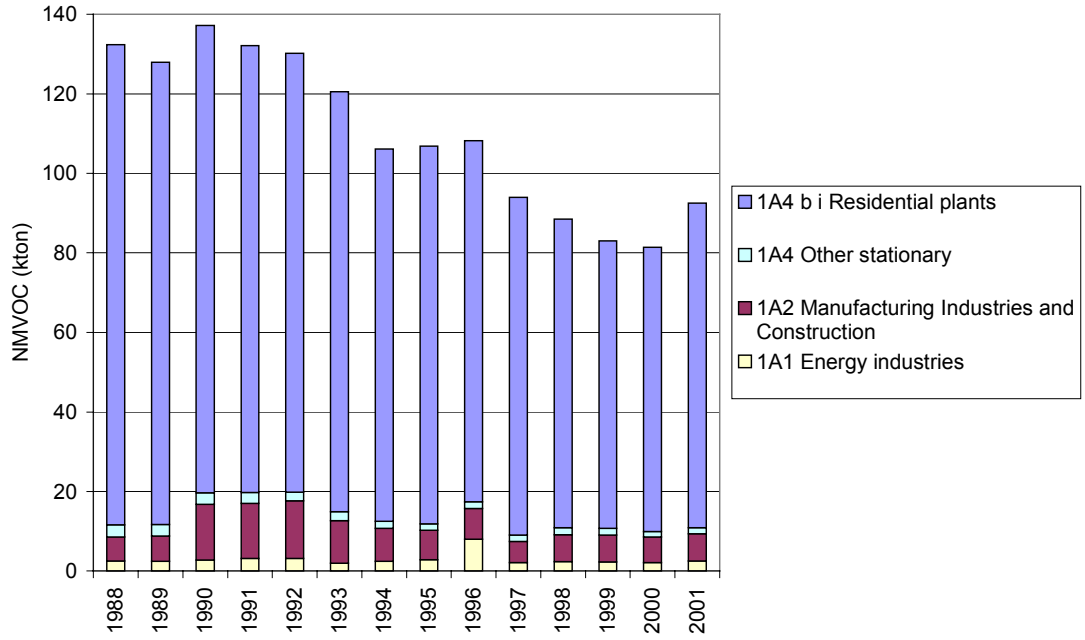


Figure 4.5 Emissions of NMVOC (kton) from stationary combustion 1988-2001.

4.4.1. Energy industries (1A1)

The code Energy industries comprise combustion activities in public electricity and heat production, in refineries and from manufacturing of solid fuels. The larger share of emissions from this group of activities is estimated to arise from public electricity and heat production. Estimated emissions are presented in Appendix 1.

4.4.2. Manufacturing industries and construction (1A2)

Combustion in manufacturing industries is calculated separately for the iron- and steel industry, non-ferrous industry, the chemical industry, from pulp and paper production and from food processing. Other manufacturing industries are estimated and reported as a sum. Estimated emissions from each sub-sector are presented in Appendix 1.

4.4.3. Other sectors, including residential combustion (1A4)

This sector consists of estimated emissions from residential combustion, commercial and institutional combustion, as well as from stationary combustion in agriculture, forestry and fishing. The all-dominating source in this sector is the residential combustion (Figure 4.5), where most of the NMVOC-emissions arise from combustion of wood. Estimated emissions from each sub-sector are presented in Appendix 1.

4.5. Fugitive emissions of NMVOC (1B)

Fugitive emissions of NMVOC from fuels include emissions from solid fuels (transmission losses of coke oven gas and blast furnace gas), fugitive emissions from refinery process areas, from depots and from gasoline distribution (Figure 4.6). Estimated emissions from the sub-sectors are presented in Appendix 1.

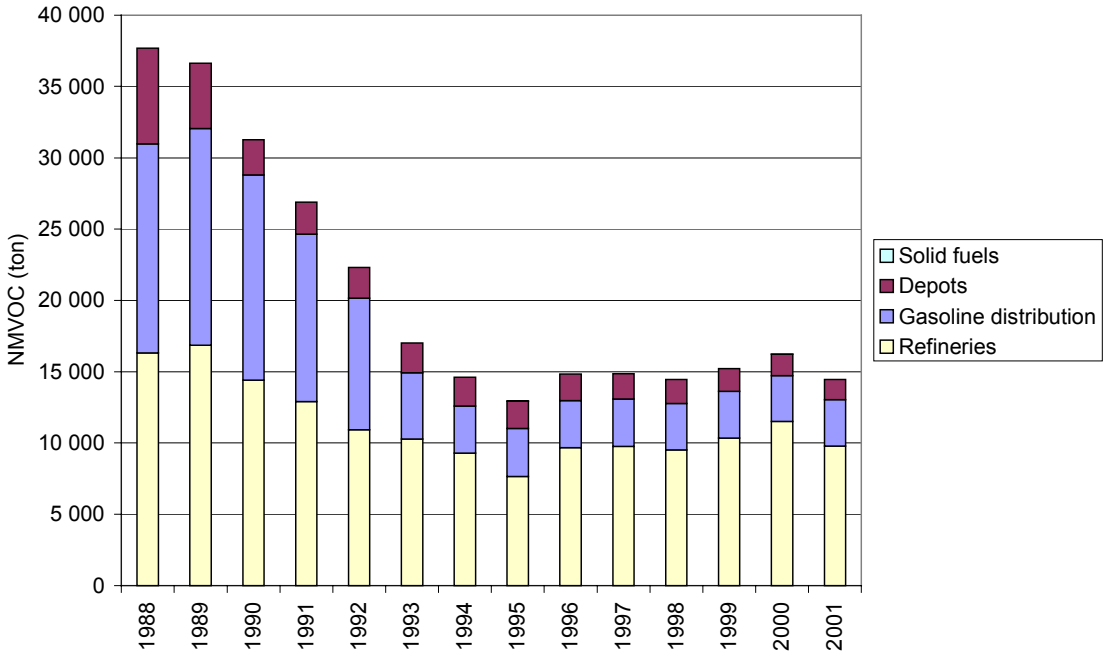


Figure 4.6 Estimated fugitive emissions of NMVOC from fuels.

4.5.1. Fugitive emissions from solid fuels (1B1)

The NMVOC emissions reported in this code are fugitive emissions from transmission losses of coke oven gas and blast furnace gas. These estimated emissions are small compared to fugitive emissions from other sources in 1B.

Table 4.2 Estimated fugitive emissions of NMVOC from solid fuels (ton)

Year	Emissions of NMVOC (ton)
1988	3.7
1989	4.3
1990	5.3
1991	5.2
1992	4.2
1993	4.8
1994	7.6
1995	6.9
1996	6.1
1997	4.9
1998	5.7
1999	6.2
2000	6.0
2001	6.0

4.5.2. Fugitive emissions from handling and storage of oil products (CRF 1B2a, NFR 1B2a iv and 1B2a v)

Refineries (CRF 1B2a, NFR 1B2a iv and 1B2a v)

There are five refineries in Sweden. Three of these refineries produce fuel products such as petrol, diesel fuel and burning fuel oils. The other two refineries mainly produce bitumen products and naphtenic special oils.

Fugitive emissions of NMVOC from refineries include fugitive emissions from the process area as well as emissions from the refinery harbours at loading of tankers. The time series for NMVOC has been recalculated for 1988-2001. The estimates are mainly based on reported data from the facilities legal Environmental Reports that can be found in C-EMIR (the counties administrative board emission database) and older reports from the Swedish EPA and Statistics Sweden, SCB (Swedish EPA Reports 3816 (1990), 4312 (1994), 4336 (1994) and SCB (1996)). The activity data are known for almost all years.

Estimates of fugitive emissions from activities like these are rather uncertain, since the way to calculate have varied over the years, as has the opinions on how to estimate fugitive emissions. In Table 4.3 available information has been compiled and adjusted as best as possible.

Table 4.3 Throughput of crude oil in refineries and estimated fugitive emissions of NMVOC (ton) 1988-2001.

Year	Throughput of crude oil (ton)	Fugitive emissions from refining/storage (ton)	Fugitive emissions from distribution (harbours, loading at refineries) (ton)	Total emissions of NMVOC (ton)
Code				**1B2a**
1988	15 600 000	13 819	2 499	16 318
1989	16 440 000	14 351	2 499	16 850
1990	17 330 000	11 933	2 475	14 408
1991	17 600 000	10 444	2 456	12 900
1992	17 870 000	8 489	2 472	10 961
1993	18 723 684	7 848	2 463	10 311
1994	18 192 000	6 433	2 458	8 933
1995	18 130 000	6 141	1 502	7 643
1996	*	8 209	1 452	9 661
1997	20 100 000	8 347	1 402	9 749
1998	20 254 000	8 155	1 352	9 507
1999	19 483 034	9 048	1 302	10 350
2000	20 253 120	10 318	1 250	11 568
2001	19 669 316	8 885	910	9 795

* Not available

Gasoline distribution (1B2a v)

The time series for fugitive emissions of NMVOC from gasoline distribution, 1988-2001, is based on annual national petrol consumption and assumptions on the share of gasoline evaporated at different stages of the handling procedure. Effects of applied abatement technology on the fugutive emissions at gasoline stations have also been

taken into consideration (Andersson, K. 2000, Concawe 85/54). The assumptions are presented in Table 4.4.

Table 4.4 Assumptions for calculating fugutive emissions from handling and distribution of gasoline (Andersson, K. 2000)

Density of gasoline	730 kg/m^3	
Distribution of gasoline to gas stations	0.16%	of distributed volume emitted
Spill	0.01%	of distributed volume emitted
Filling of car tanks	0.18%	of filled volume emitted
Measures at distribution to gas station	90%	efficiency of measures
Measures at filling cars	70%	efficiency of measures

The measures at distribution and filling were introduced over a period of time from 1991-1994, with the extent presented in Table 4.5. The amount of gasoline sold at large and small gas stations was assumed to be 50/50 for the years between 1990-1994.

Table 4.5 Fraction of gasoline stations with technical measures installed.

Year	Large gas stations (>2000 m3)	Small gas station
1988-1990	0%	0%
1991	50%	0%
1992	75%	25%
1993	100%	75%
1994-	100%	100%

The distributed amount of gasoline is taken from the survey "Statistics of supply and delivery of petroleum products" (SCB:s omsättningsrapport).

Table 4.6 Distributed amount of gasoline and estimated fugitive emissions of NMVOC (metric tons) 1988-2001.

Year	Volume of gasoline (m^3)	Fugitive emissions of NMVOC (ton)
1988	5 739 000	14 663
1989	5 948 000	15 197
1990	5 630 000	14 385
1991	5 700 000	11 755
1992	5 879 000	9 227
1993	5 600 000	4 650
1994	5 655 329	3 303
1995	5 762 693	3 365
1996	5 682 309	3 318
1997	5 576 692	3 346
1998	5 429 396	3 258
1999	5 453 218	3 272
2000	5 372 801	3 224
2001	5 418 329	3 251

Depots (1B2a v)

Calculated fugitive emissions of NMVOC from storage of oil products have been obtained from the Swedish Petroleum Institute (Ljung, SPI). Calculations were based on the amount of gasoline handled in the depots, based on Concawe 85/54. Approximately 20 depots have been considered during later years. Gas recovery

systems and recovered amount of gas have been considered in the calculations. Some years, where no data were provided, were interpolated. The sharp decrease in fugitive emissions from 1988 to 1991 was caused by a wider introduction of gas recovery systems during this period of time.

Table 4.7 Handled amount of gasoline and fugitive emissions of NMVOC (ton) from storage at depots, 1988-2001.

Year	Amount of gasoline (m3)	Fugitive emissions of NMVOC (metric tons)
1988	5 739 000	6 700
1989	5 948 000	4 589
1990	5 630 000	2 478
1991	5 700 000	2 220
1992	5 879 000	2 149
1993	5 600 000	2 077
1994	5 655 329	2 006
1995	5 762 693	1 934
1996	5 682 309	1 861
1997	5 576 692	1 772
1998	5 429 396	1 682
1999	5 453 218	1 593
2000	5 372 801	1 503
2001	5 418 329	1 414

4.5.3. 1B2b

Reported fugitive emissions from natural gas and gas works gas consists of the difference between delivered amount and consumed amount. The gases are delivered in pipelines and fugitive emissions do not occur according to wholesale dealers. The difference could be due to measurement errors. Sweden chooses to report these emissions anyway. The uncertainty in the estimates is therefore high.

