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SMED

Swedish Methodology for Environmental Data

Emissions of particles, metals, dioxins and PAH in Sweden

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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.

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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). National emissions of SO_2, NO_x, CO, NMVOC and NH_3 have been reported extensively in the past, but emissions of particles, heavy metals, PAH and dioxins have, with a few exceptions not been included.

In 2002 SMED, Swedish Methodology for Environmental Data, was given the task by the Swedish EPA to compile time series of emissions of TSP (Total Suspended Particulate matter), PM_{10}, $PM_{2,5}$, heavy metals, PAH-4 and dioxins in Sweden. The objective was to compile data from 1980-2001 for each substance, to be included in the submission of national emissions to UNECE/LRTAP in February 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. 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. For some sources and substances only limited infomation on national emissions or emission factors was available, and therefore suggested international default emission factors were used in those cases. Further work is needed in order to reduce the uncertainty in these estimates and to verify that emission levels are relevant to Swedish conditions.

The study includes all relevant sectors, but the focus has been on sources, which account for the larger shares of the national total emissions of the covered compounds. Due to lack of data, not all sources and substances are covered for the entire time period. This report, however, presents more data and estimated emissions than was submitted to UNECE/LRTAP in 2003. For example, in the 2003 submission to UNECE/LRTAP, heavy metals were only reported for the period 1990-2001. In this report estimated metal emissions from certain sources during the 1980´s are presented, as well as discussions on sources and substances where, due to gaps in knowledge, roughly calculated emission levels are still too uncertain to be officially submitted.

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 particles, heavy metals, dioxins and PAH 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 compiled emission data, 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), suggested emission factors for particles from the CEPMEIP project (Coordinated European Programme on Particulate Matter Emission Inventories, Projections and Guidance, TNO, 2001), international research reports and relevant publications from other European countries.

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

Estimated emissions from road traffic were 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, which combined with production statistics permits the development of time series of emissions. In order to calculate emissions of PM_{10} and $PM_{2.5}$, where information is very scarce, expert judgements were used in most cases on the fractions of PM_{10} and $PM_{2.5}$ of total TSP. For some processes national statistics and emission factors for particle emissions suggested by the CEPMEIP-project was used.

For the sector solvent and product use and the agricultural sector, in most cases, national statistics on activity was used in combination with internationally suggested emission factors, while emission estimates for the waste sector mostly were based on national information on activity together with published emission factors from various sources.

In this report NFR codes (Nomenclature for Reporting) for each source are given, as defined in the Draft Guidelines for Estimating and Reporting Emissions Data (UNECE, 2002) and used in the submission of national emission estimates to UNECE/LRTAP. This was done to facilitate the reading for those who are familiar with these guidelines. Other readers may just overlook this information.

3. Particles

Particles are emitted to air from a large variety of sources, such as combustion activities, industrial processes, automobile tyre and brakewear, road abrasion and as diffuse emissions from handling of raw materials and products. The current estimates cover emissions of TSP (total suspended particulate matter), PM_{10} (particles of size <10 µm) and $PM_{2.5}$ (< 2.5µm). National information making it possible to estimate emissions of TSP has been available for most sources, while information on the fractions of TSP, as PM_{10} and $PM_{2.5}$, almost did not exist. In order to make the estimate of particle fractions, the Co-ordinated European Programme on Particulate Matter Emission Inventories, Projections and Guidance (CEPMEIP, TNO 2001) was used as a reference to a large extent.

3.1. Methodology and emission factors for particles

Particle emissions arising from combustion in the energy sector have been calculated using the emission factors presented in Appendix 1. The energy statistics is, as is further discussed in chapter 7.2, not of as good quality from the 1980´s. For the 1980´s it is not possible to separate the emission sources according to the requirements for reporting. Emission estimates for the 1980´s based on the energy statistics, are therefore only presented as total estimates from stationary sources. Activity data used in the emission estimates for the different sources are described in the specific chapters below.

Emission factors have for all sectors been compared to those compiled in the UNECE CEPMEIP-project. Where no national information was available, emission factors from the CEPMEIP project, applicable to conditions around 1995, were used. When national information on TSP-emissions or emission factors were available, the partitioning of particle emissions on PM_{10} and $PM_{2.5}$ were for several sources derived from the CEPMEIP project.

3.2. Estimated national emissions of particles

Particle emissions, as TSP, PM_{10} and $PM_{2.5}$, have for most sources been compiled for the entire time series 1980-2001, but due to the conditions of the energy statistics in the 1980´s source specific estimates are not reported for stationary combustion. For one of the most important sources of particle emissions, residential combustion of wood, reliable statistics are not available for conditions during the beginning of the 1980´s.

The most important sources of particle emissions in Sweden are:

- Energy production, where combustion of wood for residential heating contributes the larger share
- Particle emissions from mobile sources, including both emissions from combustion of fuel and emissions from road abrasion and automobile tyre and brake wear
- Emissions from industrial processes
- Particle emissions from the agricultural sector

Estimated national emissions of TSP, PM_{10} and $PM_{2.5}$ by sector are presented in Figures Figure 3.1 through Figure 3.3. According to the calculations emissions of particles in Sweden have decreased substantially from the mid 1980´s until 2001.

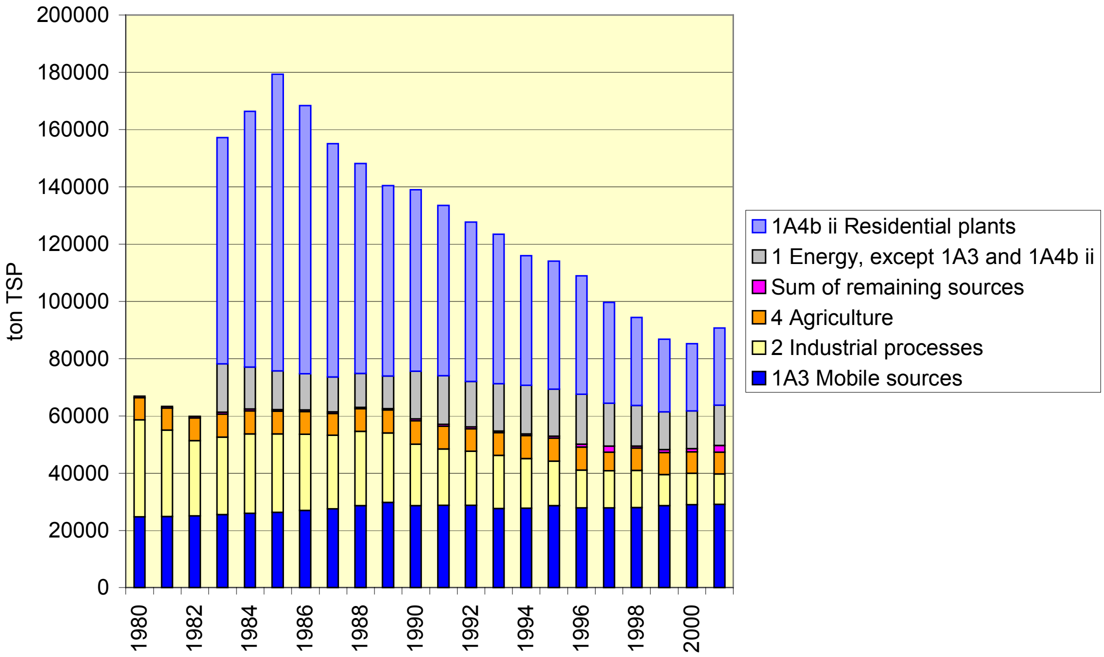

Figure 3.1 **Estimated national total emissions of TSP from different source categories, 1980-2001 (ton TSP).**

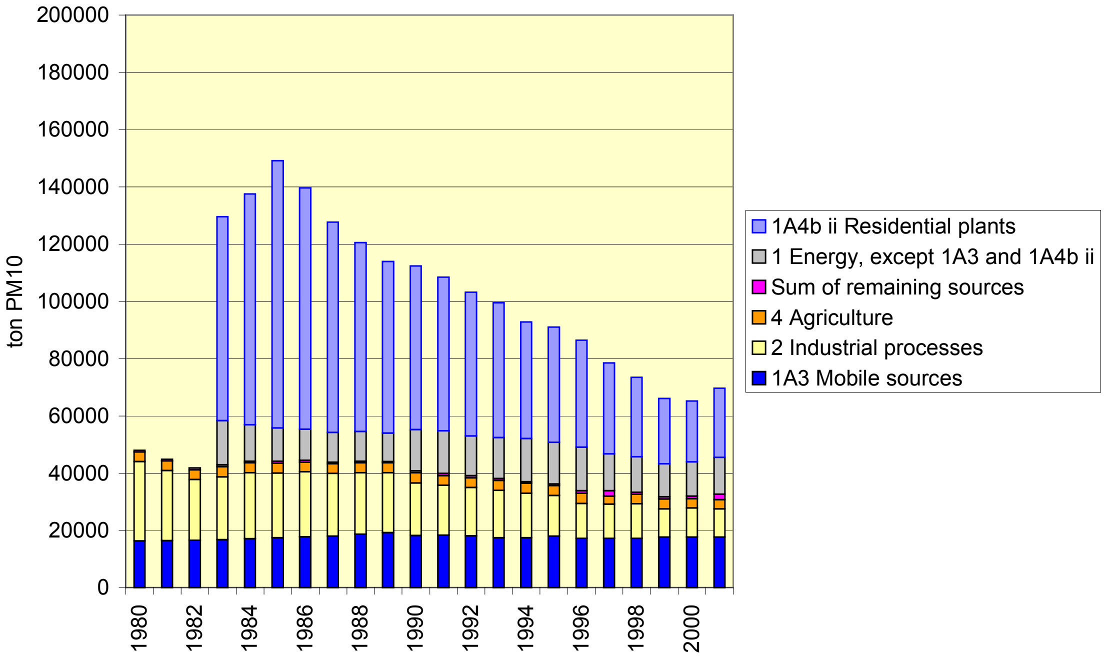

Figure 3.2 **Estimated national total emissions of PM_{10} from different source categories 1980-2001 (ton PM_{10}).**

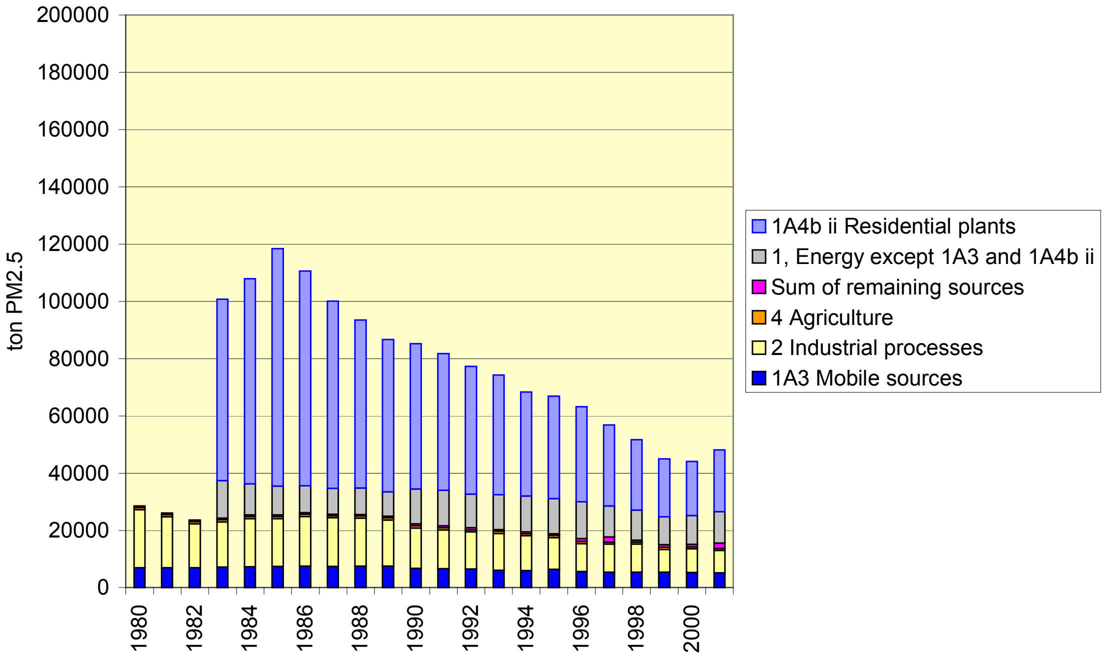

Figure 3.3 **Estimated national total emissions of $PM_{2.5}$ from different source categories 1980-2001 (ton $PM_{2.5}$).**

4. Metals

Heavy metals are emitted to air from combustion processes as well as from other processes. One important source is of course metal production, but for certain metals other sources may dominate the national emissions. The metals included, as required by the Draft Reporting Guidelines (UNECE, 2002), are As, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn. The estimated national total emissions of each of these metals are presented by sector in the figures below, and further discussed in the following chapters.

4.1. Methodology and emission factors for metals

Activity data for combustion in the energy sector has, as for all substances, been the national energy statistics. For other sources, mainly industrial processes, activity data or emission figures have been compiled from various types of information sources, e.g. information from trade associations, from individual facilities and from earlier reports on emissions of metals in Sweden. Emission factors for metals from stationary combustion have been compiled based on various literature sources and expert judgement (Chapter 7.3). Emission factors for metals from industrial processes usually were developed from available data on activity and reported emissions at plant level, subsequently used on national activity data to calculate emissions.

4.2. Estimated national emissions of metals

The metals that have been covered in the inventory are As, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn. For Se, selenium, only emissions from stationary combustion within the energy sector have been estimated. For other sources sufficient information was not available to estimate emissions of Se. Time series of national metal emissions were compiled for the period 1990-2001, but additional information for earlier years is discussed and presented in some of the chapters on individual sources below.

In Figure 4.1 through Figure 4.8 the estimated national total emissions of metals are presented by sector. Important sectors vary between the metals, but for all metals process emissions from metal production (NFR 2C) contribute significantly. The estimated emissions from individual sectors are discussed further in the specific chapters below.

For Ni, a change in energy statistics method for refineries 2000 and 2001 is visible in Figure 4.6. The presented emissions of Cd, Cu and Zn from mobile sources are estimated emissions from automobile road abrasion and tyre and brake wear, while the Pb emissions from mobile sources originate from combustion of leaded fuel.

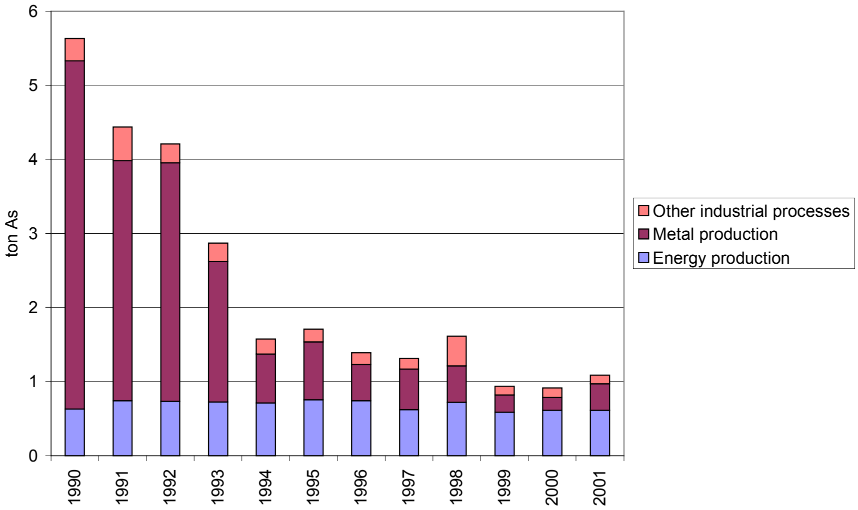

Figure 4.1 National emissions of Arsenic (As) 1990-2001 (ton).

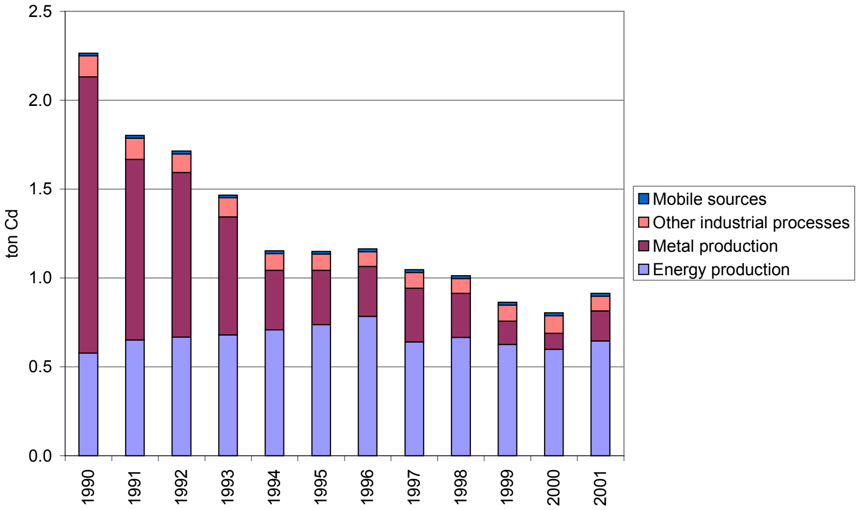

Figure 4.2 National emissions of Cadmium (Cd) 1990-2001 (ton)

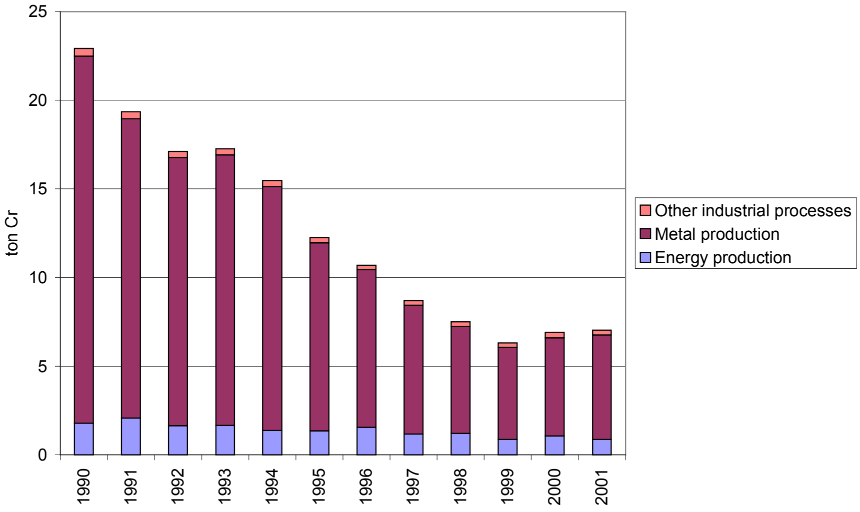

Figure 4.3 National emissions of Chromium (Cr) 1990-2001 (ton).

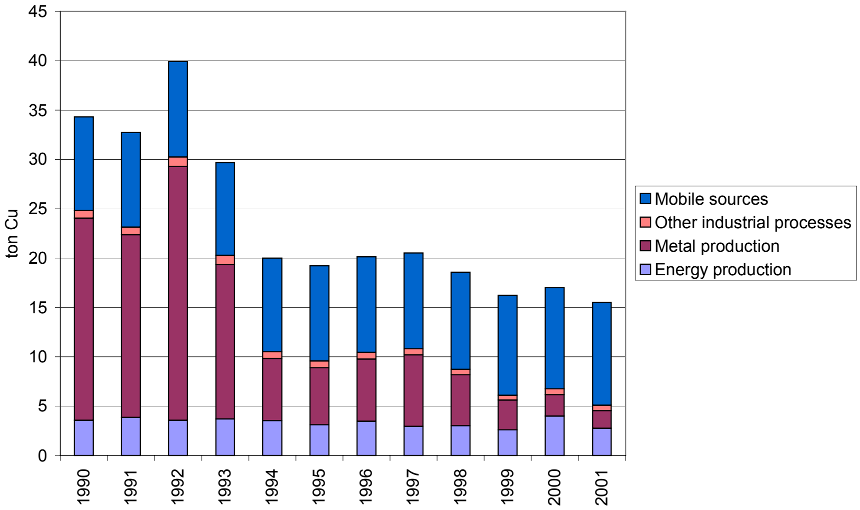

Figure 4.4 National emissions of Copper (Cu) 1990-2001 (ton).

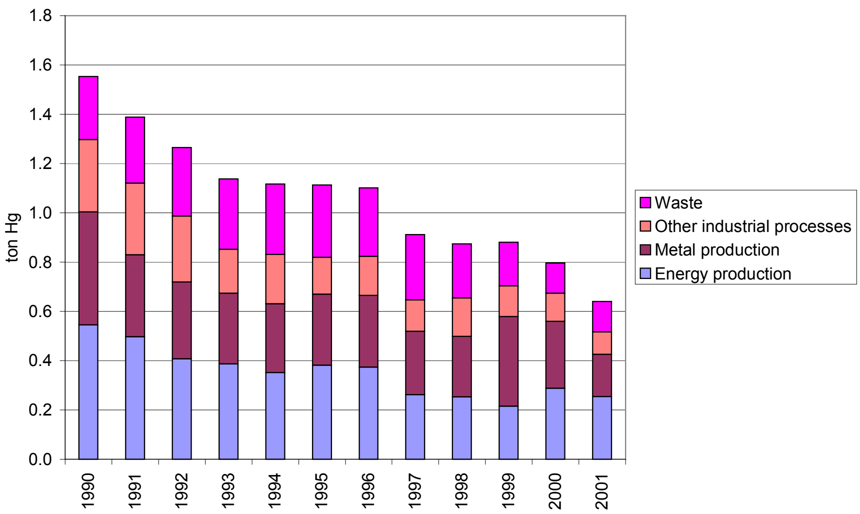

Figure 4.5 National emissions of Mercury (Hg) 1990-2001 (ton).

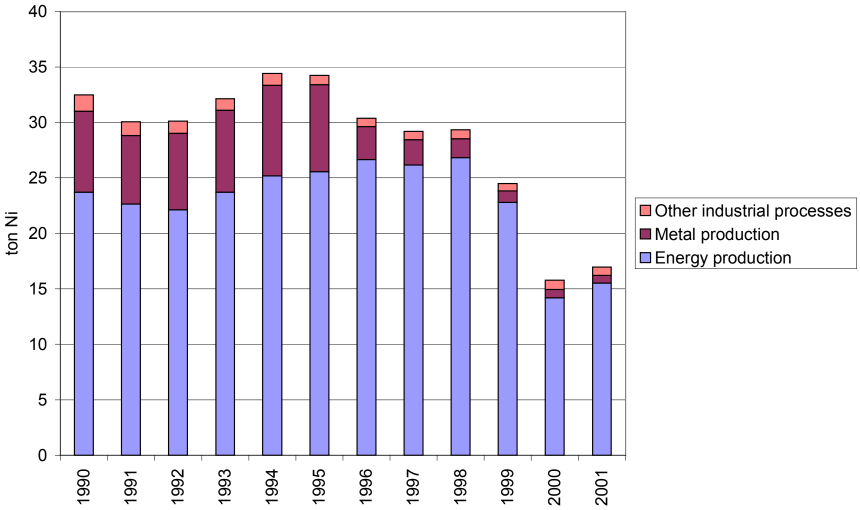

Figure 4.6 National emissions of Nickel (Ni) 1990-2001 (ton).

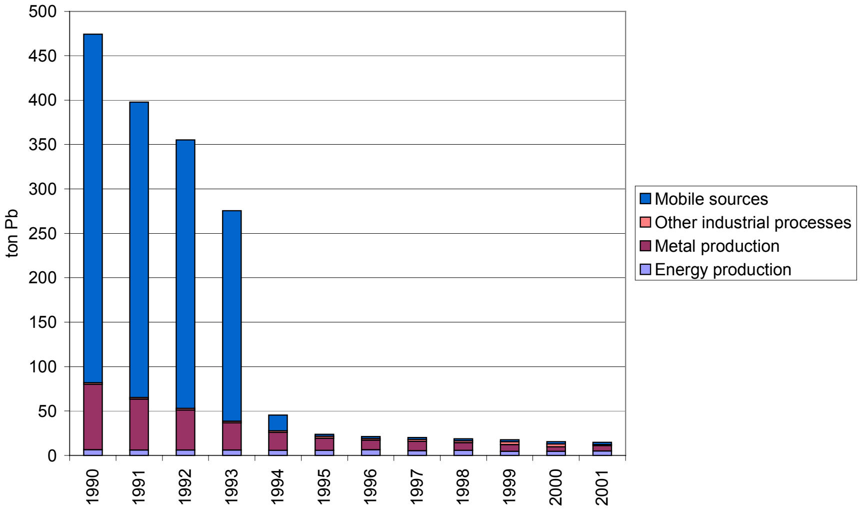

Figure 4.7 National emissions of Lead (Pb) 1990-2001 (ton).

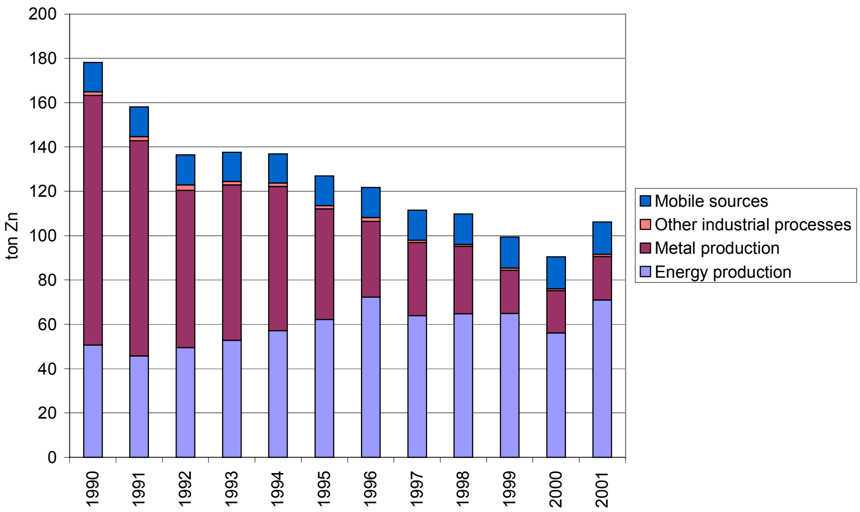

Figure 4.8 National emissions of Zinc (Zn) 1990-2001 (ton).

5. Dioxins

Polychlorinated dioxins and furans, referred to as dioxins in this report, are formed unintentionally as a result of several industrial and combustion processes. The production of dioxins is strongly dependent on certain physical and chemical conditions. For instance, temperatures between 200 ºC and 600º are optimal and the chlorine must be available (e.g. Ahlgren and Marklund, 2001). Whether organic chlorine is more efficient than inorganic chlorine in forming dioxins has been the scope of several studies. Results so far are inconclusive. Dioxin formation is favoured under conditions of incomplete combustion. Formation and emissions of dioxins are therefore difficult to predict quantitatively, since incomplete combustion is typical for uncontrolled processes. In Sweden, a general awareness of the problem with unintentional production and emission of dioxins appeared during the mid 1980´s.

An inventory of Swedish dioxin emissions to air was made for 1993 but is unpublished (deWit, unpubl.). This study is referred to and summarised in e.g. Ahlgren and Marklund (2001) and in UNEP (2001). That inventory also serves as a starting point for the data on Sweden in the European Dioxin Inventory (EDI). Several activities in the 1993 inventory are presented with intervals rather than a single value. Using their highest estimates, these are the potentially most important sources, given in declining order:

- landfill fires
- primary iron and steel plants
- secondary iron and steel plants
- woodfired stoves
- secondary production of aluminium and copper
- biomass power plants
- lime
- municipal waste incineration
- cement kilns
- pulp and paper mills
- combustion of oil and coal
- road traffic
- foundries
- cremation
- ferries, aircraft

5.1. Methodology and emission factors for dioxins

From 2001 on, all facilities emitting more than 0.001 g TEQ/year to air are required to report annual emissions in their Environmental Reports. Such information is public in Sweden. Previously, such measurements covered only a few industrial categories and facilities.

Although annual emissions from individual facilities may be based on a few spot tests, we consider them frequently to be more reliable than data obtained using generic emission factors. Therefore, when reported emissions are considered reliable we use those data for indiviudal facilities in a certain source category. When not, emissions are calculated using activities and emission factors for each source category.

There are several systems for converting amounts of dioxins to their toxic equivalents (TEQ). If a value is presented in one system, it cannot be recalculated to another system without access to data on all congeners. In the European Dioxin Inventory, it is stated that the difference between these systems is negligible compared to the inherent uncertainties in all the underlying measurements. Thus, we have adopted this approach.

Several compilations of dioxin emission factors are available, although substantial crossreferring occur, e.g.:

- UNEP (2001) Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases- draft. UNEP Chemicals, Geneva, Switzerland

- USEPA (1997) Locating and estimating air emissions from sources of dioxins and furans.

- The European Dioxin Inventory

- EMEP/CORINAIR Emission Inventory Guidebook (EEA, 2001).

In addition, there are several reports on national inventories that contain emission factors, e.g. Finstad et al. (2002) for Norway, and Hansen (2000) for Denmark. When emission factors were required, these and other sources were considered. As far as possible, care was taken to select representative values by considering, e.g., type of flue gas cleaning, type of fuel and impurities etc.

5.2. Estimated national emissions of dioxins

As for all other substances, emission estimates based on the energy statistics from the 1980´s are uncertain, which is evident in Figure 5.1, especially for the years 1980-1985. Although the energy statistics are uncertain, an increase in dioxin emissions from energy industries (NFR 1A1) in the early 1980´s would be expected, caused by increased combustion of municipal waste during these years. The substantial decrease in dioxin emissions from energy industries from approximately 1985 to the beginning of the 1990´s is primarily due to regulations of emissions leading to introduction of abatement techniques for the combustion of municipal waste. During the 1990´s and until 2001 the most important sources contributing to dioxin emissions are combustion in energy industries and in manufacturing industries, emissions from metal production and the source “other waste”, which consists of estimated emissions from landfill fires.

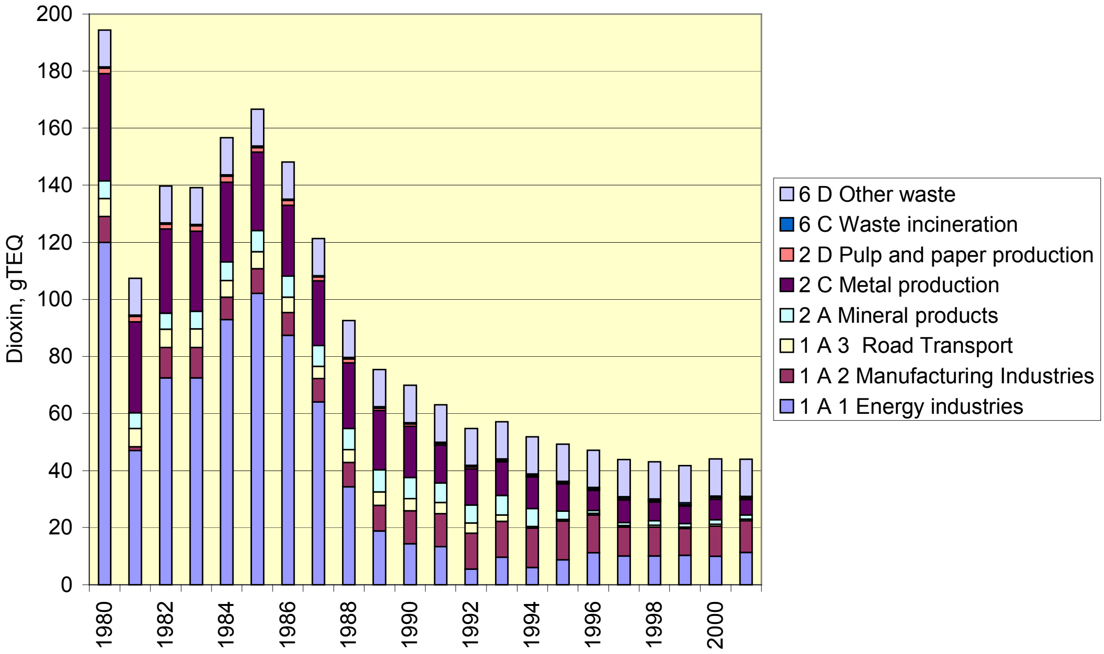

Figure 5.1 National total emissions of dioxins (g TEQ) 1980-2001. The dioxin emissions from Energy Industries (1A1) primarily arises from municipal waste combustion.

6. PAH

Polycyclic aromatic hydrocarbons (PAHs) is the collective name for a large group of chemicals, which all have in common that they consist of two or more ring structures, where at least one ring has the structure of a benzene. Figure 6.1 shows four examples of commonly occurring PAHs.

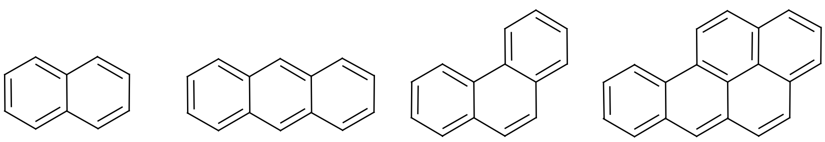

Figure 6.1 Molecular structures of four PAHs commonly occurring in the environment.