Reported fugitive emissions from other fuels consist of transmission losses (transports in pipelines) and some flaring according to Statistics Sweden, energy statistics. These estimates are of good quality.

There also exists some flaring from iron and steel companies that should be reported in section 1B. Currently these emissions are included in section 1A due to lack of proper background data. This will be revised in the near future.

5. Mobile Sources, CRF/NFR 1

5.1. Activity data for fuel consumption in mobile sources

Information on fuel consumption and allocation to end use activities for mobile sources for the purpose of international reporting of emissions, are presented in Lidén (2003). The information presented below is mainly extracted from this report.

5.1.1. Fuel statistics

Calculations are mainly based on statistics on delivered amount of fuels from Statistics Sweden, published as reports EN31SM, but for the purpose of international reporting of emissions additional background data is also being used. The statistics are based on monthly investigations including all oil trade companies and large importers. The investigation is carried out through a mail survey, which includes 70 companies. The largest source of uncertainty is measurement errors, which could have a large impact on the result due to the relatively heavy weight of each object investigated. In total, the reliability is assumed to be very high.

5.1.2. Allocation of gasoline consumption on end-use activities

The calculations are based on total delivered amount of gasoline according to Statistics Sweden EN31SM, allocated to sub-groups.

According to a report from the Swedish EPA (Report 3993, 1992) 1.5 percent of the delivered amount of gasoline is assumed to be used by domestic leisure crafts. For off road vehicles and other machinery a constant amount of 174 920 m^3 is set for 1995-1999, based on Persson and Kindbom (1999). For 1990, 132 000 m^3 is allocated (ÅF Industriteknik AB, 1990, and 3K Engineering AB, 1989), and estimates for 1991-1994 are interpolated. The remaining fuel consumption is located to road traffic, see Table 5.1. Fuel consumption for road traffic according to the national road vehicle emission model (EMV) is 11%-14% lower for some years 1990-2001, with no apparent trend. The resulting distribution of the delivered total amount of gasoline on end use sectors is presented in Figure 5.1.

Table 5.1 Allocation of gasoline on sectors

Sector	Estimation of amount of gasoline consumed
Small boats	1.5 % of delivered amount of gasoline according to Swedish EPA report 3993 (1992)
Off road vehicles and other machinery	According to IVL report L99/21 (1999), ÅF Industriteknik AB (1990) and 3K Engineering AB (1989)
Military road transports	Exact amount given by the Swedish Armed Forces
Military navigation	Exact amount given by the Swedish Armed Forces
Civil road traffic	Remaining fuel consumption

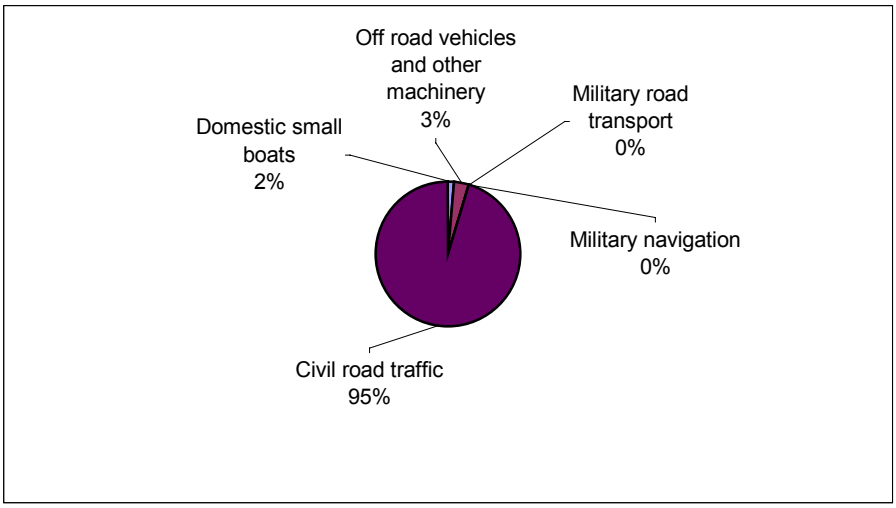


Figure 5.1 Approximate distribution of delivered amount of gasoline.

The allocation of gasoline consumption for off-road vehicles and working machinery in different sectors (Agriculture, Forestry, Residential, Industrial and Other), Table 5.2, is based on Andersson (2000), a Swedish EPA internal report, in turn based on Persson and Kindbom (1999).

Table 5.2 Distribution of gasoline consumption on sectors for off road vehicles and working machinery.

CRF	Sector	Gasoline consumption
1A4a	Agriculture	-
1A4c	Forestry	5,3%
1A4b	Residential	86,2%
1A2f	Industrial	2,5%
1A3e	Other	6,0%

Allocation of gasoline consumption for different vehicles in road traffic (private cars, light trucks, mopeds and motorbikes) is based on estimations by the Swedish National Road Administration according to the EMV-model described in chapter 5.2.

5.1.3. Allocation of diesel consumption on end-use activities

The calculations are based on total delivered amount of diesel according to Statistics Sweden EN31SM. The allocation of the diesel consumption on subgroups, for the purpose of emissions calculations, is presented in Table 5.3.

Very precise information on consumed amount of diesel is collected from the Swedish National Rail Administration and the Swedish Armed Forces. Consumed amount for domestic navigation is given in background data from Statistics Sweden EN31SM. For off-road vehicles a constant amount is used (1 314 410 m^3), based on Persson and Kindbom (1999). The diesel consumption for road traffic is estimated by the EMV model (Table 5.3).

Table 5.3 Distribution of diesel on sectors

Sector	Estimation of amount of diesel consumed
Railway	Exact amount given by the Swedish National Rail Administration
Military road transports	Exact amount given by the Swedish Armed Forces
Military navigation	Exact amount given by the Swedish Armed Forces
Domestic navigation	Background data Statistics Sweden EN31SM
Off road vehicles and other machinery	According to IVL report L99/21
Civil road transport	EMV Model estimation from the Swedish National Road Administration

The sum of estimated consumed amount of diesel in all sectors differ from delivered amount in a way that suggests that consumers store diesel during the period before an increase in price. In previous submissions to UNECE/LRTAP and UNFCCC, the amount of diesel oil used for calculating emissions had been corrected in order to eliminate annual fluctuations. This resulted in a smoothed-out time series for all emissions from diesel oil usage. The UNFCCC Expert Review Team (ERT), who carried out an in-country review in Sweden in November 2001, recommended Sweden not to include any such corrections due to non-compliance with the IPCC Good Practice Guidance (2000). Hence, the correction has been excluded in the submission of 2003, see Figure 5.2.

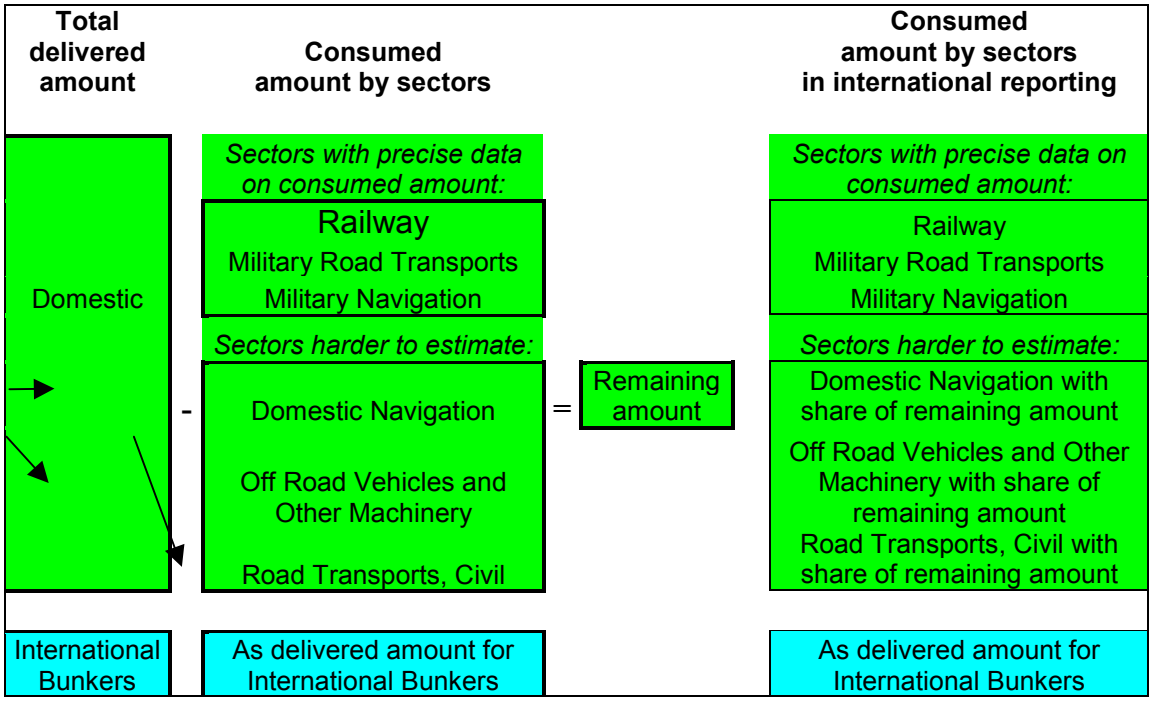


Figure 5.2 Current model for allocating delivered amount of diesel on subgroups without correction for private storing.

Consumption in the different sectors is estimated. The difference between total delivered amount and the sum of the sectors will result in a remaining amount (3-25% of total delivered amount of diesel for different years 1990-2001, with no apparent trend). The remaining amount is distributed on sectors that are harder to estimate,

according to their relative size. The resulting approximate distribution of total consumption of diesel on sub-groups is presented in Figure 5.3.

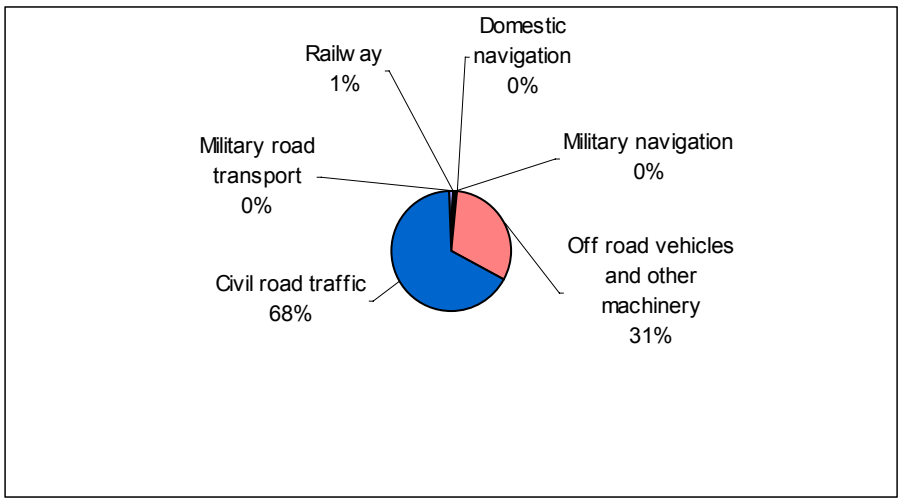


Figure 5.3 Approximate distribution of delivered amount of diesel oil.

The distribution of diesel consumption for working machines and off- road vehicles in different sectors (Agriculture, Forestry, Residential, Industrial and Other) is based on Andersson (2000), which in turn was based on Persson and Kindbom (1999), see Table 5.4.

Table 5.4 Distribution of diesel consumption on sectors for off road vehicles and working machinery.

CRF	Sector	Diesel consumption
1A4a	Agriculture	29,5%
1A4c	Forestry	9,2%
1A4b	Residential	1,5%
1A2f	Industrial	50,6%
1A3e	Other	9,2%

Distribution of diesel consumption for different vehicles in road traffic (private cars, light trucks, heavy trucks and buses) is based on estimations by the Swedish National Road Administration by means of the EMV-model described in chapter 5.2.

5.2. Emissions from combustion of fuels in mobile sources (CRF/NFR 1A3-1A5)

Total estimated emissions of NMVOC from combustion of fuels in mobile sources are presented in Figure 5.4. The dominant source is road traffic. Other sources that, according to the calculations, contribute significantly are national shipping and off-road machinery (only estimated from 1990-2001, 1988 and 1989 have been assigned the same figure as calculated for 1990). Combustion of fuels within railway traffic and aviation are only minor sources to NMVOC-emissions. Estimated emissions from each sub-sector are presented in Appendix 1 and the emission factors used in Appendix 2.

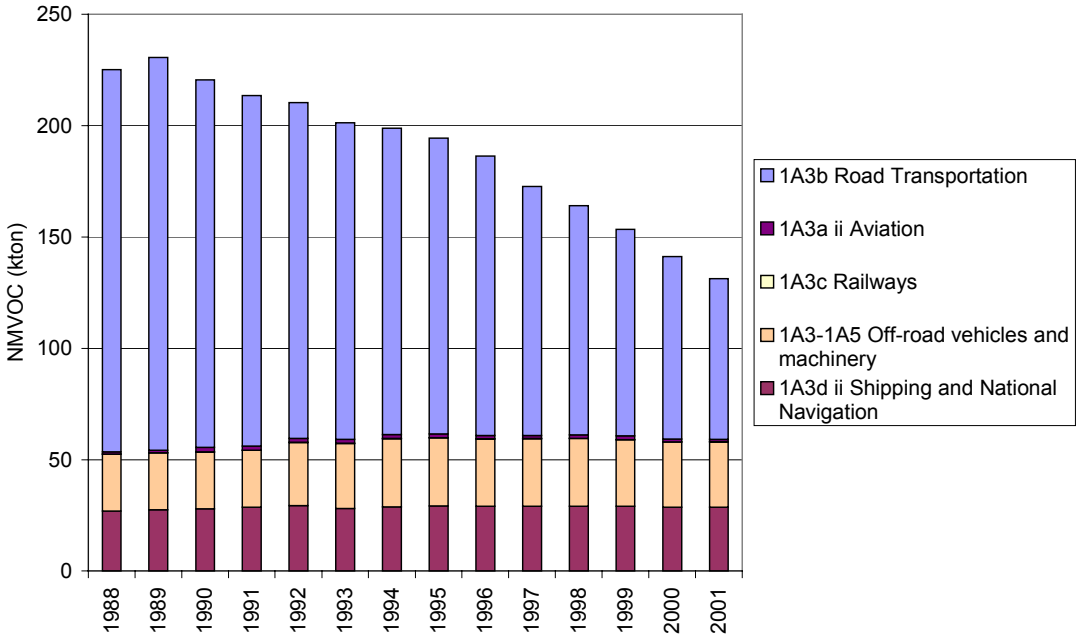


Figure 5.4 Emissions of NMVOC from combustion of fuels in mobile sources.

5.2.1. NMVOC from road traffic, combustion of fuels (NFR 1A3b)

Reported emissions submitted to EU (Monitoring Mechanisms), UNFCCC and CLRTAP differ from emissions estimated by the Swedish National Road Administration due to different methods of calculating. The Swedish National Road Administration wants to describe what is happening on Swedish roads regardless of where the fuel was bought, or nationality of vehicle, and do not take delivered amount of fuel directly into account. In reporting to EU, UNFCCC and CLRTAP only emissions from fuel *loaded into the vehicle* in Sweden should be accounted for according to the IPCC Guidelines. See Table 5.5.

Table 5.5 Emissions from road transport reported by the Swedish National Road Administration (SNRA) and in Swedish EPA reporting to EU, UNFCCC and CLRTAP (SEPA)

Fuel loaded into vehicle in	Traffic on Swedish roads	Traffic in Sweden, not on roads	Traffic to/from other country	Traffic in other countries:
Sweden	SEPA SNRA	SEPA, reported in other sectors	SEPA* SNRA to the Swedish border	SEPA*
Other country	SNRA	Not reported	SNRA to the Swedish border	Not reported

* Currently reported as domestic emission, should be reported separately as international bunkers according to guidelines.

Estimated emissions from road transportation are to a large extent based on calculations performed by the Swedish National Road Administration. They are using a model called EMV, which stands for Emissions from Road traffic. VTI, the Swedish Road- and Transport Research Institute, has developed the model by order of the

Swedish EPA. The model is described in Hammarstöm and Karlsson, (1998). In the EMV-model vehicles are separated into 11 different vehicle categories, and they are in turn separated for different fuel types, age of vehicle, urban/rural area, length of transport etc. For each vehicle type there are descriptions of emissions and specific consumption (Johansson, H. 2001). All road transports in Sweden are included regardless of nationality of vehicle or where the fuel was loaded into the vehicle. Military road transports are included in the EMV- model and separated from civil road transports using information from the Swedish Armed Forces.

Emissions of HC (hydrocarbons) are collected from the EMV-model described above. Emissions of HC are separated into NMVOC and CH_4 (methane) according to quotas for CH_4 from the Swedish EPA, based on measurements from the MTC (MotorTestCenter) car exhaust laboratory.

5.2.2. Military use, combustion of fuels (1A5)

Emissions of NMVOC from military road traffic are derived from emission data from the EMV model and consumption of fuels for all military activities according to information from the Swedish Armed Forces. Fuel consumption from some military activities such as FMV (Swedish Defence Material Administration), FORTV (The National Fortifications Administration), FOI (Swedish Defence Research Agency) and FRA (Swedish Defence Radio Agency) are not included in the calculations.

Emissions of NMVOC from military navigation and aviation are calculated based on the same emission factors as are used for civil navigation and aviation.

5.2.3. NMVOC emissions from civil aviation (NFR 1A3a)

Information on emissions from Swedish Civil Aviation Administration (SCAA) published annual environmental reports do not correspond with international reporting since the definition of domestic traffic differs.

SCAA calculates emissions from aviation based on statistics on number of flights (domestic and international), type of airplanes, amount of fuel needed for different flights and emissions on specific flights based on data on airplane acceleration during different phases of the flight and the distance between destinations. This information is summed up into groups; domestic landing and take-off (LTO), domestic cruise, international LTO and international cruise. This is according to CORINAIR guidelines. Thus, the results could be used for international reporting. Good data exists from 1995 and later years. SCAA also compares the data with information from Statistics Sweden on delivered amount of fuel. Coherence between these two sources has been relatively good, the difference is between 2.9% and 14.6% during the period 1995-2001.

Emissions of NMVOC are calculated on basis of emissions of hydrocarbons from SCAA and emission factors from CORINAIR (EEA, 2001).

5.2.4. NMVOC emissions from railway traffic (NFR 1A3c)

Information on emissions from railways is collected from environmental reports from the Swedish National Rail Administration. The Swedish National Rail Administration

gives information on consumed amount of diesel based on fees paid by operators. These estimates are considered to be of very high quality.

The reports are used to calculate emissions of NMVOC and CH_4 based on total emissions of hydrocarbons. NMVOC and CH_4 are separated with emission factors from CORINAIR (EEA, 2001).

5.2.5. NMVOC emissions from navigation (NFR1A3d)

Emissions from domestic navigation and bunker emissions cannot be compared with emissions reported by the National Administration of Shipping and Navigation since the latter include emissions from the whole region of the Baltic Sea.

Emissions from domestic navigation are calculated on the basis of fuels that are bought and consumed in Sweden according to Statistics Sweden EN31SM, see Table 5.6. Emissions from fuels that are bought in Sweden and used abroad are reported separately as international bunker emissions.

Table 5.6 Reporting of emissions from navigation according to IPCC Good Practice Guidance.

Fuel bought in	Traffic between Swedish harbours	Traffic between Swedish harbours and international harbours	International traffic: between two international harbours
Sweden	Domestic emission, reported	International bunkers, reported separately	International bunkers, reported separately
Other country	Not included	Not included	Not included

Emissions of NMVOCare based on the emission factors of CORINAIR (EEA, 2001) for petrol and diesel. There are no emission factors for residual fuel oil and the emissions are therefore calculated as diesel. The emissions are a bit over-estimated in general, due to that the emission factors (are general and) do not consider catalytic exhaust systems, according to the National Administration of Shipping and Navigation (Trafikverkens Miljörapport 2001).

5.2.6. NMVOC emissions from off-road vehicles and machinery (NFR 1A3-1A5)

Because of different methods for calculating and estimating emissions of NMVOC from off-road vehicles and machinery, the time series 1990-2001 previously suffered from incoherence. To ensure time series consistency, estimates for all years 1990-2001 are based on the same emission factors as for the year 2000. Hence, differences in the NMVOC time series are but due to various fuel consumption. The emission factors for the year 2000 are according to Andersson (2000), in turn based on Persson and Kindbom (1999).

6. Emissions from Industrial processes (CRF/NFR 2)

6.1. Activity data for industrial processes

The compilation of data concerning emissions from industrial processes has been based on a variety of information sources. In the early 1990´s quite a lot of effort was put into estimating and compiling information concerning NMVOC emissions in Sweden. This work was presented in several reports from the Swedish EPA, which have been used as background material to compile time series of NMVOC emissions from 1988 and onwards, in combination with information from e.g. trade associations and from individual facilities. For later years important information sources were industrial companies legal Environmental Reports to the environmental authorities, direct contact with companies, trade associations, experts at county administrations and at the Swedish EPA. Further information sources are the counties administrative board emissions database (C-EMIR), national official production statistics and expert judgements.

Information in companies Environmental Reports, which have been mandatory to submit for larger companies since 1993, are of varying quality and usefulness for the purpose of compiling emission estimates. In later years the information has generally improved, both as to the level of detail in the reporting, and as to the number of emitted substances reported as an emission figure. The database, C-EMIR, consists of emission data from Environmental Reports, but does not include all facilities that have submitted reports.

In order to compile activity data, or emission data as such, for the late 1980´s and beginning of the 1990´s, usually nationwide information from official statistics, trade associations or older reports from the Swedish EPA was used. For some processes there are only a few facilities within the country, and these were contacted directly to obtain information.

For some sources only sparse data have been available, e.g. from older reports or emission data compilations. In those cases interpolations have been done and in some cases data from adjoining years have been used.

6.2. Emissions from industrial processes (CRF and NFR 2)

Estimated emissions of NMVOC from industrial processes have, as a total, decreased from approximately 23 000 tons in 1988 to less than 15 000 tons in 2001. The major sources have been the pulp and paper industry, chemical industry, road paving with asphalt and the food and drink industry. Minor sources that were estimated separately are glass- and mineral wool production, battery manufacture and metal production. Estimated emissions from each sub sector are presented in Appendix 1.

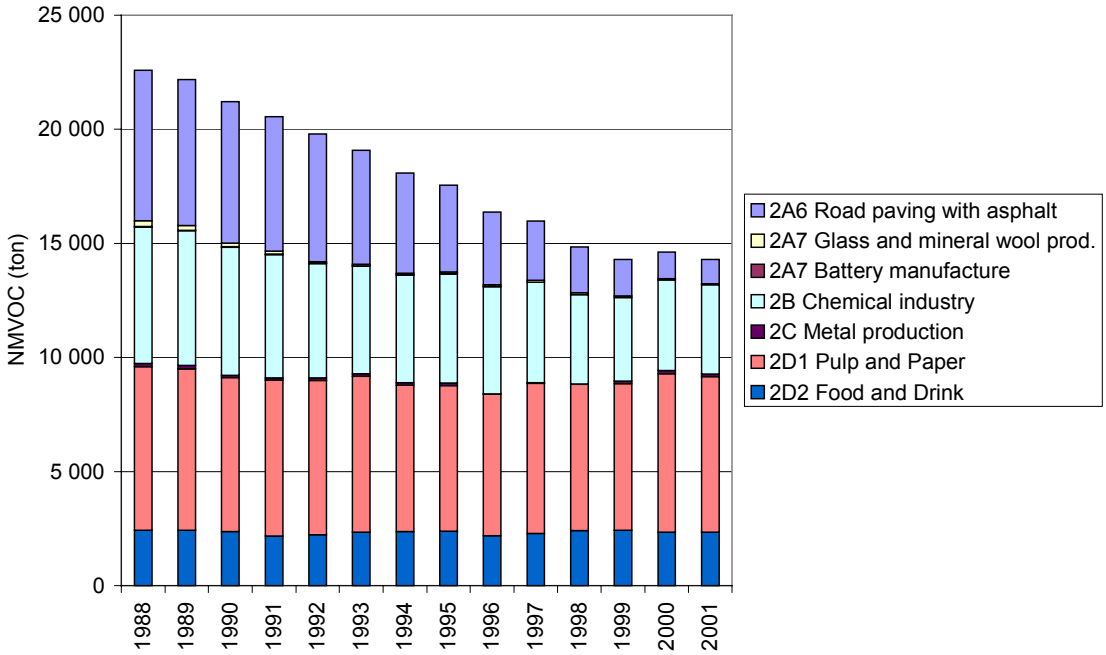


Figure 6.1 Emissions of NMVOC (ton) from industrial processes 1988-2001.