Just like dioxins, PAHs are predominantly formed during incomplete combustion processes and are emitted to the air both from stationary and mobile sources. Previously identified emission sources include e.g. traffic, small-scale residential heating, i.e. wood-burning, and industrial processes such as aluminium production (e.g. Finstad et al., 2001). Emissions of PAHs are generally associated with emissions of soot and particles. PAHs are semivolatile, and as such they can occur either in the gas phase or in the particle phase of the atmosphere. The partitioning between the two phases is controlled by factors such as substance-specific vapour pressure, air temperature, the particle content of the air, and the properties of the particles themselves. PAHs are mainly associated with fine particles (less than 10 µm), for which EU has recently adopted an air quality directive (1999/30/EC, amended by Commission decision 2001/744/EC).

Historically, it has not been possible to separate different PAHs from each other, due to analytical difficulties. Thus they have been reported as "total PAH" or "sum of PAH", without any further information about which substances were included in the chemical analysis. Today, broad knowledge exists on the different toxic and physical-chemical properties of different PAH substances, and it is generally conceived that separation of individual substances is necessary.

The UNECE POPs Protocol specifies that the following 4 PAHs should be used as indicators for the purposes of emission inventories:

- benzo(a)pyrene
- benzo(b)fluoranthene
- benzo(k)fluoranthene
- indeno(123cd)pyrene

These four substances belong to the heavier molecules in the PAH group and to those regarded as the most carcinogenic.

6.1. Methodology and emission factors for PAH

The current emission inventory comprises the four substances specified in the UNECE POPs protocol (BaP, BbF, BkF and Ind, hereafter referred to as PAH-4). It should be noted, however, that the selected substances often occur at low concentrations when compared to more volatile PAHs. Thus, this inventory should not be regarded as a complete emission inventory for PAHs. The main purpose at this stage is to establish an emission reporting system, where updating of individual figures can be done relatively easily, and to estimate current and past emissions of the four prioritised substances. Once established, more substances can be included, and data can be updated.

The Emission Inventory Guidebook (EEA, 2001) suggests emission factors for different source types for benzo(a)pyrene (BaP) and typical profiles for the four substances BaP BbF, BkF and Ind are given, as are identified important emission sources. It is, however, emphasised that there might be regional differences to this general pattern. The possible emission sources that have been treated/investigated in this emission inventory are listed below. For some of these sources, it was concluded that emissions are likely to be so low, that further investigation was not necessary. For others, however, emissions have been regarded as significant, and thus emission factors have been sought.

- Energy production
    - wood combustion
    - coal combustion
    - municipal waste incineration
- Industrial processes
    - aluminium production
    - coke production
    - iron- and steel production
- Mobile sources
    - road traffic

- Other sources
  - forest fires
  - garden burning
  - lawn mowers
  - cooking (frying, barbecuing)
  - cigarette smoking

As mentioned earlier, emissions of PAH have traditionally been reported as a sum, thus it is often difficult to obtain information on emissions of individual substances. In this inventory, we have used environmental reports produced by individual companies as far as possible and based emission factors on emissions given in these. Where emission data were lacking, factors have been taken from the literature. Local or national data have been used where possible. If emission factors were obtained only for BaP, these were combined with the profiles given by EEA (2001) for the given source in order to obtain factors for all four substances.

6.2. Estimated national emissions of PAH-4

According to the current inventory, the most important source of emissions of PAH-4 is by far combustion of wood for residential heating (Figure 6.2). Other important sources are metal production (i.e. primary aluminium production), stationary combustion in energy industries and in manufacturing industries and from coke production at primary iron- and steel plants. Emissions of PAH from mobile sources, which have been suggested to be important, have not been submitted due to very disperse infomation on emission factors. This issue is discussed in more detail in Chapter 8.2.4.

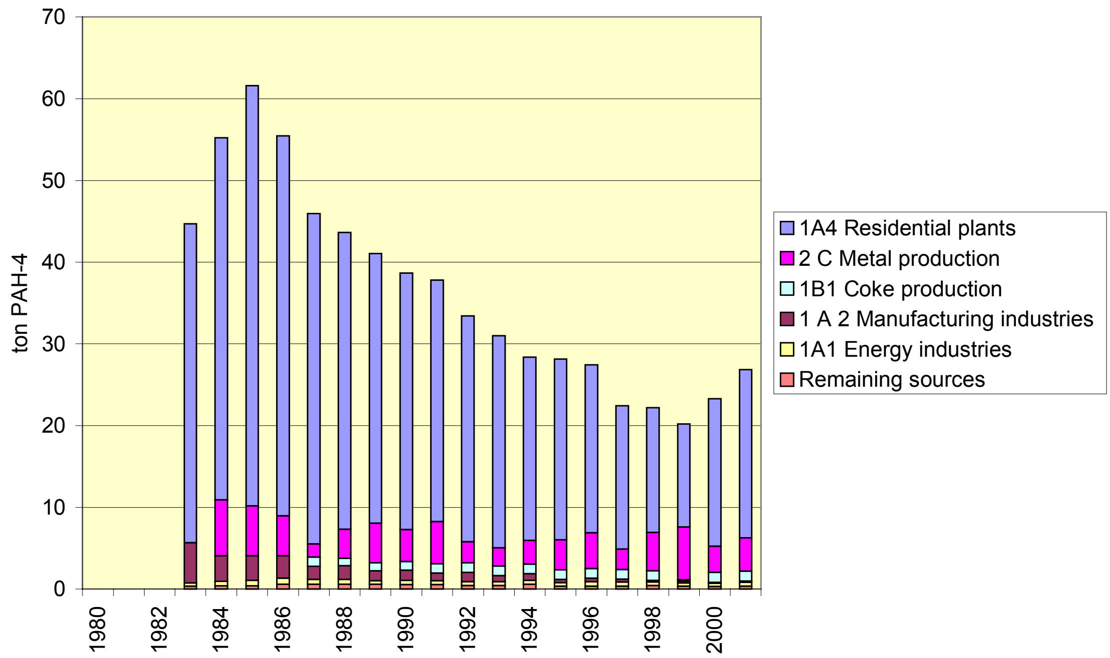

Figure 6.2 Estimated national total emissions of PAH-4 1983-2001 (ton). Data for metal production only from 1984-2001, from coke production from 1987-2001).

7. Stationary sources within the Energy sector (NFR 1)

7.1. Energy statistics

Since 1980 the Swedish energy system has changed substantially. 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 bio fuels today (wood chips, bark). Incineration of municipal waste is also common in district heating plants (5 TWh in year 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 bio fuels.

The largest sectors in stationary combustion in Sweden today are district heating (50 TWh, Figure 7.1), combustion in manufacturing industry (96 TWh from combustion, Figure 7.2, presents total energy consumption in industry, including electricity and district heating) and combustion in the commercial and residential sector (35 TWh from combustion, Figure 7.3).

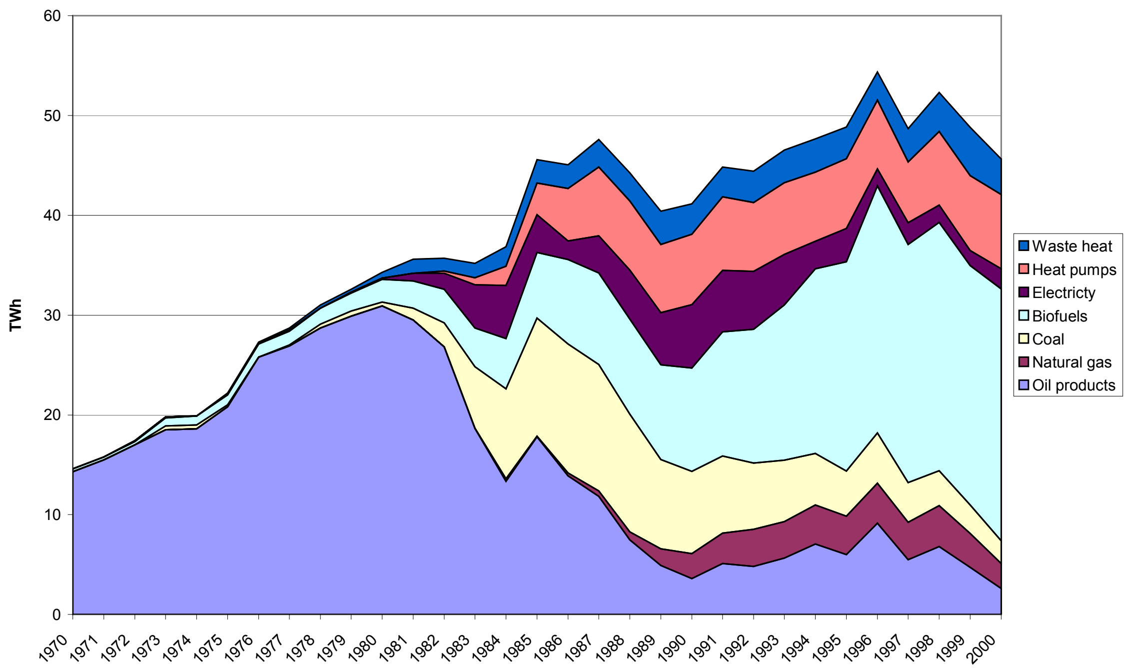

Figure 7.1 Energy supply to the Swedish district heating sector, 1970-2000.

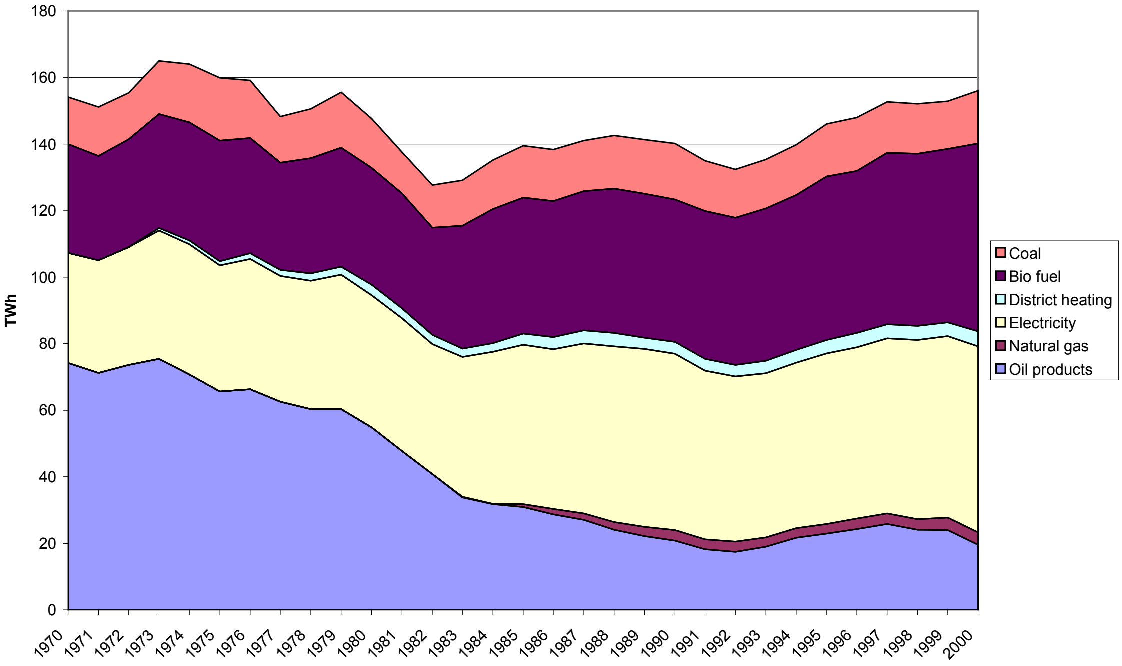

Figure 7.2 Energy consumption in Swedish industry, 1970-2000.

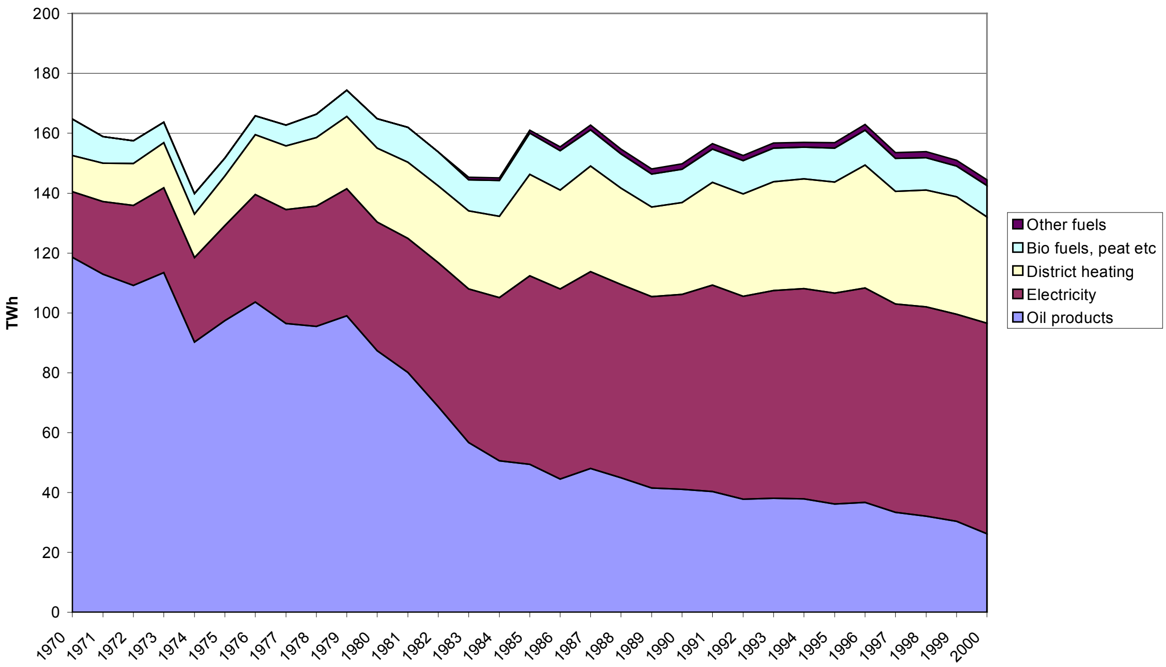

Figure 7.3 Energy consumption in commercial and residential buildings, 1970-2000.

7.2. Energy statistics as activity data for stationary combustion

7.2.1. 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 larger 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 the 1980´s.

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

Emissions of particles, metals, PAH, and dioxins 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. 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 1980-2001. 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 7.1.

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 1980-2001, and is thus consistent for this time period.

Statistics on fuel consumption for industries (SNI 10-37) for the years 1980-1996 were based on total surveys to all companies with more than 4 employees the years 1980-1989 and to all companies with more than 9 empolyees the years 1990-1996. All years 1980-1996 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 sector and company size within each SNI-classification. Adjustments were made to reach yearly national estimates.

Statistics on industrial fuel consumption for the year 2000 was again based on a yearly 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,

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

instead of *economic activities, working units* were surveyed. Adjustments were made to reach 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 worse quality.

Table 7.1 Methodology for fuel consumption survey of industry (SNI 10-37) for the years 1980-2001.

Year	**Survey sampling**	**Included areas**	**Adjustments**	**Quality**
1980-2001	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.
1980-1989	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. This is evident in the results of the calculations on emissions that have been made. Figure 7.4 shows that, apart from the very varying estimates in the early 1980´s, there also seem to be a shift in total emissions from stationary sources between 1989 and 1990. Considering the changes in compilation of energy statistics, and the uncertain results, emission data arising from using the energy statistics as activity data before 1990 are only presented further for some sources for illustrative reasons in this report.

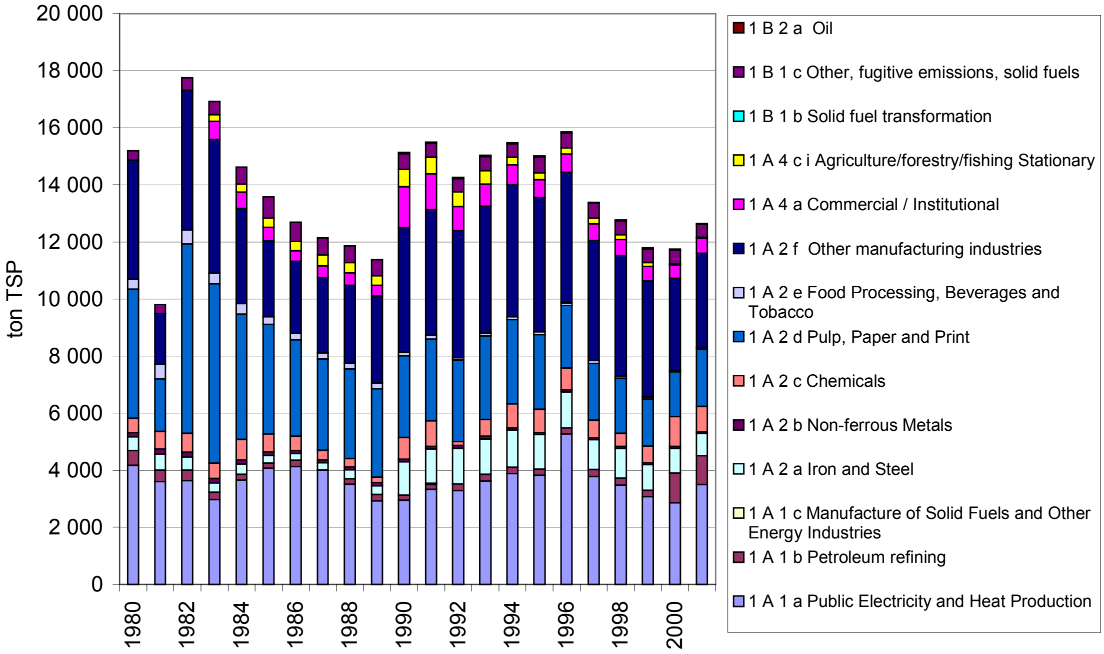

Figure 7.4 Estimated emissions of TSP from stationary combustion 1980-2001 (except residential combustion).