6.2.1. Road paving with asphalt (2A6)

Emissions of NMVOC from road paving with asphalt have been recalculated for the whole time series. Estimates from the early 1990´s were taken from investigations and inventories made in the beginning of 1990´s (national reporting to Corinair, Swedish EPA report 4312, SCB 1996). Data for the last three years have been calculated based on information from the asphalt producers on the amount of solvent (naphta) used in producing the bitumen solution. The producers have also provided estimates on the total amount of solvent-based bitumen delivered in Sweden. All solvent in the solvent-based bitumen is estimated to be emitted when used. Emissions of NMVOC reported for the years in mid- and late 1990´s were interpolated.

Large changes have occurred in the technology of asphalt paving during the last decade with a gradual change to the use of water based emulsions instead of solvent containing bitumen solutions. In 2002 industry representatives estimated that 90% of the glue used was water based. In the reported emissions only NMVOC emitted in the process of paving the roads is included.

Table 6.1 Emissions of NMVOC (ton) from road paving with asphalt 1988-2001.

Year	Emissions of NMVOC (ton)
1988	6600
1989	6400
1990	6200
1991	5900
1992	5600
1993	5000
1994	4400
1995	3800
1996	3200
1997	2600
1998	2000
1999	1600
2000	1170
2001	1080

6.2.2. Battery manufacture (2A7)

From batteries manufacturing, the emissions of NMVOC from 1988-2001 have been compiled. Only one facility has used iso-propanol, and this facility stopped using solvent in their manufacture in 1998. All data were provided by the company (Table 6.2).

Table 6.2 Emissions of NMVOC from battery manufacturing, 1988-1999.

Year	Emissions of NMVOC (ton)
1988	28
1989	28
1990	28
1991	28
1992	28
1993	28
1994	28
1995	28
1996	28
1997	28
1998	16
1999-	0

6.2.3. Glass and mineral wool production (2A7)

For glass- and mineral wool production, occurring at five facilities run by two companies, emission data have been received from one company (three facilities) for the whole time series 1988-2001 (see Table 6.3). Recalculated time series of emissions based on these facilities has been developed in combination with data for some years from the remaining two facilities and earlier total estimates from the national reporting to Corinair. The NMVOC emission reported consists of formaldehyde and phenol.

Table 6.3 Estimated emissions of NMVOC (ton) from glass and mineral wool production 1988-2001.

Year	Estimated emissions of NMVOC (ton)
1988	250
1989	200
1990	150
1991	120
1992	56
1993	54
1994	58
1995	70
1996	66
1997	78
1998	82
1999	72
2000	55
2001	36

6.2.4. Chemical industry (2B5)

This sub-sector includes various chemical industries, such as organic and inorganic base chemical production, production of plastics of different kinds etc, not covered elsewhere. Emissions from refineries are not included in this chapter, but are presented in chapter 4.5.2 (fugitive emissions). The primary information sources as to emissions are those reported by the companies in legal Environmental Reports. A total number of approximately 35 facilities are included. The time series of emissions of NMVOC has been developed based on earlier reports (Swedish EPA reports 4336 and 4462) as well as information from the trade association (Kemikontoret) and earlier submissions of national estimates to CORINAIR. For the years before 1991-1992, information was rather sparse, except for a few of the larger emitters, and assumptions and extrapolations had to be made.

Table 6.4 Estimated emissions of NMVOC (ton) from chemical industry 1988-2001.

Year	Emissions of NMVOC (ton)
1988	5 970
1989	5 900
1990	5 610
1991	5 410
1992	5 010
1993	4 710
1994	4 710
1995	4 770
1996	4 690
1997	4 410
1998	3 920
1999	3 660
2000	3 970
2001	3 910

6.2.5. Metal production (2C)

Iron and steel industry (2C1)

Emissions of NMVOC from the iron and steel industry as such are larger than those presented under this reporting code. The larger part of the emissions is covered under the reporting code 3, product and solvent use, where NMVOC-emissions from the use of paint and general solvent use should be allocated. The origin of NMVOC emissions is not always clear from the facilities Environmental Reports.

Data have been compiled based on various information sources, such as earlier national reports to Corinair and trade specific reports from the Swedish EPA (internal material) for the earlier years, and for later years primarily from Environmental Reports and the EMIR database. The NMVOC emissions included in this reporting code are primarily from rolling mills and from electric arc furnaces. In rolling mills oil products are used in the rolling process, from which emissions of NMVOC arise. In electric arc furnaces NMVOC can be emitted in the process of smelting scrap steel.

Table 6.5 Estimated emissions of NMVOC (ton) from the iron and steel industy.

Year	Emissions of NMVOC (ton)
1988	150*
1989	150*
1990	110
1991	90
1992	100
1993	110
1994	110
1995	120
1996	120
1997	130
1998	100
1999	110
2000	140
2001	103

*Data were assumed

Aluminium production (2C3)

Emissions of NMVOC from aluminium production have been calculated based on emissions of tar to air, reported in the Environmental Reports from the facility. According to Ahmadzai (2000), 70% of the tar can be assumed to be emitted as NMVOC.

Table 6.6 Estimated emissions of NMVOC from aluminium production, 1988-2001.

Year	Emissions of NMVOC (ton)
1988	12
1989	16
1990	14
1991	9
1992	7
1993	9
1994	8
1995	10
1996	12
1997	26
1998	19
1999	15
2000	10
2001	12

6.2.6. Pulp and paper industry (2D1)

Reported emissions from pulp and paper industry were calculated based on production statistics, emission factors and expert judgement. The emission factors choosen (Table 6.7) were primarily based on Berg et al (1990), Boström et al (1992) and Boström (1993).

Table 6.7 Emission factors, NMVOC for pulp and paper production.

Process	Year	Emission factor incl. terpenes	Emission factor excl.terpenes
		kg/ton	kg/ton
Chipboard	1988-2001	1.0	0.3
Kraft process	1988-1992	1.8	0.86
	1993-2001	1.8-1.74	0.84-0.71
Sulphite	1988-2001	1.8	1.1
CTMP/TMP*	1988-2001	1.5	0.15

* CTMP, Chemo Thermo Mechanical Pulp, TMP, Thermo Mechanical Pulp.

Forty-two individual pulp and paper facilities are included in the reported emissions, as well as two manufacturers of board. The kraft process is dominating in Sweden but there are also six sulphite and 14 CTMP or TMP facilities. The industrial organisation within this sector (Skogsindustrierna, Forest industries) has for several years co-operated closely with its members in developing sector specific methods of measuring and calculating emission, which have resulted in high quality emission data. The complete time series of NMVOC emissions were recalculated since earlier there were some inconsistencies related to if terpenes were included or not. The emissions of NMVOC presently reported to international bodies do not include terpenes.

In Figure 6.2, Figure 6.3 and Table 6.6 the production statistics and estimated emissions of NMVOC as a total and separated for each type of process are presented.

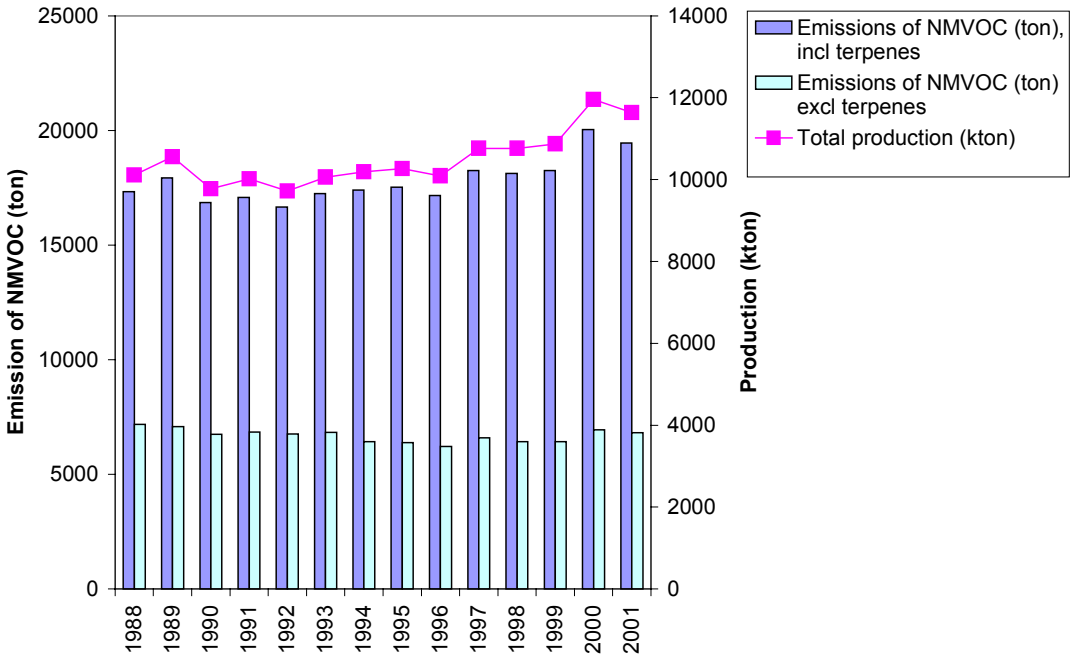


Figure 6.2 **Production statistics and estimated emissions of NMVOC from all processes in the pulp and paper industry (chipboard, kraft, sulphite, CTMP/TMP), including and excluding terpenes, 1988-2001.**

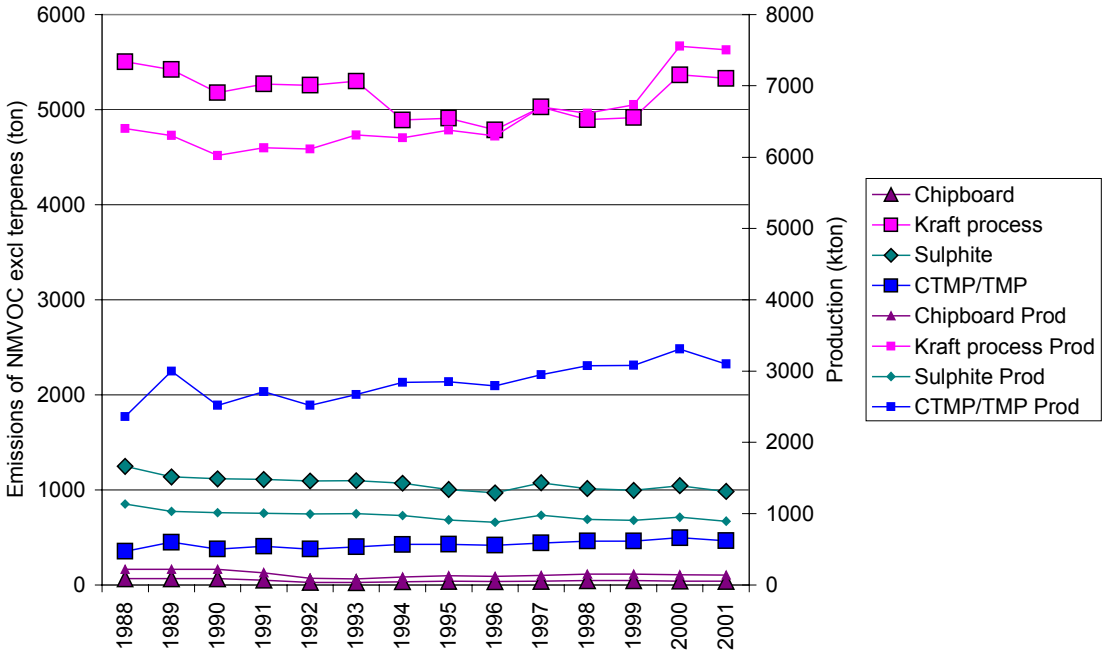


Figure 6.3 **Emissions of NMVOC (ton) excl. terpenes (larger points) and production (kton) (small points) from processes included in 2D1.**

Table 6.6 Production statistics and estimated emissions of NMVOC (excl. terpenes).

	Production (kton)				Emissions of NMVOC (ton) exkl terpenes			
	Chipboard	Kraft process	Sulphite incl NSSC	CTMP/ TMP	Chipboard	Kraft process	Sulphite incl NSSC	CTMP/ TMP
1988	220	6 400	1 135	2 360	66	5 504	1 249	354
1989	220	6 304	1 034	3 000	66	5 421	1 137	450
1990	220	6 022	1 015	2 519	66	5 179	1 117	378
1991	172	6 129	1 008	2 709	52	5 271	1 109	406
1992	93	6 113	995	2 519	28	5 257	1 095	378
1993	83	6 310	998	2 670	25	5 300	1 098	401
1994	110	6 270	973	2 840	33	4 891	1 070	426
1995	128	6 377	912	2 852	38	4 910	1 003	428
1996	120	6 298	880	2 793	36	4 786	968	419
1997	133	6 704	977	2 950	40	5 028	1 075	443
1998	152	6 615	921	3 075	46	4 895	1 013	461
1999	152	6 735	906	3 080	46	4 917	997	462
2000	140	7 557	950	3 311	42	5 365	1 045	497
2001	137	7 505	894	3 100	40	5 329	983	465

6.2.7. Food and drink (2D2)

Emission of NMVOC from food and drink production have been reviewed and recalculated for the complete time series 1988-2001. Activity data are from official statistics and emission factors used are default emission factors (Table 6.7) from the Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook (EEA, 2001). Previously reported data on NMVOC emissions from these sources only covered a few types of production, and emission data had only been estimated for a few years.

Table 6.7 Emission factors for the reported production activities (EEA, 2001).

Production activity	EF	Unit
Wine	0.08	kg/100 litres
Beer	0.035	kg/100 litres
Sprite	15	kg/100 litres
Sugar	10	kg/ton
Margarine and solid cooking fat	10	kg/ton
Cakes, biscuits and breakfast cereals	1	kg/ton
Bread	8	kg/ton
Animal feeds	1	kg/ton
Coffee roasting	0.55	kg/ton
Yeast*	18	kg/ton

*Emission factor from Finland (Finnish Environment Institute 2001)

Statistic Sweden annually collects data about the industrial production in Sweden. The survey is called Company Statistics (former Industry Statistics) and it has a full coverage, since every company with a minimum of 50 employees has to report data to Statistic Sweden's Business Register. Data for companies with less than 50 employees is collected from administrative material from the Swedish Tax Board. Until 1995 the data were presented in the publication " Industry, Part 2 "Production of products and

services". Since 1996 the information can be found in Sweden's statistical database (www.scb.se).

The activity data for the reporting sector "food and drink" have been collected from the above mentioned information sources. The data is divided according to statistical numbers (KN-number) (Table 6.8) and the activity data are presented in Table 6.9 and in Figure 6.4, together with calculated emissions of NMVOC.

Table 6.8 Production activity with accompanying statistical number

Production Activity	Statistical number/ KN-number (year)
Wine	22.05, 22.06 (-88). 22.04, 22.05 (89-)
Beer, cider	22.03, 22.07 (-87), 22.06 (88-)
Sprits	22.09 (-87), 22.08 (88-)
Bread, crispbread	19.07.100, 19.07.909 (-87). 19.05.101, 109; 902-909.1-2
Sugar and sugar products	17.01,02,03
Margarine and solid cooking fat	15.13 (-87). 15.17 (88-)
Cakes, biscuits and breakfast cereals	19.04,19.05. 009 (-87). 19.04.109.1 (88-95). 19.05.20,30 (96-)
Animal feeds	12.13,14 23.-01-09
Coffee roasting	09.01.200
Yeast	21.06101-200 (-87). 21.02.101-209 (88-)

Table 6.9 Production data for each activity 1988-2000.

Year	Wine	Beer, cider	Sprits	Bread, crispbread	Sugar, sugar prod., etc.	Margarine and solid cooking fat	Cakes, biscuits and breakfast cereals	Animal feeds	Coffee roasting	Yeast
	1000 liters	1000 liters	1000 liters	1000 ton	1000 ton	1000 ton	1000 ton	1000 ton	1000 ton	1000 ton
1988	81.156	457.815	57.385	278.333	580.670	160.255	335.718	3 106.784	72.615	18.491
1989	83.162	493.412	61.724	290.249	529.759	161.701	351.973	3 108.660	70.476	18.099
1990	82.311	479.555	60.877	279.100	574.342	162.042	339.977	2 612.216	73.432	18.120
1991	81.619	480.082	57.814	278.745	405.991	168.555	336.559	2 200.764	76.190	18.461
1992	76.597	511.292	60.946	283.126	482.877	156.048	344.072	2 075.289	71.626	18.231
1993	92.505	519.688	73.329	278.075	536.102	191.796	351.404	2 521.988	71.260	18.401
1994	137.994	545.341	108.903	281.424	505.582	197.233	390.327	2 660.405	70.365	18.140
1995	62.361	551.562	61.359	290.964	513.145	192.439	352.323	2 531.113	76.415	18.613
1996	29.030	564.424	26.278	353.474	159.665	76.106	379.752	2 453.969	72.050	19.011
1997	28.957	536.214	64.238	375.336	148.120	89.766	439.574	2 282.843	68.481	19.157
1998	23.414	511.886	67.792	388.312	172.291	87.112	456.104	2 698.698	65.657	19.015
1999	20.727	523.970	73.803	388.119	193.337	100.039	461.922	2 559.699	71.543	19.165
2000	6.913	536.997	78.517	375.375	191.363	84.790	453.892	2 418.364	73.030	18.025

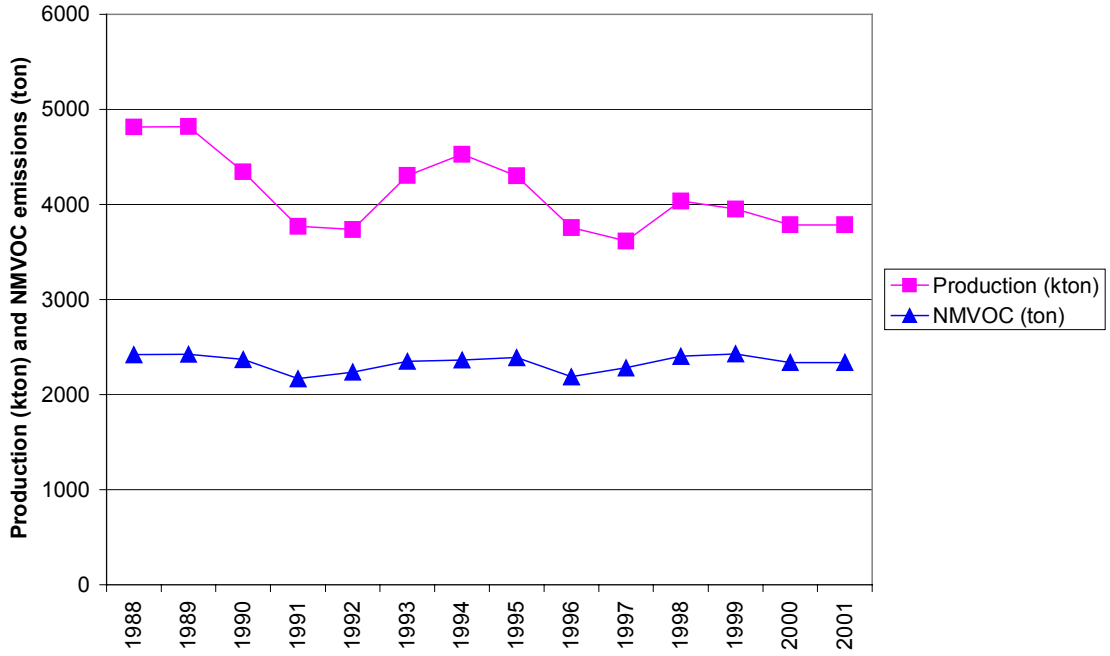


Figure 6.4 **Production statistics (kton) and estimated emissions of NMVOC (ton) from food and drink production.**

7. Solvent and product use (CRF/NFR 3)

7.1. Activity data for solvent and product use

The estimated emissions of NMVOC from solvent and other product use consist of information from various sources. These include reported data from companies legal Environmental Reports, data from the Product Register at the Swedish Chemicals Inspectorate, information from experts or trade associations, but are for the larger part of the estimated emissions based on various national reports, investigations and earlier efforts in estimating national emissions of NMVOC.

7.2. Emissions from solvent and product use

Emissions of NMVOC from various uses of solvents are presented in Figure 7.1 and Table 7.1. The three main sources are “other solvent use”, paint application and printing industry. The remaining sources, rubber industry, wood preservation, paint manufacture leather and textile industry and dry cleaning, which were studied separately, in comparison only contribute marginally. Estimated emissions are also presented in Appendix 1.

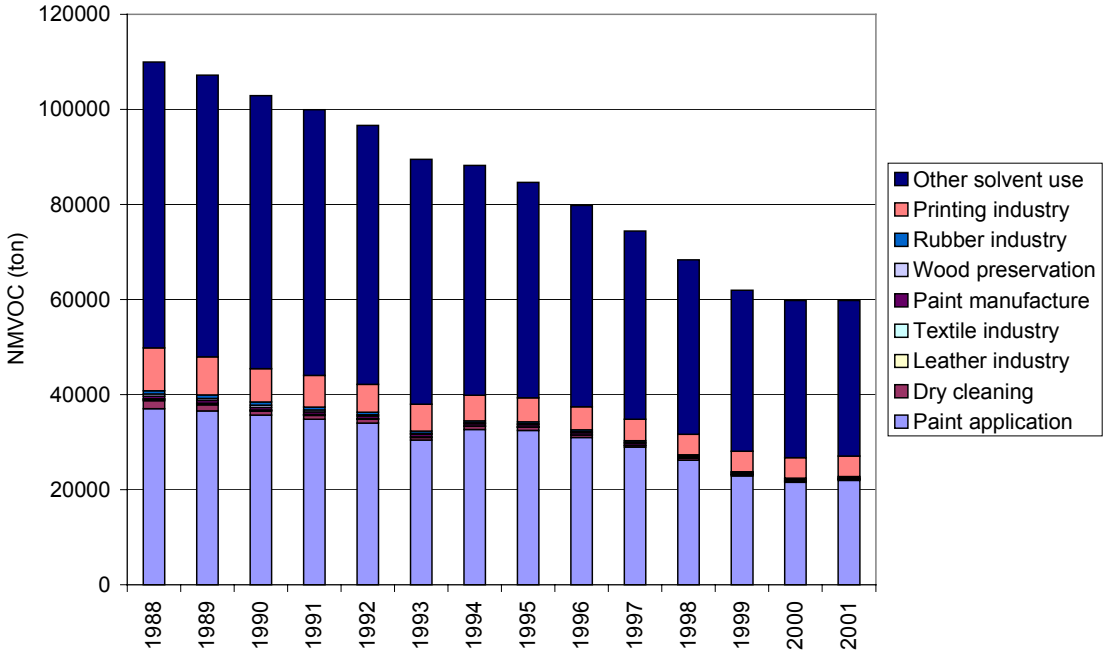


Figure 7.1 Estimated emissions of NMVOC (ton) from solvent use (CRF/NFR 3).

Table 7.1 Estimated emissions of NMVOC (ton) from solvent use (CRF/NFR 3) (rounded).

	Paint application	Dry cleaning	Leather industry	Textile industry	Paint manufacture	Printing industry	Rubber industry	Wood preservation	Other solvent use	Total NMVOC emissions (ton)
1988	37 000	1 700	295	80	600	9 000	701	437	60 130	109 940
1989	36 600	1 250	245	80	600	8 000	701	440	59 310	107 220
1990	35 700	800	140	80	600	7 000	701	435	57 390	102 850
1991	34 800	800	105	80	600	6 680	660	340	55 880	99 930
1992	34 000	800	115	25	560	5 900	510	266	54 450	96 630
1993	30 400	600	95	25	510	5 630	475	238	51 570	89 550
1994	32 610	700	50	23	465	5 370	430	219	48 370	88 240
1995	32 480	670	42	22	420	5 100	380	222	45 310	84 640
1996	31 000	480	49	20	370	4 830	385	260	42 350	79 750
1997	29 000	345	61	21	325	4 570	295	237	39 580	74 400
1998	26 160	395	55	16	280	4 300	230	212	36 660	68 300
1999	22 880	250	52	15	230	4 300	170	209	33 860	61 970
2000	21 540	230	51	15	192	4 300	165	226	33 060	59 780
2001	21 930	230	31	17	154	4 300	150	213	32 780	59 800

7.2.1. Paint application (3A)

For the years 1992-2001 estimates are based on sales statistics of paints in Sweden, obtained from SVEFF, The Swedish Paint and Print Ink Makers Association. Statistics are divided in paints for industrial use and paints for consumer and other professional use. SVEFF has suggested emission factors for industrial use and for other use for the later years (2000-2001), based on average solvent content. In 1992 a study was made (Swedish EPA report 4460) where emissions from paint application was studied

thoroughly, and estimated to be approximately 34 000 tons. The results from this report and the information from SVEFF have been used to develop emission factors and a time series for the years 1992-1999. In the Swedish EPA report 4460 a total annual amount of 37 000 tons of solvent was estimated to be used for paint manufacture in the later 1980´s and early 1990´s. For 1988, 37 000 tons of NMVOC-emissions have thus been assumed from paint application, and emissions were interpolated for the years between 1988 and 1992 (Table 7.2). The exact distinction between the solvent as constituent of the paint as such, and solvents used for e.g. cleaning equipment or diluting paints is sometimes not clear in the background material. In Table 7.2 the estimated use of solvent in paintwork, amounting to from 3.5 kton in 1988 to 2 kton in 2001, is not included. The solvents are reported in code 3D.