Special comments on energy statistics relating to refineries, iron-and steel production and residential combustion

For refineries as well as for primary iron- and steel plants 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 (NFR 1), or as process emission in the industrial processes sector (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. This has resulted in higher calculated emissions from refineries from combustion allocated within the energy sector in 2000 and 2001, as compared 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.

Energy statistics for the 1980´s and especially for the early 1980´s are not of as good quality as later data, as has been mentioned above. For wood used in the residential sector, no usable data before 1983 exist.

7.3. Emission factors for stationary combustion

The emission factors developed for calculation of emissions of particles, metals, dioxin and PAH 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 of 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 1980–1990, are to a large extent based on results from these research programs. The information in these reports are in many ways still usable for estimating emission factors after 1990. As an example, the results from the elementary analysis of different fuels are of great importance and also the presentation of different abatement techniques.

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 abatement measures in combination with regulations and requirements from authorities. Installation of electrical precipitator or bag house filters has, as an example, become standard on large combustion sources. This primarily reduces the TSP emission. Combustion of MSW (municipal solid waste) also became strictly regulated, and as a consequence of that, flue gas cleaning equipment of different types was installed to reduce the emissions, primarily of dioxins and mercury. 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 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 most difficult task, with the least available information, was concerning the development with time of the particle size fractions of the emissions of TSP. The emissions of TSP have for a long time been reported from different sources, including stationary combustion, in Enviromental reports. With the common knowledge regarding cleaning efficiency of particles with different abatement techniques (cyclones, electric precipitators, textile filters etc.) the fraction of PM_{10} and $PM_{2,5}$ in TSP after a cleaning equipment can be estimated. Generally, for most particle emission sources, the fraction of smaller particles have been assumed to increase with time. This is known to be the case, considering the introduction of abatement measures, which predominantely removes the larger particles from the flue gases. The CEPMEIP project was used as a reference for suggested conditions in the mid 1990´s.

All emission factors for TSP, PM_{10}, $PM_{2.5}$, the nine metals, dioxins and PAH-4, used to calculate emissions from stationary combustion are presented in Appendix 1.

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 the report.

7.4. Emissions of particles from stationary sources

The NFR sector 1, Energy, includes stationary combustion sources, mobile sources and fugitive emissions from fuels. The methods for estimating emissions from mobile sources are presented in chapter 8, while stationary combustion sources and fugitive emissions from fuels both are presented in this chapter.

Emissions of particles from stationary sources within the energy sector were calculated based on fuel statistics and emission factors (Appendix 1). The single dominant source is particles emitted from wood combustion in the residential sector. The total emissions of TSP from stationary sources in the energy sector are presented in Figure 7.5 for 1980-2001, where emissions from residential plants are shown separated from the sum of all other stationary sources. The overall time trend in total TSP emissions is clearly decreasing, largely depending on the decrease in emissions from residential wood combustion. Variations in emissions between the years for the remaining sources are, at least for the 1980´s, probably partly due to an unclear quality of the energy statistics.

The contributions from the individual stationary source categories within the energy sector, except residential combustion, are presented in Figure 7.6 for 1990-2001. No source specific calculations are presented for the 1980´s. Stationary combustion for public electricity and heat production (NFR 1A1a), in the pulp and paper industry (NFR 1A2d) and in other manufacturing industries (NFR 1A2f) are the largest contributors among these sources.

The calculated emissions of PM_{10} and $PM_{2.5}$ show largely similar patterns as to dominant contributors and time trend, as do emissions of TSP, but the total levels are lower (Figure 7.7, Figure 7.8).

Since few measurements regarding the particle size distribution have been conducted in Sweden, estimations have been done based on the common knowledge about different abatement techniques capability to reduce particles in different fractions of size (PM_{10}, $PM_{2.5}$) (Hinds, IEACoalResearch, 1998, Maartman, 2001), see Table 7.2.

Table 7.2 Fraction of PM_{10} and $PM_{2.5}$ in TSP after cleaning (mass).

Technology	PM_{10} (%)	$PM_{2.5}$ (%)
Electric precipitator	90-98	75-85
Textile filters, bag house	95-99	85-95
Wet scrubbers	80-98	70-80
Mecanical collectors	40-60	10-30
Cyclones/multicyclones		

This basic data have been used together with the knowledge about commonly installed abatement techniques at different kind of sources in the judgement of particle size distribution. In contacts with many plants/industries information regarding flue gas cleaning have been asked for and this has been taken into consideration in the estimation of the particle size distribution from different source categories. During the time period 1980-2000 the number of installations of dust control devices have increased at most of the sources. Furthermore an exchange from cyclones to more sophisticated techniques (electric precipitators, textile filters) have increased over the years. The technical improvement of the abatement technique over the years is also factors that have to be accounted for in the final judgement.

This overall methodology to assign particle size fractions of emitted TSP has been used not only for stationary combustion but also for most of the other sources (iron and steel, pulp and paper, lime and cement etc.).

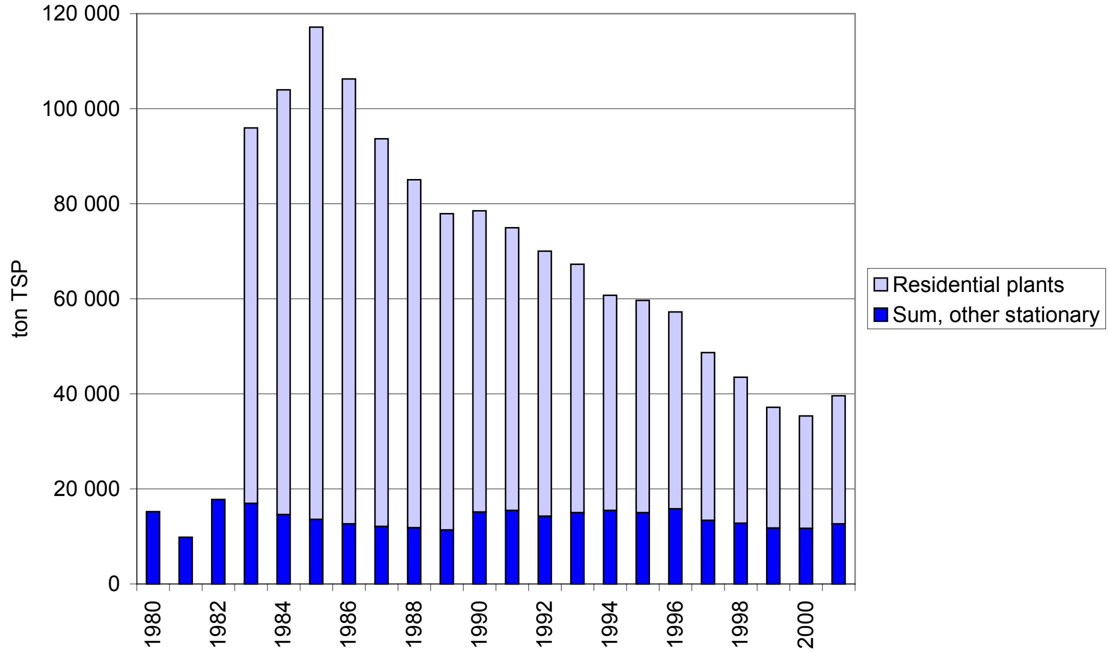

Figure 7.5 **Emissions of TSP from stationary sources in the Energy sector.**

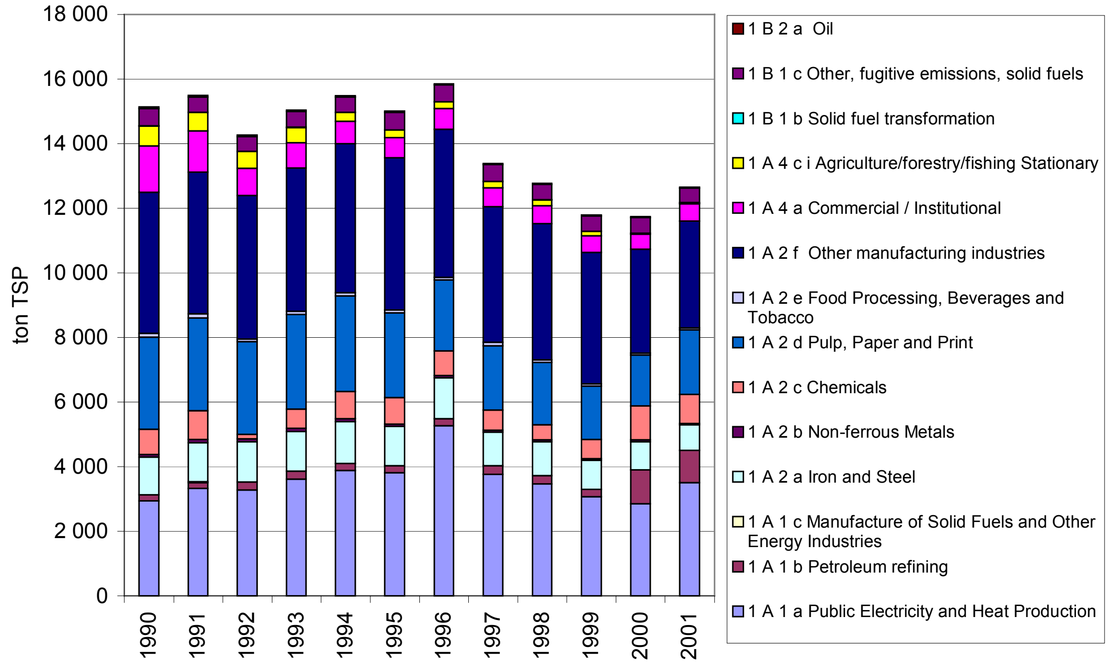

Figure 7.6 **Emissions of TSP from stationary sources within the energy sector, except residential. Energy industries (codes 1A1), combustion in manufacturing industries (codes 1A2), other energy production (codes 1A4), fugitive emissions from fuels (codes 1B).**

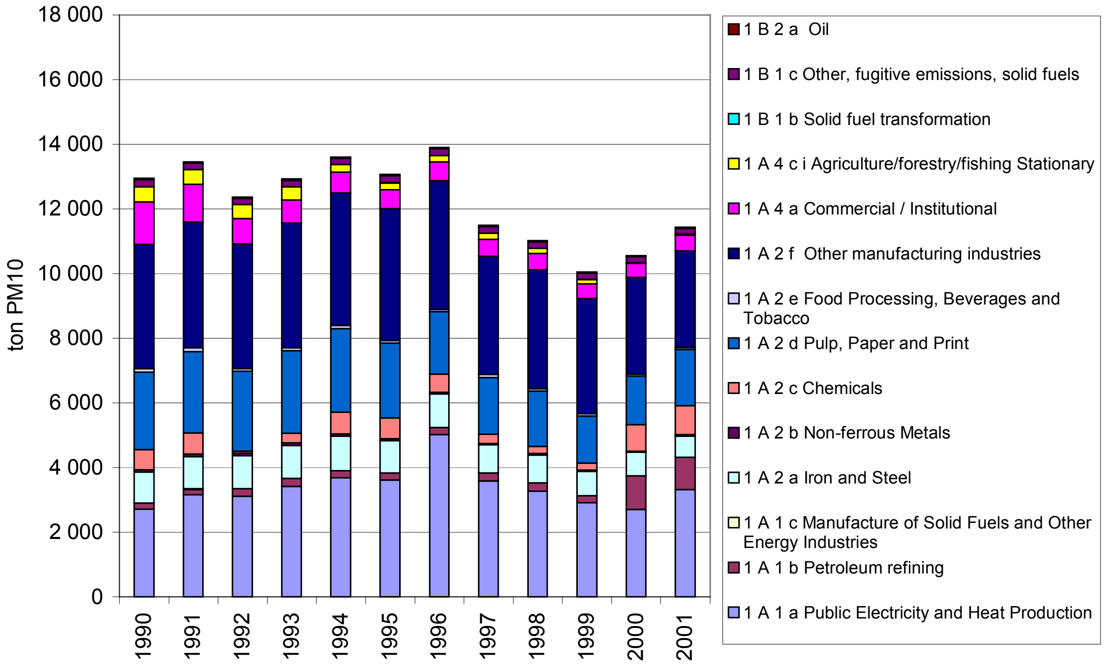

Figure 7.7 Emissions of PM_{10} from stationary sources within the energy sector, except residential plants.

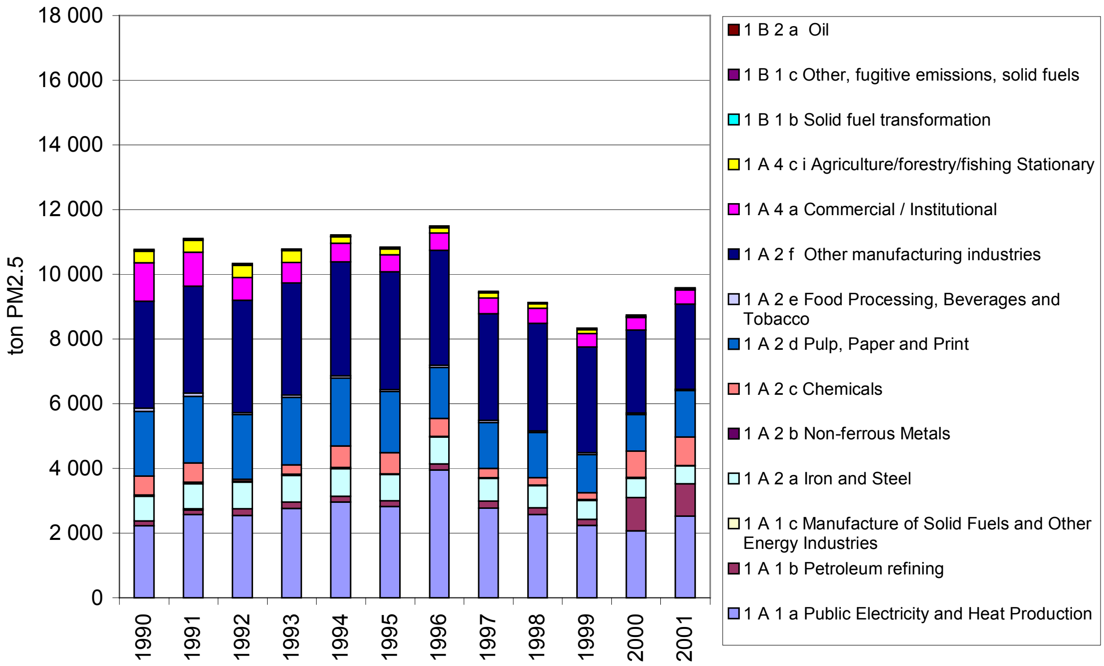

Figure 7.8 Emissions of $PM_{2.5}$ from stationary sources within the energy sector, except residential plants.

7.4.1. Particles from handling of solid fuels (NFR 1B1c)

Particle emissions from handling of solid fuels were calculated for the period 1980-2001 (Table 7.3). Activity data from official statistics, including import of coal and peat, are available for the period 1980-2001. No production of coal occurs in Sweden.

Peat production was not included in the estimate, since available activity data was not consistent, and of unknown quality. Emission factors used are those suggested for handling of coal from the UN/ECE CEPMEIP-project. The emission factor for TSP is 0.15 kg/ton where PM_{10} constitutes 40% and $PM_{2.5}$ 4% of the total particulate emissions. The same emission factors have been used for the entire time series.

Table 7.3 Particulate emissions from handling of imported solid fuels

Year	Import of coal and peat	Emissions		
		TSP	PM_{10}	$PM_{2.5}$
	kton	ton	ton	ton
1980	2196	329	132	13
1981	2086	313	125	13
1982	2961	444	178	18
1983	3103	465	186	19
1984	3989	598	239	24
1985	4896	734	294	29
1986	4506	676	270	27
1987	4020	603	241	24
1988	3871	581	232	23
1989	3731	560	224	22
1990	3591	539	215	22
1991	3195	479	192	19
1992	3079	462	185	18
1993	3274	491	196	20
1994	3126	469	188	19
1995	3620	543	217	22
1996	3416	512	205	20
1997	3439	516	206	21
1998	3216	482	193	19
1999	3107	466	186	19
2000	3190	478	191	19
2001	3009	451	181	18

Fugitive emissions of particles from handling of coke have not been included since these emissions are considered to be included in the reporting of particle emissions from the industrial facilities that produce or use coke in the process. Separate calculations based on statistics on coke and petrocoke, using emission factors for handling of coal from CEPMEIP results in a rough estimate of 300 tons TSP/year.

7.4.2. Particles from catalytic cracking at refineries (NFR 1B2a iv)

The particle emissions from petroleum cracking, which occurs at only one facility, have only been estimated for 1990-2001 due to lack of data for earlier years. The emissions from cracking have been compiled from information in the company's legal Environmental Report, reported data in the EMIR database (the regional authorities database) and from earlier submissions to CORINAIR. The emissions from the facility are known for most years, but for years with lack of information data have been interpolated. The emissions allocated to the cracking unit, as a part of the total emissions from the facility, has been calculated based on information in the Environmental Reports for 2000 and 2001, and used for all years (Table 7.4). The particle size distributions have been estimated with expert judgment. The assumed size distributions is 95% for PM_{10} and 85% for $PM_{2.5}$ of TSP for the whole time-series.

Table 7.4 Estimated emissions of TSP, PM_{10} and $PM_{2.5}$ (ton) from catalytic cracking.

Year	TSP (ton)	PM_{10} (ton)	$PM_{2.5}$ (ton)
1990	42	40	36
1991	42	40	36
1992	42	40	36
1993	42	40	36
1994	42	40	36
1995	41	39	35
1996	39	37	33
1997	37	35	31
1998	35	33	30
1999	35	33	30
2000	36	34	31
2001	33	31	28

7.5. Metal emissions from stationary sources

Metal emissions from stationary combustion sources have been calculated for the period 1990-2001, based on the energy statistics and emission factors in Appendix 1. The results are presented in Figure 7.9 through Figure 7.17.

The emission of metals from stationary combustion depends on both the metal content in the fuel and on the dust control device installed. Most of the metals are emitted as particles or adsorbed to particles, where any dust control technique will highly influence the emissions and emissions factors for metals. Only a very small fraction of most metals (Cd, Cu, Cr, Ni, Pb, Se and Zn) may be emitted as gas. Mercury and partly arsenic are emitted in gaseous form, where dust control techniques does not reduce emissions. In the judgement to choose a proper emission factor this has been taking into consideration.

The inconsistencies in the energy statistics for the iron and steel industry 1997-99 and for refineries in 2000 and 2001 as compared to the 1990´s are visible in the figures for some of the calculated metal emissions.

Emissions of zinc have increased according to the calculations, which is caused by an increased combustion of bio fuels.

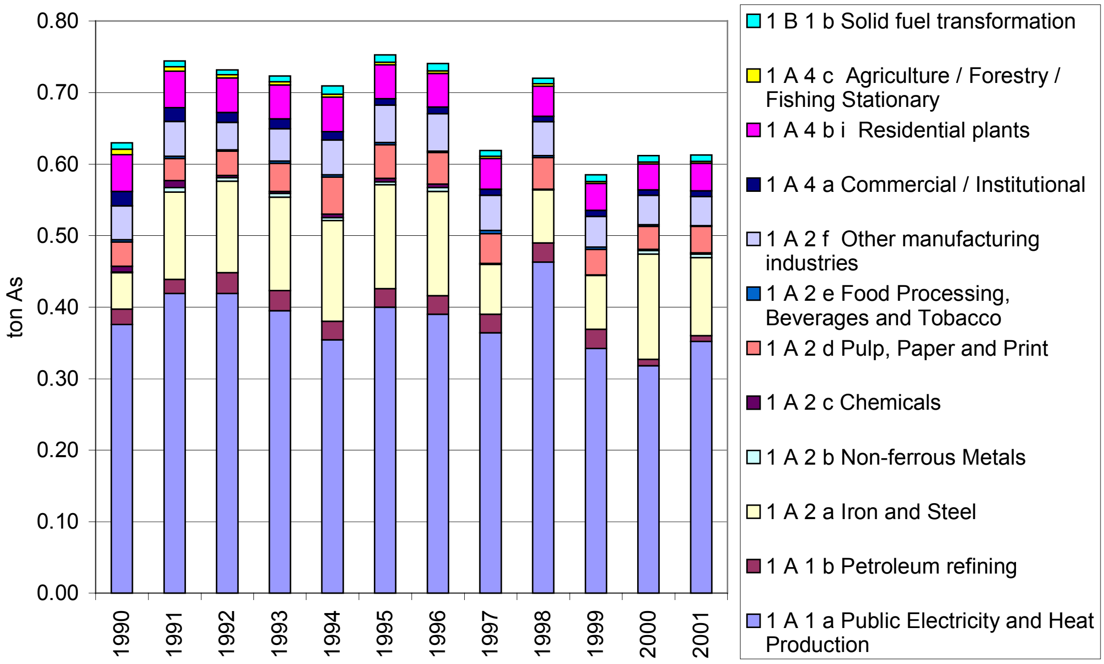

Figure 7.9 Emissions of Arsenic (As) from stationary combustion 1990-2001 (ton).

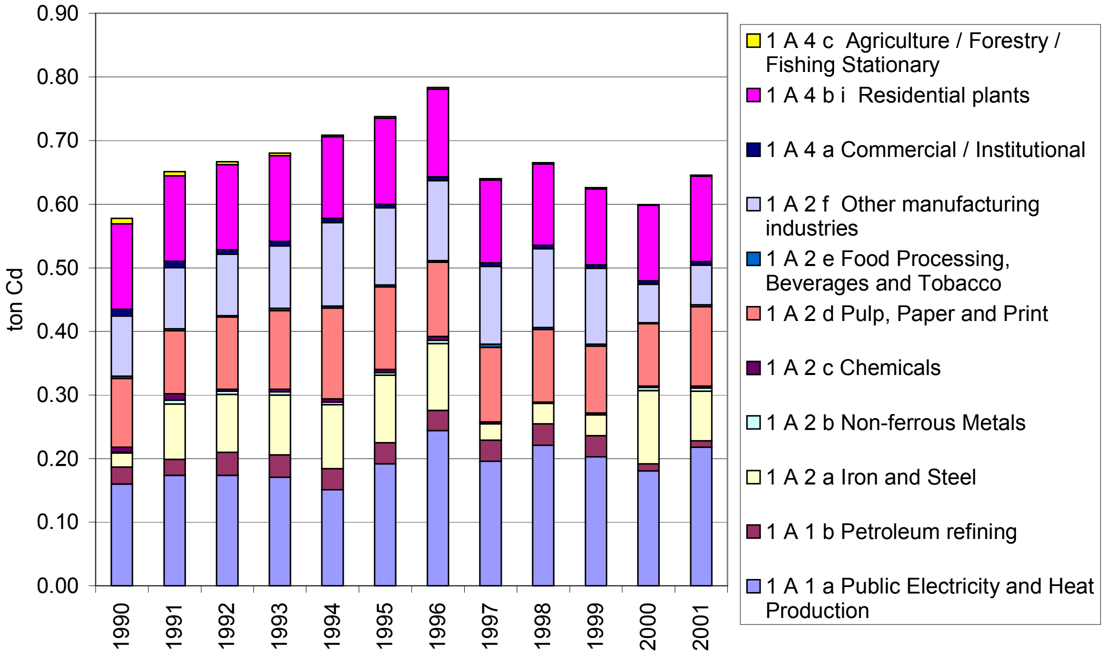

Figure 7.10 Emissions of Cadmium (Cd) from stationary combustion 1990-2001 (ton).

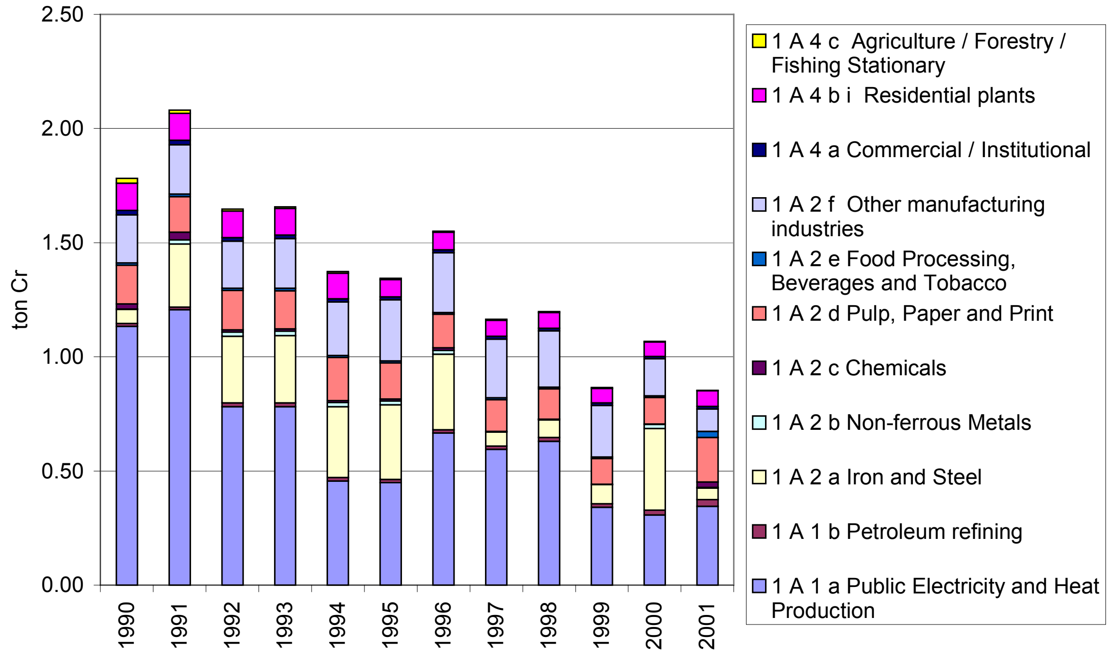

Figure 7.11 Emissions of Chromium (Cr) from stationary combustion 1990-2001 (ton).

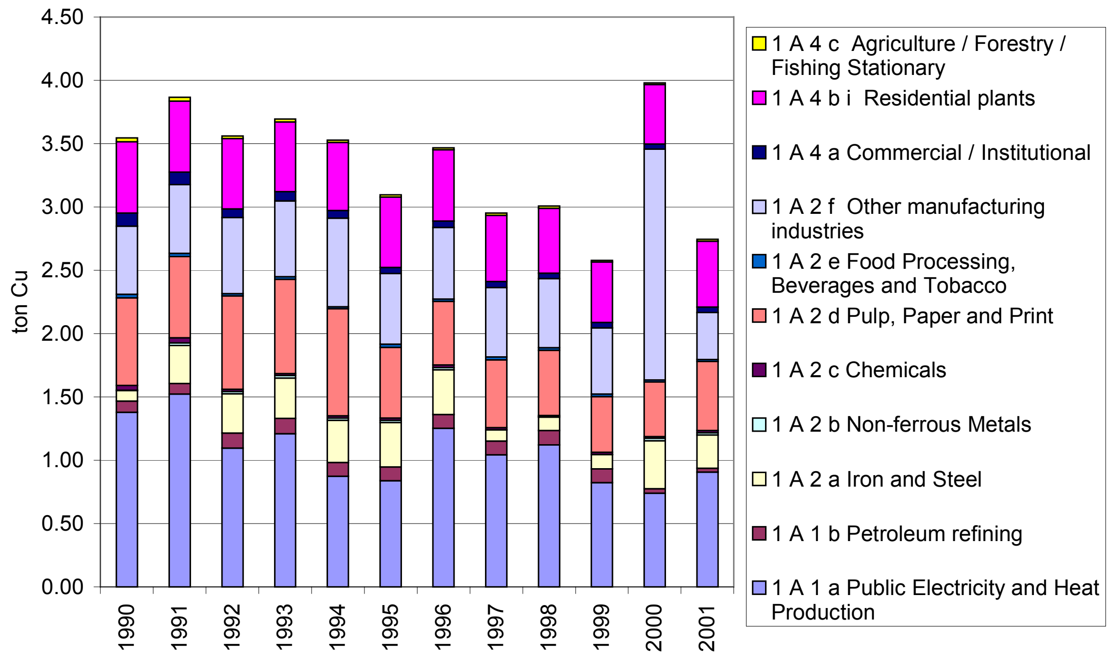

Figure 7.12 Emissions of Copper (Cu) from stationary combustion 1990-2001 (ton).

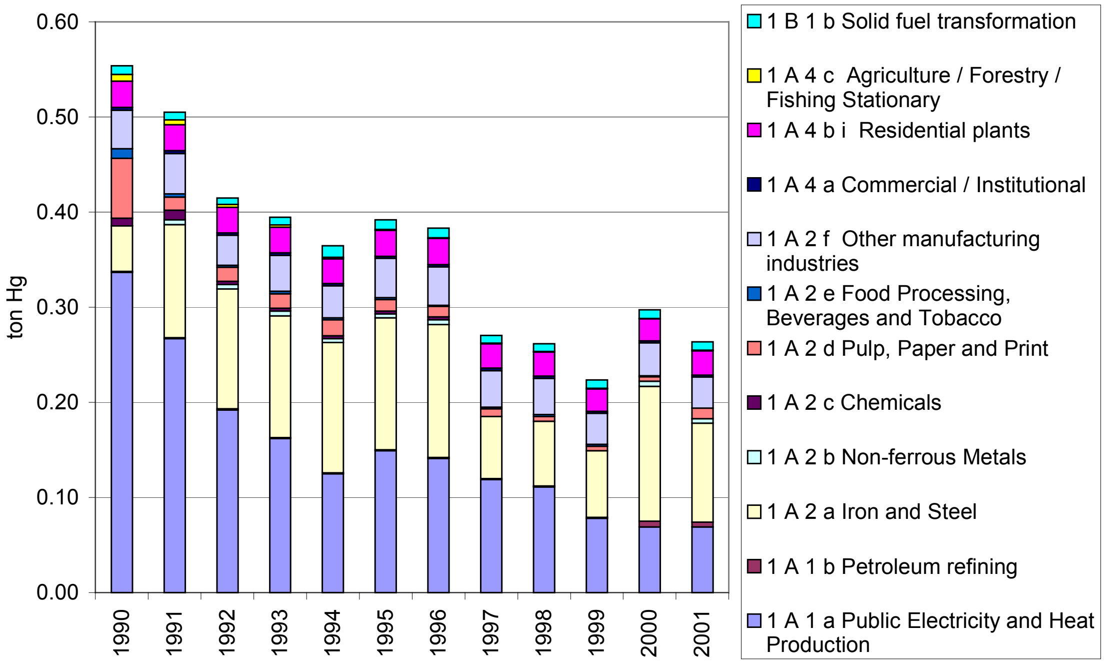

Figure 7.13 Emissions of Mercury (Hg) from stationary combustion 1990-2001 (ton).

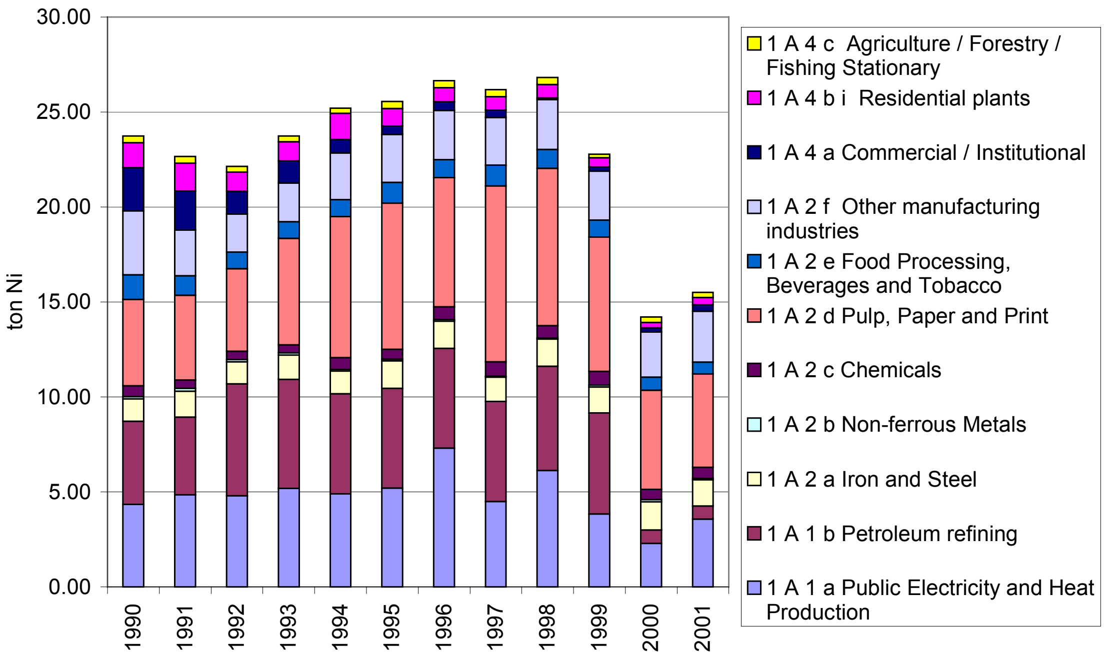

Figure 7.14 Emissions of Nickel (Ni) from stationary combustion 1990-2001 (ton).