Table 7.2 Activity data, emission factors and estimated emissions of NMVOC from paint application 1988-2001.

Year	Domestic and professional use	Industrial use	Total	Domestic and professional use	Industrial use	Emissions of NMVOC
	kton paint	kton paint	kton paint	Emission factor (ton/ton)	Emission factor (ton/ton)	kton NMVOC
1988						37.0
1989						36.6
1990						35.7
1991						34.8
1992	90.88	46.30	137.18	0.23	0.29	34.0
1993	83.70	44.43	128.13	0.21	0.29	30.4
1994	85.28	50.90	136.19	0.21	0.29	32.6
1995	83.34	51.84	135.18	0.21	0.29	32.5
1996	81.39	52.79	134.18	0.19	0.29	31.0
1997	83.45	54.66	138.11	0.18	0.25	29.0
1998	78.52	49.69	128.21	0.18	0.25	26.2
1999	79.90	45.90	125.80	0.17	0.21	22.9
2000	82.26	46.99	129.25	0.17	0.17	21.5
2001	86.14	45.43	131.57	0.17	0.17	21.9

7.2.2. Degreasing and dry cleaning (3B)

Reported data include only emissions from dry cleaning. Data on the used amount of chemical (Tetrachloroethylene) has been obtained from the Product Register at the Swedish National Chemicals Inspectorate for most years. Some interpolations have been made, and for the earliest years in the 1990´s data have been taken from earliernational reporting to Corinair. An emission factor of 1.0 (ton/ton) has been used, which means that the used amount of solvent equals the estimated emissions of NMVOC. The calculated emissions for the time-series 1988-2001 is presented in Table 7.3.

Table 7.3 Emissions of NMVOC from dry-cleaning

Year	NMVOC (ton)
1988	1 700
1989*	1 250
1990	800
1991*	800
1992	800
1993	600
1994	700
1995	670
1996*	482
1997	345
1998	395
1999	250
2000	230
2001	230

* Interpolated value

7.2.3. Chemical Products, Manufacture and Processing (3C)

No separate estimate of NMVOC emissions has been made for 3C. In the national background information available it is in several cases difficult to clearly distinguish NMVOC emissions arising from manufacture and processing of chemical products from those arising from general solvent use. It was therefore chosen to include estimates for 3C in 3D, other solvent use.

7.2.4. Printing industry (3D)

Information for later years has been obtained primarily from an expert (Embertsén), and for data from the early 1990´s from investigations and inventories made at that time (Swedish EPA report 3763, 1990, Swedish EPA report 4312, 1994, SCB, 1996). In the Swedish EPA report 4312 from 1994, it was estimated that emissions had decreased by 40% between 1988-1992 from approximately 60 of the larger facilities (from 7000 to 3900 ton). At the same time it was estimated that 4000 smaller facilites contributed ca 2000 ton NMVOC annually.

Emission estimates are based on knowledge on the amount of solvent used, as well as knowledge on the different printing techniques used. Estimates on the amounts of NMVOC emitted to air and the fraction disposed of (not emitted to air) for later years have been obtained from Embertsén.

Table 7.4 Estimated emissions of NMVOC (ton) from printing industry 1988-2001.

Year	Emissions of NMVOC (ton)	Sources
1988	9 000	9000-10 000 ton, SCB (1996) 9000 ton, Swedish EPA report 4312 (1994) 7000 ton, Swedish EPA report 3763 (1990)
1989	8 000	Interpolated
1990	7 000	Swedish EPA report 4312 (1994)
1991	6 675	Assumed
1992	5 900	Swedish EPA report 4312 (1994)
1993	5 633	Interpolated
1994	5 367	Interpolated (5300-6300 ton, SCB, 1996)
1995	5 100	Interpolated
1996	4 833	Interpolated
1997	4 567	Interpolated
1998	4 300	Embertsén (1999)
1999	4 300	Embertsén (1999)
2000	4 300	Embertsén (2001)
2001	4 300	Embertsén (2002)

7.2.5. Preservation of wood (3D)

Calculations are based on information, for the whole time series, obtained from The Swedish Wood Preservation Institute (2001) and personal communication with an expert at the Institute (Estberg, 2002). Data used was the amount of wood preserved using solvent-containing products, the amount of preservation substance used, given as kg/m^3 of treated wood, and the fraction of solvent, 35%, that is assumed to be emitted to air in the process. Since 1988 abatement techniques have been installed at the facilities, which is estimated to destroy 50% of the solvent from the process. 15% of the applied solvent is assumed to remain in the treated wood, and the remaining 35% is the amount of NMVOC actually emitted at the preservation process or later in the life-cycle of the impregnated products.

To this calculated time series, data on emissions of NMVOC obtained directly from two facilities impregnating wooden furniture for outdoor use were added.

Table 7.5 Activity data for the wood preservation industry and estimated emissions of NMVOC. Data from two individual facilities for outdoor wooden furniture were added to estimates calculated from activity data

Year	Amount of preserved wood (m^3)	Amount of preservation substance used (kg/m^3 wood)	Emissions of NMVOC (ton)
1988	32 100	30	437
1989	35 100	28	440
1990	37 800	25	435
1991	30 900	23	340
1992	25 134	20	266
1993	22 300	20	238
1994	19 800	20	219
1995	20 500	20	222
1996	26 027	20	260
1997	23 105	20	237
1998	19 847	20	212
1999	24 134	20	209
2000	25 631	20	226
2001	25 631	20	213

7.2.6. Leather industry and textile industry (3D)

Data on emitted amounts of NMVOC from these processes have been collected through Environmental Reports, published by the companies, combined with information from earlier investigations and inventories, and discussions with an expert (Hansson, S.), especially concerning the earlier years.

For the leather industry, one company producing leather seats for the car industry has dominated the emissions for the whole time series. This company has contributed at least 65% of the estimated emissions. Besides this company there are approximately 5 smaller enterprises concerned.

The NMVOC emissions from textile industry were at the beginning of the 1990´s dominated by one facility. This facility changed production method between 1991 and 1992, which is evident in the presented time series of emissions (Table 7.6). As a total approximately 20 facilities have been included in the estimates.

Table 7.6 Estimated emissions of NMVOC (ton) from the leather and textile industries 1988-2001.

Year	Leather industry NMVOC (ton)	Textile industry NMVOC (ton)
1988	295	80
1989	246	80
1990	142	80
1991	105	80
1992	116	25
1993	94	25
1994	51	23
1995	42	22
1996	49	20
1997	61	21
1998	55	16
1999	52	15
2000	51	15
2001	31	17

7.2.7. Paint production (3D)

Data on emissions of NMVOC from paint producers have been obtained, for the earlier years, from emission inventories made at that time (Table 7.7), for later years from SVEFF, The Swedish Paint and Print Ink Makers Association, and the companies annual Environmental Reports. Some interpolations have been made in the reported time series.

Table 7.7 Estimated emissions of NMVOC (ton) from paint production 1988-2001.

Year	Emissions of NMVOC (ton) from Paint manufacture	Source
1988	600	Assumed (400 ton, Swedish EPA report 4312 (1994)
1989	600	Assumed
1990	600	Assumed
1991	600	Swedish EPA report 4312 (1994)
1992	560	SVEFF and Swedish EPA report 4460 (1995)
1993	513	Interpolated
1994	466	Interpolated
1995	419	Interpolated
1996	373	Interpolated
1997	326	Interpolated
1998	279	Interpolated
1999	232	SVEFF
2000	192	SVEFF
2001	154	Environmental Reports from facilities

7.2.8. Rubber industry (3D)

Data on emissions of NMVOC from the rubber industry were obtained from companies legal Environmental Reports and direct contact with the larger companies, combined with general estimates for smaller companies. These estimates were based on expert judgements from persons working in the rubber industry, as well as information from earlier inventories and studies (Swedish EPA report 4312, 1994, Swedish EPA report 3763). The information in these reports, however, usually combines rubber industry and plastic industry or other not defined industries, which limits the usefulness of the information. The adjusted time series is thus a compilation of information from many different sources, calculated based on facility-specific information, including a rather high degree of interpolations.

Two companies have dominated the emissions for the whole time series. In 1988 the contribution from these two were more than 80%, down to about 60% in 2001.

Table 7.8 Emissions of NMVOC (ton) from the rubber industry 1988-2001.

Year	NMVOC (ton)	Source
1988	701	800 ton, incl repair shops etc in the mid 1980´s, Swedish EPA report 3763
1989	701	
1990	701	
1991	658	
1992	512	
1993	477	
1994	429	
1995	381	
1996	387	
1997	296	
1998	229	
1999	168	
2000	163	
2001	150	

7.2.9. Other solvent use (3D)

This time series includes degreasing substances and general solvent use by industry as well as in the domestic sector. The estimates are based on information from several reports from the 1980´s and early 1990´s (e.g. Swedish EPA reports, 4532, 3763, 3733, 4312, 4460, SCB 1996, Jernelöv and Lövblad, 1984), combined with information from the Product Register at the Swedish National Chemicals Inspectorate. From the Product Register, reasonably reliable data for some specific areas of use exist beginning in 1995. There is also information available from some special studies of good quality that were performed by the Swedish National Chemicals Inspectorate, on behalf of the Swedish EPA (unpublished) in the earlier 1990´s. Earlier reports from Sweden to CORINAIR (1996-1999), based on these special studies from the Product Register, have also been used. Based on the information from these different sources, a time series has been developed.

In the referred reports and earlier compilations and estimates, the allocation of estimated emissions are not always comparable. Sometimes the general solvent use is included together with process emissions in the presented data for an industrial sector, and sometimes it is not. Especially estimates for consumer available solvent use were very diverse in the background material.

In Table 7.9 information from available references is compiled. The data in the table, has as best as possible, been adjusted to represent the same collection of sources. There is however no clear-cut allocations in the material, but the orders of magnitude should be reasonable. Some cross-referring is evident in the referred material.

Table 7.9 Information from different reports concerning process and solvent emissions from industry and from other, fugitive sources including consumer use (ton NMVOC).

	Data publ		**Data publ**	**Data publ**	**Data publ**	**Data publ**	**Data publ**
	1984/5		**1996**	**1994**	**1994**	**1994**	**1996**
Source	SEPA# 1973	SEPA 3763	SCB 1996	SEPA 4312	SEPA 4312	SEPA 4312	SCB 1996
Emission year	**1982**	**1988**	**1988**	**1988**	**1990**	**1992**	**1994**
Industry	76 100	62 470	88 900	80 700	68 600	61 750	61 500
Other, including consumers*	41 600	40 400	37 000	37 000	37 000	37 900	40 450
Total NMVOC (ton)	117 700	102 870	**125 900**	117 700	**105 600**	**99 650**	**101 950**

SEPA, Swedish EPA report and number
* in some sources, only consumer use.

In order to estimate the source “other solvent use”, avoiding double counting or unintentionally omitting sources, was firstly to sum available information from references on process emissions and general solvent use to total national level (Table 7.9). Secondly, the relevant derived time series of emissions from specific sources developed within the present project were added to an annual sum. The national totals from literature, for available years, were compared to the estimates made within this inventory. The difference was considered to represent the level of emissions from “consumer available” solvent use. In addition to literature data, the national reports to CORINAIR for 1996-1999 were used as reference material.