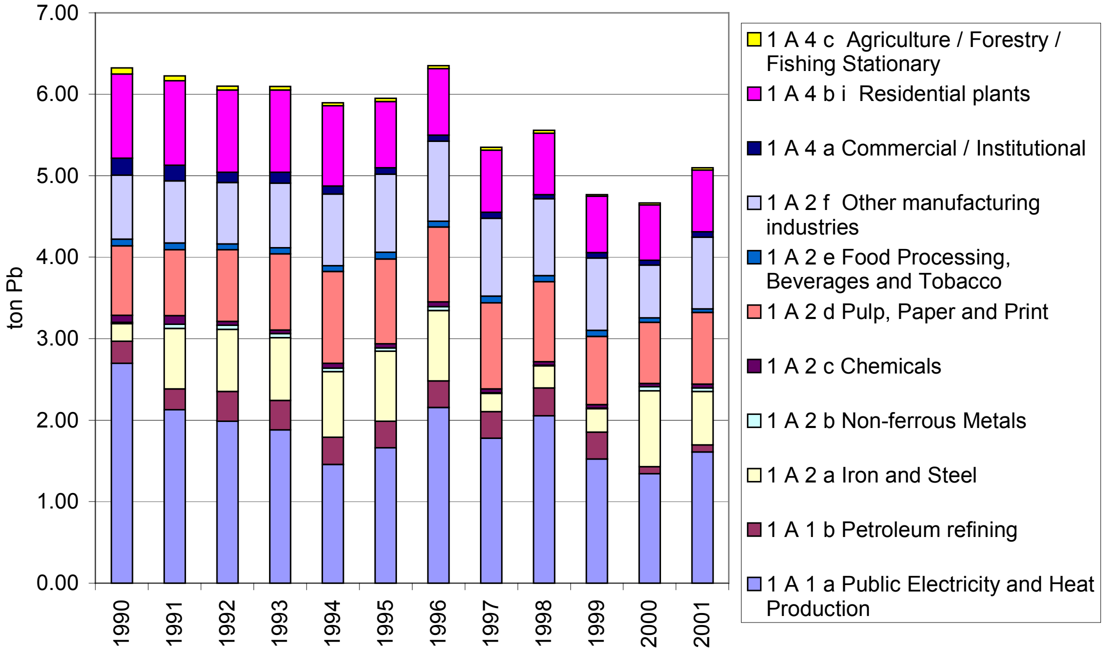

Figure 7.15 Emissions of Lead (Pb) from stationary combustion 1990-2001 (ton).

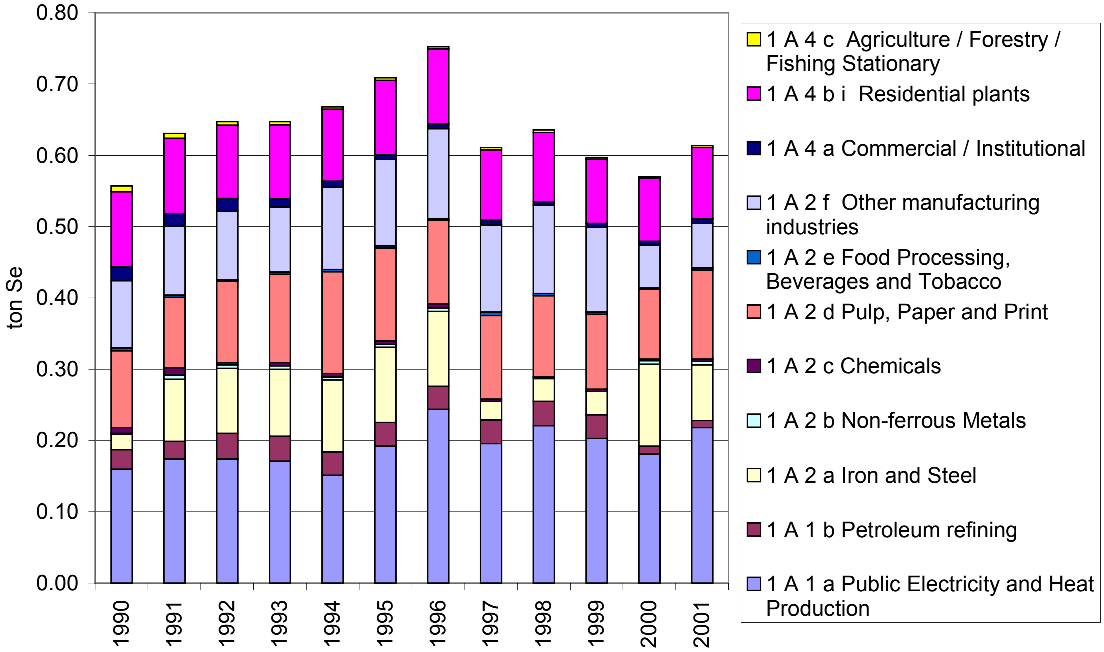

Figure 7.16 Emissions of Selenium (Se) from stationary combustion 1990-2001 (ton).

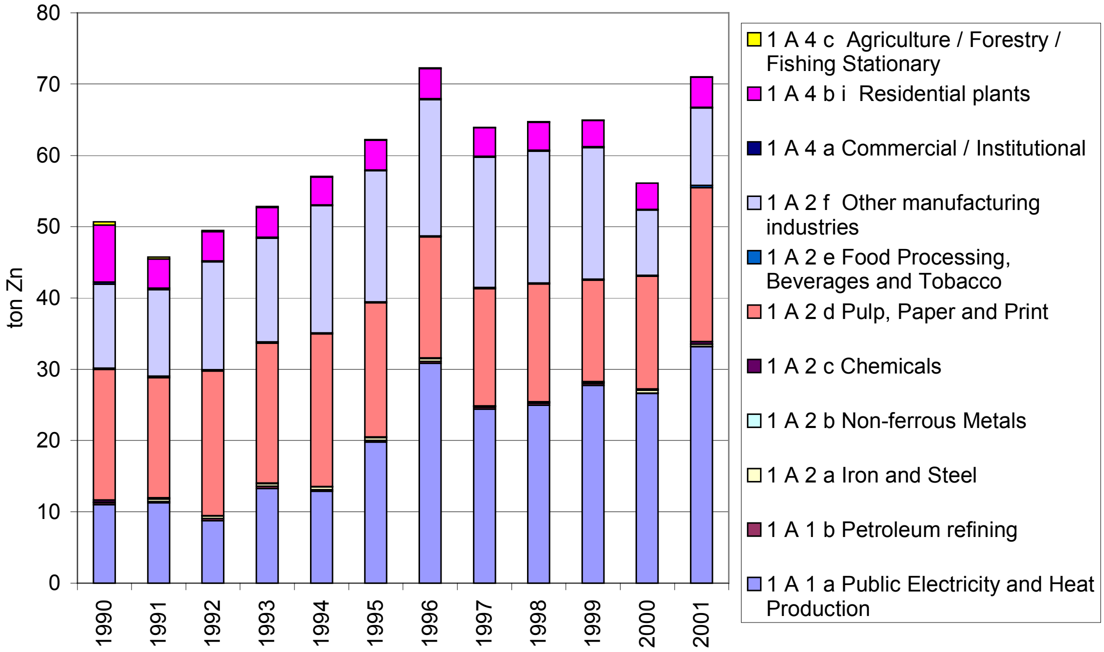

Figure 7.17 Emissions of Zinc (Zn) from stationary combustion 1990-2001 (ton).

7.6. Dioxin emissions from stationary combustion

Estimated emissions of dioxins from stationary combustion, 1985-2001, are presented in Figure 7.18. The dominant source of dioxin emissions during the 1980´s was municipal waste incineration (NFR1A1a), and large changes are known to have occurred (Ahlgren and Marklund, 2001). Reliable data are available for 1985 and then from the beginning of the 1990´s (Table 7.7). Even though the energy statistics for other fuels is not really good enough for the 1980´s, calculated emissions are presented here, together with calculated dioxin emissions from municipal solid waste incineration. Emissions have thus decreased substantially from 1985-2001, primarily due to improved abatement measures.

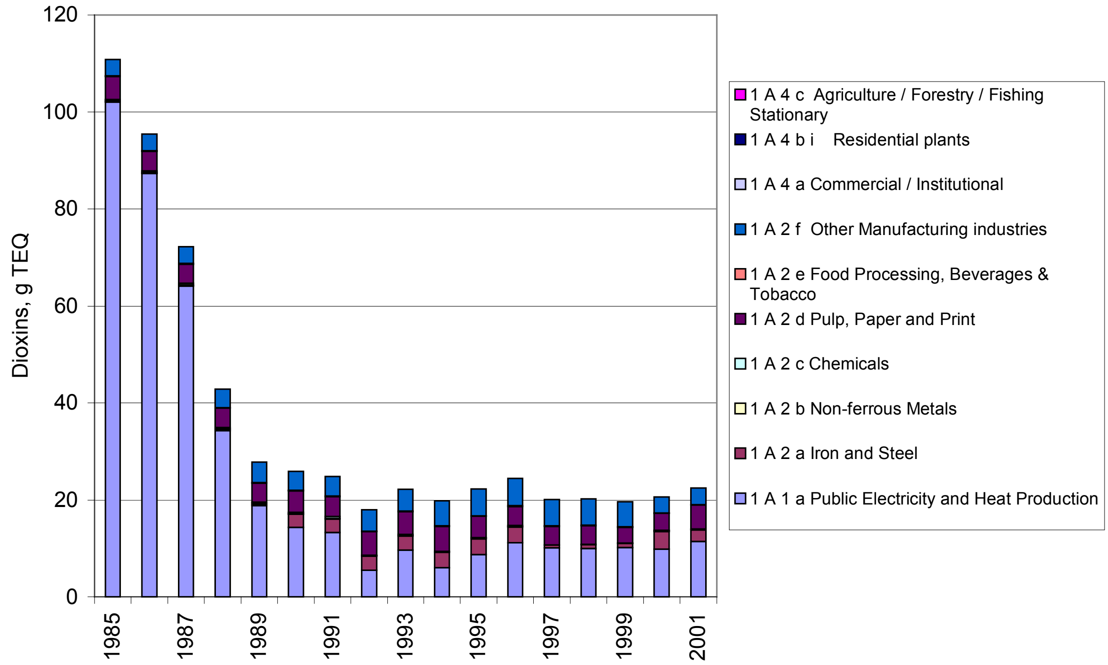

Figure 7.18 Emissions of dioxins from stationary combustion, 1985-2001. 1A1a is dominated by municipal waste incineration.

Calculated emissions from public electricity and heat production in large combustion plants include separate estimates for the different fuels used. Regarding dioxin emissions the use of biomass, municipal waste and coal as fuels are the most important sources. These are discussed separately below.

7.6.1. Dioxin emissions from large-scale biomass combustion (NFR 1A1a)

Biomass plants for energy and heat production became important during the 1990´s, and have replaced most of the oil combustion previously used for this purpose. There are a large number of such plants in Sweden, but the use of flue gas cleaning techniques is not consistent. Abatement techniques to control particle emissions have been commonly used for a longer period of time, while flue gas condensation has become more common in later years. Flue gas condensation may highly influence the emissions of dioxins to air. Furthermore, biomass is sometimes combusted together with other fuels. Table 7.5 presents an inventory of emission factors for this category. Values from 0.00055 to 0.55 ng TEQ/MJ are obtained, excluding two high outliers that probably are not representative for the average biomass. The influence of e.g. refuse derived fuels (RDF) or demolition waste on the emissions of dioxins is apparent, as is the role of flue gas cleaning.

There are very few Swedish plants that report dioxin emissions. One large plant reports emissions that can be translated to an emission factor of 0.02 µg/ton =0.0011 ng/MJ, if it is assumed that the oil that is co-combusted does not contribute to the dioxins.

Clearly it is difficult to select a single emission factor that accounts for the variability of the Swedish biomass plants. The emission factors used in the calculations are 0.11 ng/MJ for large combustion plants.

Table 7.5. Dioxin emission factors from biomass combustion plants.

Fuel type	ng TEQ/MJ	µg TEQ /ton	Reference
Wood chips	ca 0		Thunell (1998)
Wood chips/RDF	0.03		Thunell (1998)
Peat	ca 0		Thunell (1998)
Peat/RDF	0.01		Thunell (1998)
New wood	0.002-0.5	0.036-9	Thunell (1998)
Demolition waste	9	160	Thunell (1998)
Demolition waste with SNCR	0.02	0.36	Thunell (1998)
Straw with no flue gas cleaning	0.5	9	Thunell (1998)
Swedish plant	0.0011	0.02	Environmental report
Wood fired power boilers	2.8	50	UNEP (2001)
Wood, with flue gas cleaning	0.00055-0.28	0.01-5	Hansen (2000)
Wood, without flue gas cleaning	0.01-0.55	0.2-10	Hansen (2000)

7.6.2. Dioxin emissions from residential wood stoves

This is an important category according to the previous Swedish inventory (de Wit, unpubl.). However, this is also a very diverse category, both in terms of combustion conditions and fuel composition. Emission factors from literature are compiled in Table 7.6.

The quality of the fuel is a parameter of major significance. It is assumed that most wood stoves in Sweden are fired with local wood, i.e. uncontaminated wood. Emission factors chosen in the calculations were 0.07 ng/MJ for the 1980´s and 0.05 ng/MJ for 1990-2001.

Table 7.6 Dioxin emission factors for small scale wood combustion.

Fuel type	Emission factor (µg TEQ/ton)	Emissionfactor (ng TEQ/MJ)*	Source	Original reference
hardwood & softwood	1.9	0.13	Hansen (2000)	Hansen et al.- 94
birch	5.1	0.34	Hansen (2000)	DK-Teknik 2000
excess wood from manufacturing	1.7	0.11	Hansen (2000)	DK-Teknik 2000
Virgin wood/biomass fired stoves	100	6.7	UNEP (2001)	
	0.13-0.3	0.01-0.02	Hansen (2000)	De Wit (1993) unpubl.
clean wood	1	0.07	EDI	average of several investigations
contaminated wood but no PCP	50	3.3	EDI	average of several investigations
wood contaminated with PCP	500	33.3	EDI	average of several investigations
90% clean wood; 10% slightly contaminated wood	5.9	0.39	Finstad et al. (2001)	EDI
birch		0.02-0.05	Åkesson (1988)	

* The emission factors expressed as ng TEQ/MJ have been calculated by SMED assuming an energy value of 15 MJ/kg wood.

7.6.3. Dioxin emissions from large-scale municipal waste incineration (NFR 1A1a)

A detailed historical review of waste combustion and dioxins in Sweden is presented in a recent report (Ahlgren och Marklund, 2001). The importance of combustion as a means of treating waste has increased during the past 30 years in Sweden. There are at present 22 facilities where municipal waste is incinerated and energy is gained. During the 1980´s, there were 27 facilities, seven of which were closed in the late 1980´s, as a result of stricter environmental legislation. During the mid 1990´s, waste combustion was responsible for ca. 10% of the Swedish district heating (Ahlgren and Marklund, 2001). In most of these 22 facilities, municipal waste is combusted together with waste from various industries. Industrial waste has increased in importance during the last few years.

Dioxin emissions from this source category are represented by measurements at the individual facilities. Data have been compiled for most years from 1985 to 1999 and supplied by RVF - The Swedish Association of Waste Management. Although the activity has increased over time, emissions decreased strongly between 1985 and the early 1990´s as a result of technological improvements (Table 7.7).

Table 7.7 Dioxin emissions to air from municipal waste incineration.

Year	Emissions (Eadon TEQ g/yr)	Emission factor (ng/MJ)	Activity (MWh)
1985	90	8.3	3.0
1991	8	0.55	4.0
1993	3.8	0.25	4.3
1994	1.7	0.11	4.4
1995	2.2	0.12	5.0
1996	2.0	0.11	5.1
1997	3.0	0.15	5.7
1998	3.0	0.12	7.1
1999	2.8	0.12	6.4

In the reported national emissions, as presented in Figure 7.18, the emissions given in Table 7.7 were not used directly as input data, but calculated from emission factors and the energy statistics. This was done in order to keep the consistency with calculations of other emitted substances. Emission factors used were adjusted to comply with the emissions in Table 7.7 and to the energy statistics. The emission factors for municipal waste combustion for the source sector "Public electricity and heat production", range from 8.3 ng/MJ in 1985 to 0.12 ng/MJ in 2001. The emissions from municipal waste incineration obviously contribute to the larger share of dioxin emissions from this source category.

7.6.4. Dioxin emissions from large-scale coal combustion (NFR 1A1a)

During 1998, ca 3.4 millions ton coal was used in Sweden, mainly in industrial processes such as steel production. Energy production accounted for 0.72 millions ton. Emission of dioxins is strongly dependent on the type of flue gas cleaning used. Emission factors for energy production of coal has been reported as in Table 7.8. There is obviously a wide range and poor specifications of the technical details. Using 0.033 and 0.4 µg/ton (1.2 pg to 14.5 pg/MJ) gives total emissions of 0.024 to 0.29 g TEQ during 1998. Clearly, this category can at most be of minor significance for the total Swedish emissions. In the emission estimations an emission factor of 0.1 ng/MJ was used for the whole time period, 1985-2001. Available data are uncertain, and we chose rather to apply a somewhat higher emission factor. This does, however, not influence the total emissions in any way.

Table 7.8 Emission factors for dioxins for coal combustion in energy and heat production.

Operation details	Reference	Emission factor ng TEQ /MJ
Coal powder > 50 MW	Thunell (1998)	<0.04
Coal powder, energy	Thunell (1998)	0.005
Modern coal combustion plant	Hansen (2000)	0.001
Not specified	UNEP (2001)	0.01
Not specified	Finstad et al. (2002)	0.01

7.7. PAH emissions from stationary sources

Estimated emissions of PAH-4 from stationary sources in the Energy sector are presented in Figure 7.19. The dominant source is combustion in residential homes. Other important sources are combustion in the pulp and paper industry and coke production (Figure 7.20). In the early 1990´s PAH emissions from combustion in the pulp and paper industry declined due to improved abatement techniques as well as improved combustion techniques. Another important source is coke production. Below some of the sources are described in more detail.

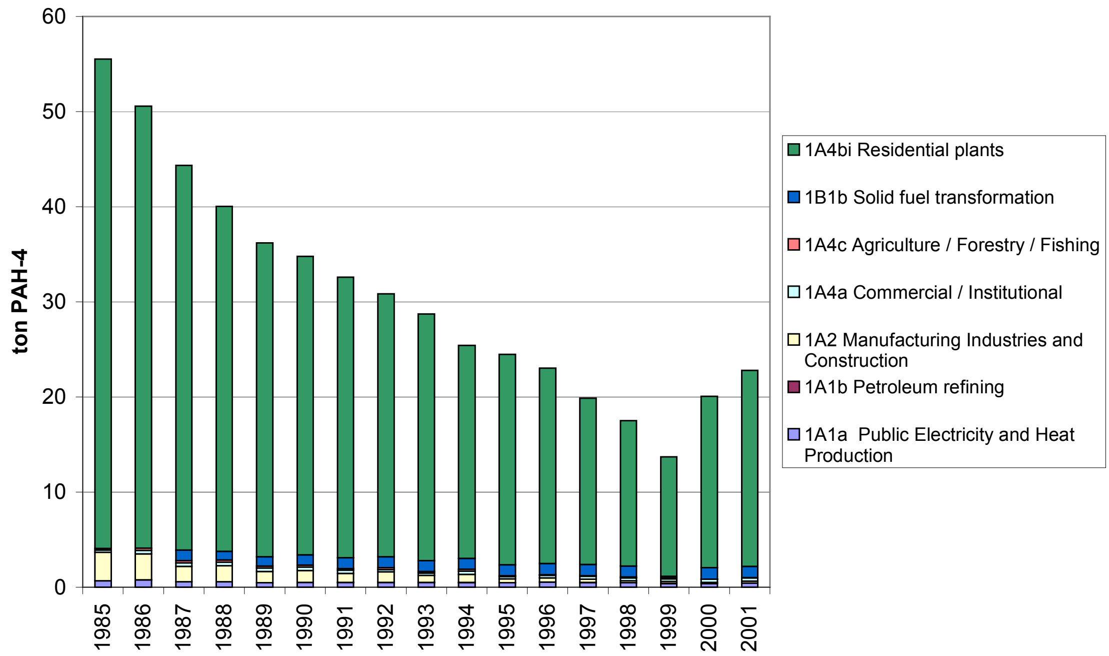

Figure 7.19 Estimated emissions of PAH-4 (ton) from stationary sources 1985-2001.

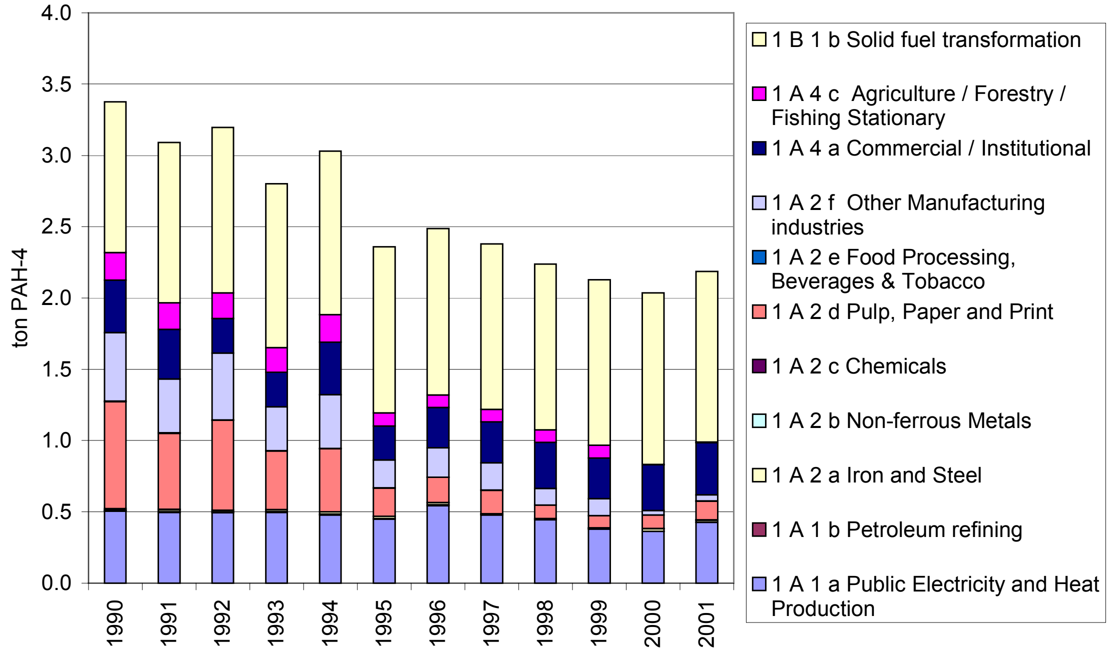

Figure 7.20 Emissions of PAH-4- from stationary sources, except residential combustion, 1990-2001.

7.7.1. PAH emissions from large-scale biomass combustion

A recent emission study of PAH from industrial wood combustion was performed by AEA technology in the UK (Thistlethwaite, 2001). The obtained emission factors are up to 19 000 times lower than the suggested factors in EEA (2001), and also profiles differ. The uncertainty in the factors was estimated to be 32 %, based on the variability between the measurements. Large-scale industrial wood burning thus seems to cause much less PAH emissions than small-scale wood combustion, as may be expected. Adopting the emission factors by Thistlethwaite (2001), generates emissions, which are a factor of 10 000 lower than the emissions obtained when adopting the factors from measurement results from the mid 1980´s (IVL, 2002) see Figure 7.21. As a worst case scenario for Swedish conditions, we have adopted the higher emission factors (100, 130, 30 and 55 µg/MJ for BaP, BbF, BkF and Ind respectively), resulting in PAH-4 emissions to air of about **200 kg/year** from large-scale combustion. Although these factors result in much higher emissions than obtained if the British numbers are used, the PAH-4 emissions derived from large-scale combustion are still a factor of 100 lower compared to the contribution from small-scale burning on a national level.

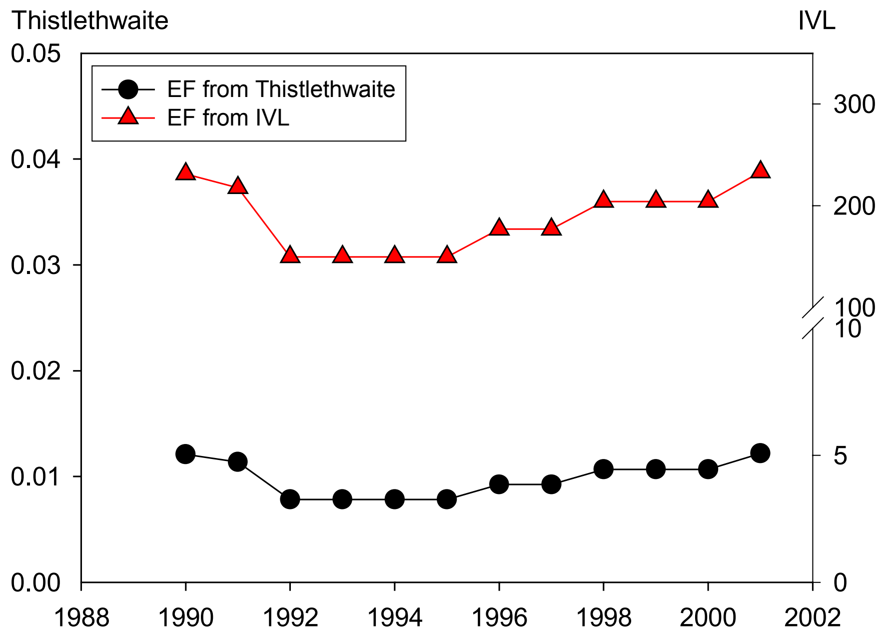

Figure 7.21 Emissions of PAH-4 from large-scale wood combustion (kg) calculated with emission factors from Swedish measurement results (IVL, 2002) and from Thistlethwaite (2001). Observe the different scales on the y-axes. The axis on the right represents the emissions based on emission factors derived from Swedish measurement results (IVL, 2002), and the left axis emission factors from Thistlethwaite (2001)

7.7.2. PAH emissions from small-scale wood combustion

PAH emissions from small-scale wood burning have been investigated in several studies (e.g. references cited in Table 7.9). Few of these, however, specify emissions of the four substances prioritised in the UN ECE protocol. EEA (2001) provides default emission factors for these four substances both from residential and industrial wood combustion. It is pointed out, however, that regional differences might occur, and that the emissions are strongly dependent on the combustion technology and the composition and humidity of the fuel. Thus, locally derived emission factors are likely to be more accurate.

Emission factors for individual PAH from small-scale wood burning in Scandinavia have been reported previously (Rudling et al., 1980; Hansen, 1991; see Table 7.9). Hansen (1991) studied the emissions of 15 PAH, and values for 4 PAH were calculated from the outcome of that study, combined with profiles obtained from USEPA (USEPA, 1998; Haakonsen & Kvingedal, 2001). The resulting emission factor concerns the sum of the four substances, these were not separated.

Emissions of individual PAHs from different wood-fired household furnaces have recently been measured within an on-going project (IVL, 2002, BHM Biofuel Health and Environment). Table 7.9 shows average emission factors obtained for pellets and wood. This study is considered to be the most updated and relevant for Swedish conditions, and the obtained emission factors are thus used in this inventory for later years. As wood is still the more dominating fuel type for small-scale residential heating when compared to pellets, emission factors for wood furnaces are used in the inventory. Emission factors for PAH-4 used range from 1 mg/MJ in the mid 1980´s to 0.325

mg/MJ in 2001. The annual emissions to air of PAH-4 from small-scale wood combustion are estimated to be about 13 tonnes during later years (Figure 7.19).

Table 7.9 Emission factors for PAH from small-scale wood combustion as obtained in previous studies.

	EEA, 2001		Rudling et al., 1980	Hansen, 1991		IVL, 2002	
						Pellets[1]	**Wood[2]**
	mg/ton	µg/MJ	µg/MJ	mg/ton	µg/MJ	µg/MJ	µg/MJ
BaP	1300	68.4	21			16	110
BbF	520	27.4	22			21	30
BkF	1560	82.1	7			6.8	130
Ind	130	6.8	9			1.2	55
Sum 4			59	2700	142	45	325

[1] Average of 8 samples. Detection limits have been used in the calculation of the average if the substance was not detected.
[2]Average of four samples.

7.7.3. PAH emissions from large-scale municipal waste incineration

The Emission Inventory Guidebook (EEA, 2001), states that municipal waste incineration is unlikely to be a large source for PAH emissions. USEPA (1998) specifies emission factors from this source category only for one PAH, namely naphthalene. In Sweden, emissions of PAH from municipal waste incineration plants have been reported to be insignificant (ENA, Energi ur Avfall, Energy from Waste, 1980´s), thus we consider this source as being negligible. Calculations were however included in the national estimates, where the emission factors for PAH-4 assigned were 4.2 µg/MJ for the 1980´s and 1 µg/MJ 1990-2001.

7.7.4. PAH emissions from large-scale coal combustion

Coal combustion is relatively limited in Sweden today, and mainly occurs in industrial processes. Emission factors for large, small and coal combustion plants of unknown size are given in EEA (2001) and USEPA has specified emissions from so-called stokers (see Table 7.10). As shown in the table, the emission factors vary considerably. Adopting the emission factors from EEA (2001) for facilities of unknown size results in total emissions of **4.9 g** PAH-4. An emission factor for PAH-4 of 0.5 µg/MJ was chosen in the inventory.

Table 7.10 Emission factors of individual PAH substances from coal combustion

Substance	*EEA (2001) large plant*		*EEA (2001) small plant*		*EEA (2001) unknown size*		*U.S. EPA (1998) "stoker"*	
	mg/ton	mg/MJ	mg/ton	mg/MJ	mg/ton	mg/MJ	mg/ton	mg/MJ
BaP	0.14	6.6×10^{-6}	1550	7.3×10^{-2}	775	3.6×10^{-2}	23	1.1×10^{-3}
BbF	0.007	3.3×10^{-7}	77.5	3.6×10^{-3}	38.75	1.8×10^{-3}		
BkF	0.0014	6.6×10^{-8}	15.5	7.3×10^{-4}	7.75	3.6×10^{-4}		
Ind	0.112	5.3×10^{-6}	1240	5.8×10^{-2}	620	2.9×10^{-2}	0.00062	2.9×10^{-8}

7.7.5. PAH emissions from small-scale coal combustion

Coal is not used for residential heating in Sweden. Thus, the small-scale coal combustion mainly consists of activities such as barbecuing using charcoal and charcoal briquettes. This is further discussed in Chapter 12.2.

7.7.6. PAH emissions from coke production (NFR 1B1b)

Emissions of PAH from coke production at integrated iron and steel plants, including quenching and extinction, have been calculated based on production statistics and emission factors derived from USEPA (1998). Separate emission factors for quenching and extinction, as given in Table 7.11. were used in the calculations. Total estimated emissions for the time period 1987-2001 are presented in Table 7.12, together with the annual production statistics. Production data was only available from 1987.

Table 7.11 Emission factors for PAH-species (mg/ton) for coke production (USEPA, 1998).

	BaP	BbF	BkF	Ind	Unit
Extinction	320	78	0	3.3	mg/ton
Quenching	170	210	150	81	mg/ton

Table 7.12 Coke production and estimated PAH emissions

Year	Production (kton)	Benzo(a)pyrene (ton)	Benzo(b)fluo-ranthene (ton)	Benzo(k)fluo-ranthene (ton)	Indeno(1,2,3-cd)pyrene (ton)	Sum PAH-4 (ton)
1987	1105	0.541	0.318	0.166	0.093	1.12
1988	893	0.438	0.257	0.134	0.075	0.90
1989	976	0.479	0.281	0.146	0.082	0.99
1990	1044	0.512	0.301	0.157	0.088	1.06
1991	1112	0.545	0.320	0.167	0.094	1.12
1992	1146	0.562	0.330	0.172	0.097	1.16
1993	1137	0.557	0.327	0.171	0.096	1.15
1994	1134	0.556	0.327	0.170	0.096	1.15
1995	1149	0.563	0.331	0.172	0.097	1.16
1996	1153	0.565	0.332	0.173	0.097	1.17
1997	1147	0.562	0.330	0.172	0.097	1.16
1998	1148	0.563	0.331	0.172	0.097	1.16
1999	1146	0.561	0.330	0.172	0.097	1.16
2000	1187	0.582	0.342	0.178	0.100	1.20
2001	1185	0.581	0.341	0.178	0.100	1.20

8. Mobile sources (NFR 1)

When estimating the emissions from mobile sources, emissions from combustion of fuels, as well as emissions from road abrasion and tyre and brake wear were considered. The estimated emissions from road abrasion and tyre and brake wear includes only road traffic, while emissions from combustion of fuels include road traffic, national shipping, civil aviation, railway and off-road machinery.