In order to calculate the remaining amount, to be allocated as consumer available in the source "other solvent use", for all years all available information (literature and earlier estimates to CORINAIR) on industrial and more general sources, excluding combustion and mobile sources, was used. Road paving with asphalt was not included in any of the references cited, and is thus not included in the table where comparisons were made (Table 7.10). The resulting time series of emissions of NMVOC from consumer available solvent use is thus derived based on new time series for industrial sources (from this study) for all coloured rows in the table, in combination with data from various references (shaded in Table 7.9, yellow cells in Table 7.10) and finally, interpolations and adjustments to a reasonable time series.

In order to make the comparisons, data for "diluting solvent" and for "solvents, degreasing, industry" were assumed for all years where no literature or other reference data was available. These time series are not reported separately, but were only used as a basis for developing one timeseries for the general "other solvent use" (the sum of the industrial and consumer use). The time series for "extraction, industry" is based on facility-specific information, including interpolations. These emissions are also included in the time series for general "other solvent use".

Data in the time series for "diluting solvent", consumer use, were interpolated between those years where data from references could be found, and for the later years a development in accordance with calculated emissions of NMVOC from consumer use of paints was applied. For "solvents, degreasing, industry", interpolations were made for missing years before 1994. In order to extrapolate data from the latest available year (1994) data from the Product Register was used to try to assign a reasonable level for these emissions in later years. The changes in solvent use in industry, according to literature, were very large before 1994, and a decrease after 1994 should be expected. An amount of 1000 tons for 2001 was assumed based on data from the Product Register, but this figure is highly uncertain.

The data for emissions of NMVOC from general solvent use are uncertain, as can be deducted from the descriptions above. No new thorough inventory has been made, but rather comparisons and judgements of reasonableness in earlier estimates, and a subsequent adjustment of the time series. When comparing the present estimates for Sweden with a Norwegian inventory (Flugsrud et al 2000), the level, however, seems to be reasonable. According to Flugsrud et al (2000) approximately 51 000 tons of NMVOC from solvent use in industry, processes and from consumer use was emitted in Norway in 1996. Adjusting the present Swedish estimates to correspond with the sources included in the Norwegian presentation, the emitted amount of NMVOC in Sweden amounts to 87 000 tons for 1996. The ratio of estimated emissions of NMVOC between Sweden and Norway is roughly the same as that of the populations.

In order to make better estimates, a totally different approach, such as studying the overall solvent balance in Sweden would be needed.

Table 7.10 Background to estimated emissions of NMVOC from "consumer available" and other solvent use.

		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
2A7	Glass and mineral wool	250	200	150	120	56	54	58	70	66	78	82	72	55	36
2B5	Chemical industry	5970	5900	5610	5410	5010	4710	4710	4770	4690	4410	3920	3660	3970	3910
2C1	Metal industry	150	150	110	90	100	110	110	120	120	130	100	110	140	103
2D1	Pulp and paper industry	7173	7075	6739	6838	6757	6824	6420	6380	6209	6585	6415	6421	6949	6817
2D2	Food and drink	2420	2424	2370	2167	2237	2350	2362	2388	2188	2281	2403	2427	2337	2337
3A	Paint application	37000	36600	35700	34800	34000	30396	32614	32484	30997	28964	26163	22879	21542	21928
3B	Dry cleaning	1700	1250	800	800	800	600	700	670	482	345	395	250	230	230
3D	Printing industry	9000	8000	7000	6675	5900	5633	5367	5100	4833	4567	4300	4300	4300	4300
3D	Leather industry	295	246	142	105	116	94	51	42	49	61	55	52	51	31
3D	Textile industry	80	80	80	80	25	25	23	22	20	21	16	15	15	17
3D	Paint manufacture	600	600	600	600	560	500	450	420	400	350	300	232	192	154
3D	Rubber industry	701	701	701	658	512	477	429	381	387	296	229	168	163	150
3D	Wood preservation	437	440	435	340	266	238	219	222	260	237	212	209	226	213
3D	**Diluting solvent, consumer**	**3500**	***3400***	***3300***	***3200***	**3200**	***3000***	**2454**	**2083**	**1872**	***1836***	***1649***	***1598***	***1645***	***1723***
3D	**Solvents, degreasing, industry**	**11700**	***11400***	**10000**	***9000***	**8000**	***5750***	**3500**	***3143***	***2786***	***2429***	***2072***	***1715***	***1358***	***1001***
3D	**Extraction, industry**	**25**	**25**	**24**	**26.5**	**15.75**	**8.7**	**18.5**	**59.3**	**55**	**55**	**55**	**50.2**	**59.4**	**55**
	Sum	**81000**	**78491**	**73761**	**70909**	**67555**	**60769**	**59485**	**58354**	**55414**	**52645**	**48365**	**44157**	**43233**	**43006**
	References, total	**125900**		**105600**		**99650**		**101950**							
	Difference, references-sum	44900		31839		32095		42465		34294	37527	32063	30526		
3D	**Adjusted time series for "consumer available" solvent use**	**44900**	**44483**	**44066**	**43649**	**43232**	**42815**	**42400**	**40020**	**37640**	**35260**	**32880**	**30500**	**30000**	**30000**
	Total, processes*+solvent use	**125900**	**122974**	**117827**	**114558**	**110787**	**103584**	**101885**	**98374**	**93054**	**87905**	**81245**	**74657**	**73233**	**73006**
3D	**Reported time series for solvent use**	**60125**	**59308**	**57390**	**55876**	**54448**	**51574**	**48373**	**45306**	**42353**	**39580**	**36656**	**33863**	**33063**	**32779**

* Except Road paving with asphalt

Reported in code NFR/ CRF2

Reported separately in code NFR/CRF 3

Italics, interpolated or assumed

Data from references

Derived from reports to Corinair

Added to be included in 3D

Reported time series for solvent use, not allocated elsewhere

8. Conclusions

The aim of the project was to review and recalculate time series of emissions of NMVOC in Sweden from 1988-2001, in order to improve the quality, accuracy and completeness of reported emissions, according to requirements laid out in international guidelines.

By completing this project, the presented time series are consistently calculated, and the accuracy, transparency and completeness of the reporting have improved.

Some sources have been found to need further attention, primarily concerning developing methods and sources of background data, in order to facilitate and make it possible to perform consistent annual updates of the estimated emissions in the future. This is especially obvious for the solvent use sector, where at present no defined method for annual updates is available.

A more detailed, readily available, reporting of emissions and activity data from facilities, both from industrial facilities and power generation plants, would facilitate the work on periodically checking and updating emission factors for combustion and industrial processes in the future. An environmental reporting more adapted to the international reporting requirements would also reduce the risk of unintentionally omitting or double counting emissions of NMVOC, as well as providing a better possibility to correctly allocate NMVOC emissions to the proper codes in the reporting system.

9. References

Refererences used to derive emission factors for stationary and mobile combustion, as well as other information

Boström, C-Å., Cooper, D. (1992). Sameldning av bioslam och bark i en rostpanna: Emissioner till luft. Skogsindustrins Miljöforskningsprojekt. Miljö 93. Rapport nr 31.

Boström, C-Å., Cooper, D., Lövblad, G. (1998). Nationell redovisning av emissioner till luft – Förslag till emissionsfaktorer för energiproduktion. IVL internt material.

EEA. (2001). Joint EMEP/Corinair Atmospheric Emission Inventory Guidebook. 3rd Edition

Flugsrud, K., Gjerald, E., Haakonsen, G., Holtskog, S., Höie, H., Rypdal, K., Tornsjö, B., Weidemann, F. (2000). The Norwegian Emission Inventory. Documentation of methodology and data for estimating emissions of greenhouse gases and long-range transboundary air pollutants. Rapport 2000/1, Statens forurensningstillsyn och Statistisk sentralbyrå.

Froste, H. (1996). Swedish EPA, internal material

Haakonsen, G., Kvingedal, E. (2001). Utslipp till luft fra vedfyring i Norge. Utslippsfaktorer, ildstedsbestand og fyringsvaner. Statistics Norway, 2001/36.

Karlsson, M-L.,Gustavsson, L. (1992). Karaktärisering av rökgaser från vedpannor. Swedish National Testing and Research Institute. SP Rapport 1992:49.

Karlsson, M-L. (1992). Emissioner från vedpannor – lastförhållandets betydelse. Swedish National Testing and Research Institute. SP Rapport 1992:48.

Kol Hälsa Miljö (1981). Kolets hälso- och miljöeffekter. Lägesrapport oktober 1981.

Kol Hälsa Miljö (1983). Kolets hälso- och miljöeffekter. Slutrapport april 1983. Underlagsdel 1, Teknik för kolanvändning.

SNV PM 1708 (1983). Miljöeffekter av ved- och torvförbränning.

Statens Energiverk, Naturvårdsverket (1986). Energi ur avfall. 1986:6.

Swedish EPA report 3816 (1990). Utsläpp till luft från raffinaderier- emissioner och åtgärdsförslag

Swedish EPA report 4687 (1996). Åtgärder för att minska utsläpp från småskalig vedeldning. Redovisning av Regeringsuppdrag.

Swedish EPA Report 4912 (1998). Småskalig vedeldning – underlag samt förslag till "Förordning om åtgärder för att minska utsläppen från små anläggningar som eldas med fasta biobränslen". Redovisning av regeringsuppdrag.

Swedish EPA (1998). Proceeding of the Workshop on "Small-scale Wood Burning (<300 kW), Impact on Health and Environment – Technical and Administrative Measures". Stockholm Sweden March 30-31 1998.

Swedish EPA Report 3993 (1992). Miljöpåverkan från fritidsbåtar, fiske- och arbetsfartyg, Swedish EPA and Swedish Maritime Administration.

Thunell, J. (1998). Utsläpp av oreglerade ämnen vid förbränning av olika bränslen. Svenskt Gastekniskt Center, Rapport SGC 090 (in Swedish).

Vattenfall (1984). Naturgas Hälsa Miljö. "State-of-the-art"-rapport, september 1984.

Whall, C. et al. (2002). Quantification of emissions from ships associated with ship movements between ports in the European Community. Report for the European Commission. Entec UK Limited. Final Report, July 2002.

Other references

Ahmadzai, H. (2002). Swedish EPA, personal communication.

Andersson, K. (2000). Rapportering av luftutsläpp till CORINAIR. Swedish EPA, 1994 -1999 2000.

Annual reports on national Swedish emissions to CORINAIR, 1996-1999.

Berg, L., Boström, C-Å., Calander, K., Lindskog, A. (1990). Utsläpp till luft av flyktiga organiska ämnen från massa- och pappersindustrin. SSVL, Miljö 90. Rapport nr 81.

Berg, L., Boström, C-Å., Cooper, D. (1992). Utsläpp till luft av flyktiga organiska ämnen från massa- och pappersindustrin. Skogsindustrins Miljöforskningsprojekt Miljö 93. Rapport nr 16.

Boström C-Å, Lindskog Anne, Mowrer J, Peterson K. (1991). Emission av flyktiga organiska föreningar från elektrostålugnar. Jernkontorets Forskning. IVL L90/296

Boström, C-Å., Andersson-Sköld, Y., Lindskog, A., Cooper, D., Moldanovna, J., Berg, L. and Malmström, J. (1992). VOC emissions from teh Swedish pulp and paper industry. TAPPI April 1992, Environmental Conference Vol. 2, 623-631.

Boström, C-Å. (1993). Ozonbildande luftföroreningar – Massa och pappersindustrin i fokus. Kemisk Tidskrift Nr 12-13 1996, 20-22.

Concawe, Hydrocarbon emissions from gasoline storage and distribution systems. Concawe report 85/54

EG (2001). Europaparlamentets och Rådets direktiv 2001/81/EG av den 23 oktober 2001 om nationella utsläppstak för vissa luftföroreningar.

Embertsén, L. (2002), County administration in Stockholm, Personal communication

Energimyndigheten (2002). Energiläget 2002. ET 18:2002

Energimyndigheten (2002). Energiläget i siffror (tables from www.stem.se)

EN31SM, SCB, Statistics Sweden. Bränslen, leveranser och förbrukning av bränsle

Estberg, M. (2002), Swedish Wood Prevention Institute, Personal communication

Finnish Environment Institute. (2001). Revised Finnish Non Methane Volatile Organic Compound Emissions, Time Series for the Years 1998-1999 with Information on the emission Sources and Calculation Methods.

Hammarstöm, U. Karlsson, B. (1998). EMV - ett PC-program för beräkning av vägtrafikens avgasemissioner, programbeskrivning och användarhandledning, VTI meddelande 848.

Hansson, S. (2002). County administration in Västra Götaland, Personal communication

IPCC (1997). Revised 1996 Guidelines for National Greenhouse Gas Inventories.

IPCC (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

Johansson, H. (2001). Uppföljning av bränsleförbrukning och koldioxidutsläpp inom vägtransportsektorn, lägesrapport och förslag till fortsatt arbete. Vägverket.

Lidén, M. (2003). Methodology for calculating emissions from mobile sources. SMED, 2003-03-03.

Persson, K. and Kindbom, K.(1999). Kartläggning av emissioner från arbetsfordon och arbetsredskap i Sverige. Report by IVL ordered by Statistics Sweden and the Swedish Environmental Protection agency, 1999.

Pålsson, A. (2001). Avgasemissioner från civil flygplanstrafik i Sverige i åren 1995-2000, Luftfartsverket.

SCB, Statistics Sweden (1996) Emissions to air in Sweden of volatile organic compounds (VOC) 1988 and 1994. Statistical appendix. (Utsläpp till luft i Sverige av flyktiga organiska ämnen (VOC) 1988 och 1994. Statistikbilaga.)

SPI, Swedish Petroelum Institute (2002). Leif Ljung, personal communication.

SVEFF, Swedish Paint and Print Ink Makers Association. M. Tannerfeldt, personal communication and data from www.sveff.se.

Swedish EPA report 1973 (1984). Jernelöv, M. Lövblad, G. Emissions to air in Sweden 1982. (Utsläpp till luft i Sverige 1982).

Swedish EPA report 3733 (1990) Solvents in consumer products (Lösningsmedel i konsumentprodukter).

Swedish EPA report 3763. Strategy for volatile organic compounds (Strategi för flyktiga organiska ämnen).

Swedish EPA report 3816 (1990), Emissions to air from refineries.

Swedish EPA Report 3993 (1992). Miljöpåverkan från fritidsbåtar, fiske- och arbetsfartyg, Naturvårdsverket och Sjöfartsverket.

Swedish EPA report 4312 (1994). Emissions to air of volatile organic compounds 1992. (Utsläpp till luft av flyktiga organiska ämnen 1992). Bilaga är Na SM 9402 från SCB

Swedish EPA report 4336 (1994). Emissions to air and water from chemical industry in 1992 (Utsläpp till luft och vatten från kemisk industri 1992.)

Swedish EPA report 4460 (1995). Paint chemicals (Färgkemikalier).

Swedish EPA report 4462 (1995). Emissions to air and water from chemical industry in 1993 (Utsläpp till luft och vatten från kemisk industri 1993)

Swedish EPA report 4532 (1996). Volatile organic compounds and nitrogen oxides. Continued work for emission reductions. (Flyktiga organiska ämnen och kväveoxider. Fortsatt arbete med utsläppsminskningar).

SVEFF, Swedish Paint Producers Association, personal contacts and sales statistics.

Swedish National Chemicals Inspectorate, personal contacts and Data from the Product Register.

The Swedish Wood Preservation Institute (2001). The Swedish Wood Preservation Industry, Statistics 2000. Report no 178. In Swedish, English summary.

Trafikverkens miljörapport 2001

UNECE (2002). Draft Guidelines for Estimating and Reporting Emissions Data, EB.AIR/GE.1/2002/7.

ÅF-industriteknik AB (1990). Kartläggning av förorenande utsläpp från motordrivna arbetsredskap. Report ordered by the Swedish EPA

3K engineering AB (1989). Kartläggning av förorenande utsläpp från traktorer, arbetsmaskiner m.m. Report ordered by the Swedish EPA.

Appendix 1 Estimated emissions of NMVOC (kton) in Sweden 1988-2001.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1 Energy	**395**	**395**	**389**	**373**	**363**	**339**	**319**	**314**	**309**	**282**	**267**	**252**	**239**	**238**
1 A 1 a Public Electricity and Heat Productio	2.39	2.25	2.62	3.02	3.04	1.85	2.27	2.64	7.82	1.96	2.18	2.03	1.93	2.32
1 A 1 b Petroleum refining	0.12	0.12	0.12	0.13	0.11	0.09	0.15	0.13	0.13	0.13	0.13	0.15	0.08	0.08
1 A 1 c Manufacture of Solid Fuels and Other	0.03	0.03	0.04	0.03	0.03	0.04	0.05	0.06	0.06	0.06	0.08	0.08	0.08	0.12
1 A 2 Manufacturing Industries and Constructi	6.04	6.42	14.0	13.8	14.5	10.7	8.31	7.42	7.72	5.23	6.76	6.76	6.51	6.83
1 A 3 a ii Civl aviation	0.98	1.06	2.10	1.90	1.74	1.72	1.67	1.68	1.49	1.44	1.52	1.59	1.25	1.04
1 A 3 b Road Transportation	172	176	165	157	151	142	138	133	125	112	103	92.9	81.9	72.1
1 A 3 c Railways	0.12	0.11	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.07	0.08	0.08	0.08	0.08
1 A 3 d ii Shipping and National Navigation	27.0	27.6	27.8	28.6	29.5	28.1	28.8	29.3	29.1	29.1	29.0	29.0	28.6	28.6
1 A 4 a Commercial / Institutional	2.27	2.25	2.25	2.03	1.37	1.37	1.29	1.2	1.32	1.29	1.38	1.36	1.34	1.52
1 A 4 b i Residential plants	121	116	118	112	110	106	93.6	95.0	90.8	84.9	77.6	72.3	71.4	81.6
1 A 4 c i Ag/for/fish Stationary	0.78	0.66	0.66	0.74	0.84	0.80	0.45	0.43	0.40	0.39	0.37	0.36	0.03	0.03
1A3-1A5 Off-road vehicles and machinery	25.5	25.5	25.5	25.6	28.2	29.2	30.7	30.5	30.2	30.3	30.5	30.0	29.4	29.4
1 B 2 a i Oil, Exploration Production, Transpor	37.7	36.6	31.3	26.9	22.3	17.0	14.2	12.9	14.8	14.9	14.5	15.2	16.3	14.5
1 B 2 b Natural gas	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1B1 Fugitive Emissions from Solid Fuels	<0.01	<0.01	0.01	0.01	<0.01	<0.01	0.01	0.01	0.01	<0.01	0.01	0.01	0.01	0.01
2 Industrial processes	**23**	**22**	**21**	**21**	**20**	**19**	**18**	**18**	**17**	**16**	**15**	**14**	**15**	**14**
2 A 6 Road Paving with Asphalt	6.60	6.40	6.20	5.90	5.60	5.00	4.40	3.80	3.20	2.60	2.00	1.60	1.17	1.08
2 A 7 Other including	0.28	0.23	0.18	0.15	0.08	0.08	0.09	0.10	0.09	0.11	0.10	0.07	0.06	0.04
2 B CHEMICAL INDUSTRY	5.97	5.90	5.61	5.41	5.01	4.71	4.71	4.77	4.69	4.41	3.92	3.66	3.97	3.91
2 C METAL PRODUCTION	0.15	0.15	0.11	0.09	0.10	0.11	0.11	0.12	0.12	0.13	0.10	0.11	0.14	0.12
2 D 1 Pulp and Paper	7.17	7.07	6.74	6.84	6.76	6.82	6.42	6.38	6.21	6.59	6.42	6.42	6.95	6.82
2 D 2 Food and Drink	2.42	2.42	2.37	2.17	2.24	2.35	2.36	2.39	2.19	2.28	2.40	2.43	2.34	2.34
3 Solvent and product use	**110**	**107**	**103**	**100**	**97**	**90**	**88**	**85**	**80**	**74**	**68**	**62**	**60**	**60**
3 A PAINT APPLICATION	37.0	36.6	35.7	34.8	34.0	30.4	32.6	32.5	31.0	29.0	26.2	22.9	21.5	21.9
3 B DEGREASING AND DRY CLEANING	1.70	1.25	0.80	0.80	0.80	0.60	0.70	0.67	0.48	0.35	0.40	0.25	0.23	0.23
3 D OTHER including products	71.2	69.4	66.4	64.3	61.8	58.5	54.9	51.5	48.3	45.1	41.8	38.8	38.0	37.6
National total	**528**	**525**	**513**	**493**	**479**	**448**	**426**	**416**	**406**	**372**	**350**	**328**	**313**	**312**

Appendix 2 Emission factors, NMVOC, for stationary combustion and for mobile sources, 1988-2001.

Emission factors for stationary combustion, 1988-2001 (g NMVOC/MJ)

		1988-1992				1993-1996				1997-2001			
Code		Industry	Residential	District Heating	Power generation	Industry	Residential	District Heating	Power generation	Industry	Residential	District Heating	Power generation.
1	Diesel Oil	0.002	0.003	0.002	0.002	0.002	0.006	0.002	0.002	0.002	0.006	0.002	0.002
2	Residual Fuel Oil	0.003	0.005	0.003	0.003	0.003	0.006	0.003	0.003	0.003	0.006	0.003	0.003
4	Liquefied Petroleum Gas	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002
5	Gas Works Gas	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002
6	Natural Gas	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002
7	Coke Oven Gas	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
8	Blast Furnace Gas	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
9	Steel Converter gas	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
10	Coking Coal	0.008	0.1	0.008	0.005	0.006	0.1	0.006	0.005	0.008	0.1	0.008	0.005
11	Coke Oven Coke	0.008	0.1	0.008	0.005	0.006	0.1	0.006	0.005	0.008	0.1	0.008	0.005
12	Wood Waste/biofuels	0.1	*	0.1	0.05	0.05	*	0.05	0.05	0.02	*	0.02	0.02
13	Peat	0.05	0.05	0.05	0.005	0.007	0.05	0.007	0.05	0.05	0.05	0.05	0.05
14	Municipal Solid Waste	0.025	0.025	0.025	0.005	0.01		0.005	0.005	0.01		0.005	0.005
15	Black Liquor	0.1	-	-	-	0.01	-	-	-	0.01	-	-	-
16	Tall oil	0.003	0.005	0.003	0.003	0.003	0.005	0.003	0.003	0.003	0.005	0.003	0.003
17	Other	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
21	Other Oil	0.002	0.005	0.002	0.002	0.002	0.005	0.002	0.002	0.002	0.005	0.002	0.002
26	Transformation losses in refineries	0,37	-	-	-	0,37	-	-	-	0,37	-	-	-
27	Transformation losses in iron and steel industry	0,01	-	-	-	0,01	-	-	-	0,01	-	-	-

*) See separate table below

-) not relevant

Appendix 2 cont.

Emission factors for stationary combustion of biomass in the residential sector, 1988-2001 (g NMVOC/MJ)

	Fuel type	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Residential, stationary	Biofuels	g/MJ	3,31	3,31	2,99	2,85	2,79	2,64	2,49	2,35	2,20	2,17	2,03	2,00	1,98	1,98

Emission Factors for NMVOC 1988-2001, mobile sources (ton NMVOC/TJ).

Sector	Fuel type	Subsector	GJ/m^3	Unit	1988-1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aviation	Avation gasoline	LTO	32,7	ton/TJ	1,31	1,31	1,31	1,31	1,31	1,49	1,34	1,42	1,38	1,45	1,43	1,59
Aviation	Avation gasoline	Cruise	32,7	ton/TJ	1,57	1,57	1,57	1,57	1,57	1,79	1,61	1,70	1,65	1,74	1,71	1,91
Aviation	Kerosene	LTO	34,5	ton/TJ	1,31	1,31	1,31	1,31	1,31	1,49	1,34	1,42	1,38	1,45	1,43	1,59
Aviation	Kerosene	Cruise	34,5	ton/TJ	1,57	1,57	1,57	1,57	1,57	1,79	1,61	1,70	1,65	1,74	1,71	1,91
Railway	Diesel	-	35,87	ton/TJ	0,08	0,08	0,08	0,08	0,08	0,08	0,09	0,08	0,09	0,08	0,07	0,07
Navigation	Diesel oil	-	35,87	ton/TJ	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11
Navigation	Residual fuel oil	-	35,87	ton/TJ	0,06	0,06	0,06	0,06	0,06	0,06	0,05	0,06	0,06	0,06	0,06	0,06
Navigation	Residual fuel oil 2-6	-	38,10	ton/TJ	0,06	0,06	0,06	0,06	0,06	0,06	0,05	0,06	0,06	0,06	0,06	0,06
Navigation	Gasoline	-	31,4	ton/TJ	9,73	9,73	9,73	9,73	9,73	9,73	9,73	9,73	9,73	9,73	9,73	9,73

Statistiska centralbyrån
Statistics Sweden