Emissions of particles, metals and dioxins from mobile sources were covered in the estimates. For road traffic, a national model, EMV, was used to calculate emissions of particles. The model is further described in chapter 8.2.1. Concerning PAH, the available information was so diverse regarding emission factors that no actual estimates were made. PAH-emissions from mobile sources is, however, assumed to be a significant source, why results from rough estimates of PAH emissions, based on different sets of emissions factors, have been made and are presented and discussed below.

According to the estimates of particle emissions from mobile sources the dominant and increasing source of larger particles, TSP and PM_{10}, is road abrasion and tyre and brake wear. For small particles, $PM_{2.5}$, the level of emissions from combustion of fuels exceeded the emissions from road abrasion and tyre and brake wear in earlier years, but because of cleaner exhaust in combination with an increase in VMT, vehicle miles travelled, the levels of emissions have become more equal in later years (Figure 8.1).

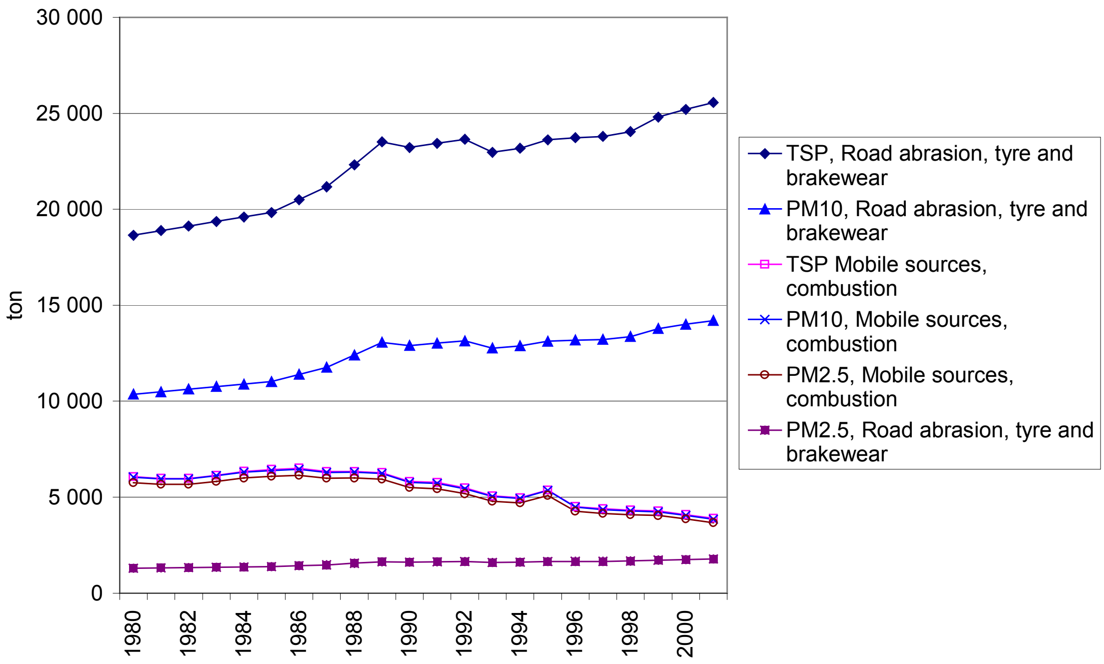

Figure 8.1 Emissions of particles from mobile sources (ton). Emissions from combustion of fuels are a sum of road traffic, national shipping, railways and civil aviation.

8.1. Activity data for fuel consumption of 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.

8.1.1. 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.

8.1.2. 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 8.1. 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 8.2.

Table 8.1 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

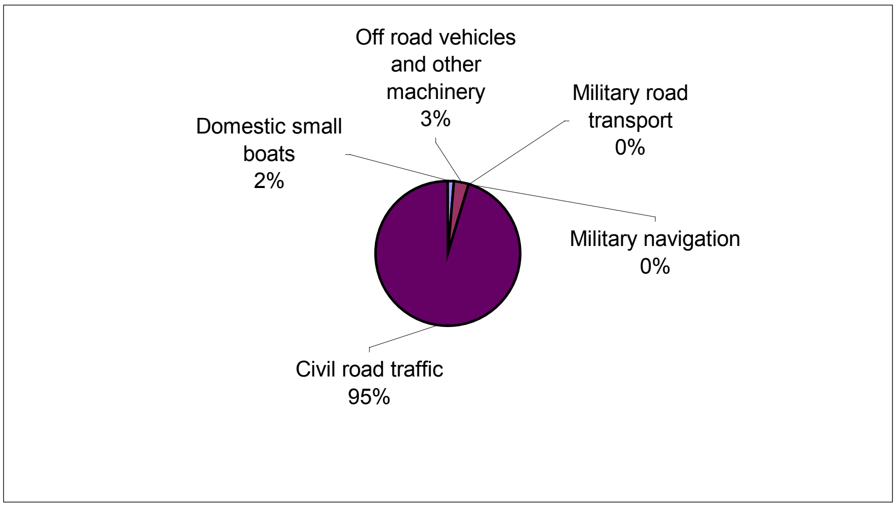

Figure 8.2 Approximate distribution of delivered amount of gasoline.

The allocation of gasoline consumption for off-road vehicles and working machinery in different sectors (Agriculture, Forestry, Residential, Industrial and Other), Table 8.2, is based on Andersson (2000), a Swedish EPA internal report, in turn based on Persson and Kindbom (1999).

Table 8.2 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 8.2.

8.1.3. 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 8.3.

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 8.3).

Table 8.3 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. Hence, the correction has been excluded in the submission of 2003, see Figure 8.3.

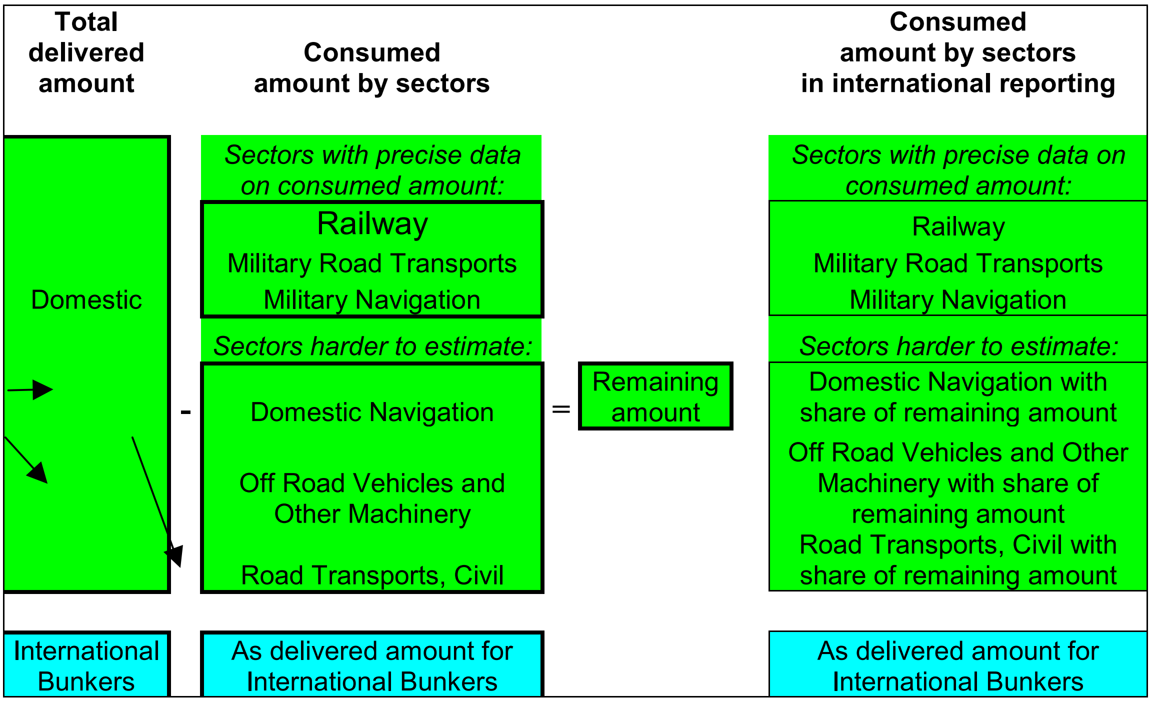

Figure 8.3 Current model for allocating delivered amount of diesel on subgroups without correction for private storing.

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 8.4.

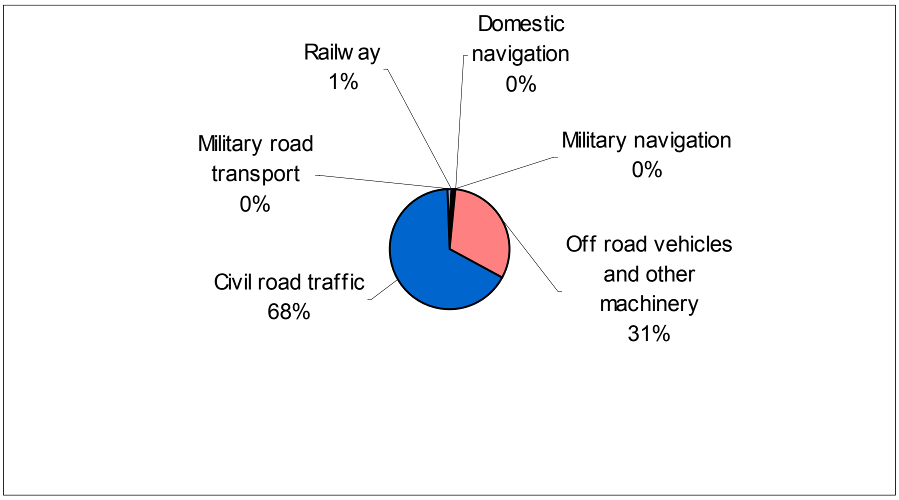

Figure 8.4 Approximate distribution of delivered amount of diesel oil.

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 8.4.

Table 8.4 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 8.2.

8.2. Emissions from combustion of fuels in mobile sources (NFR 1A3)

8.2.1. Particle emissions from mobile sources, combustion of fuels

Total estimated emissions of particles (TSP) from combustion of fuels in mobile sources are presented in Figure 8.5. 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). Combustion of fuels within railway traffic and civil aviation are only minor sources to particle emissions.

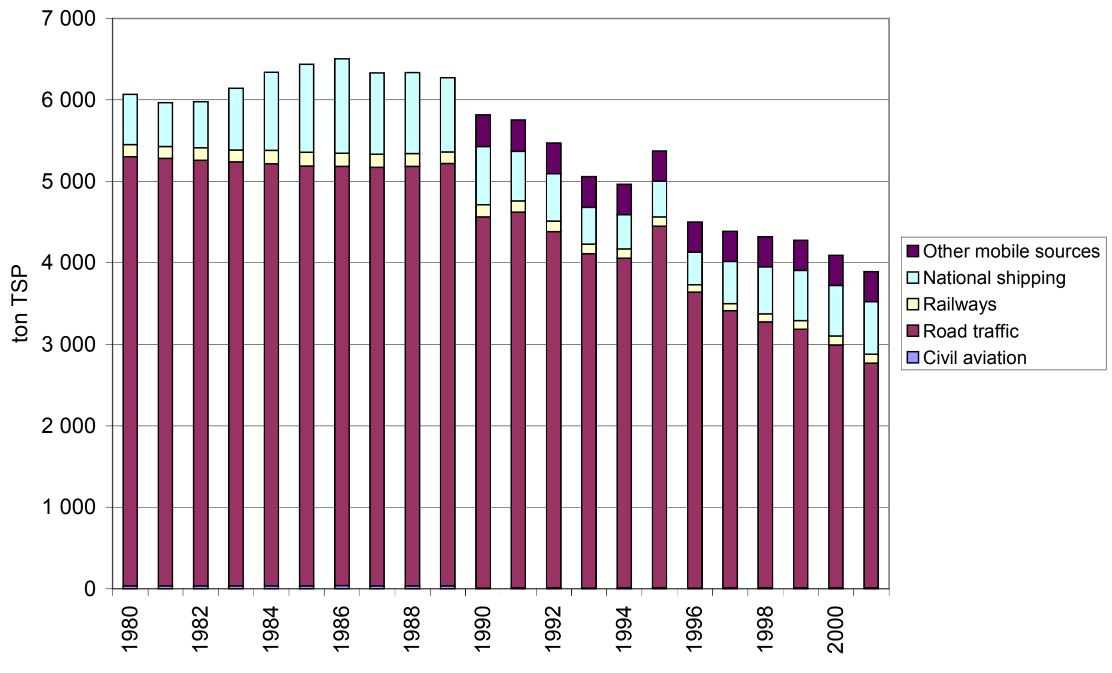

Figure 8.5 Emissions of TSP from combustion of fuels in mobile sources.

Particles from road traffic, combustion of fuels

Reported emissions by the Swedish EPA 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 does 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 8.5.

Table 8.5 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, U and Karlsson, B (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.

Data for emissions of particles from combustion of fuels in road traffic are based on calculations in the EMV-model and have only been separated into sub-sectors, i.e. passenger cars, busses etc., and not down to the level of fuel type and region (urban and country). Data for the years 1980, 1985, 1987-2001 was available, remaining years were calculated by interpolation. The model produces estimates of PM. In order to calculate emissions of PM_{10} and $PM_{2.5}$ particle size partitioning was made in the calculations, where PM_{10} was assumed to equal 100% of calculated TSP emissions and $PM_{2.5}$ 95% (Sjödin and Ekström, pers. comm). In the CEPMEIP-project, all particles are assumed to be $PM_{2.5}$.

For metals, only emissions of Pb from the use of gasoline for road traffic are reported, as estimated by the EMV model.

Military use, combustion of fuels

Emissions of particles 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 particles from military navigation have only been calculated for diesel the years 1990-2001 due to lack of information on the 80's. Because insignificant amount of consumed gasoline is reported as military navigation, its emissions of particles have not been compiled.

Particle emissions from civil aviation (NFR 1A3a)

Swedish Civil Aviation Administration (SCAA) calculates emissions from aviation based on number of flights (domestic and international), type of airplanes, amount of fuel needed for different flights and emissions per substance 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. However, emissions of particles are not included in SCAA's calculations.

Emissions of particles were estimated using delivered amount of fuel from EN31SM, Statistics Sweden and SCAA's information of group, together with emission factors suggested in the CEPMEIP-project (Table 8.6).

Table 8.6 Emission factors for particles from civil aviation

		TSP (g/GJ)	PM_{10} (g/GJ)	$PM_{2.5}$ (g/GJ)	Reference
Domestic air transport	Gasoline	10	10	10	CEPMEIP
Domestic air transport	Kerosene	1.16	1.16	1.16	CEPMEIP

Estimated emissions of particles are based on both civil and military aviation and reported under civil aviation for the eighties, since separation of civil and military use of fuel was not available. Emissions of particles from civil and military aviation for the whole time period 1990-2001 has been underestimated due to miscalculations and will be revised in the near future.

Particle emissions from railway traffic (NFR 1A3c)

Emissions of particles are calculated based on activity data from the Swedish Institute for Transport and Communication (1999) for the eighties and from the National Rail Administration for the nineties. The emission factors for particles are assumed to be constant for the whole period.

Emission factor for TSP is a default emission factor from the CORINAIR Atmospheric Emission Inventory Guidebook. The size distribution of particulate emissions has been calculated according to the CEPMEIP study (Table 8.7).

Table 8.7 Emission factors for particles for railway traffic.

Fuel	Emission factor TSP (EEA, 2001)	**Fraction PM_{10}**	**Fraction $PM_{2.5}$**	**unit**
Diesel	0.106	95%	90%	ton/TJ

Particle emissions from national 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 8.8. Emissions from fuels that are bought in Sweden and used abroad are reported separately as international bunker emissions.

Table 8.8 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 particles from small gasoline engine boats have been estimated with the assumption that they generate the same amount of emissions per energy unit as those estimated for gasoline Off Road Vehicles and Working Machinery for households. These emission factors were derived from estimated particle emissions in Persson and Kindbom (1999) and allocated amount of gasoline.

Emission factors used for estimating emissions of TSP, PM_{10} and $PM_{2.5}$ from the use of heavy oil are from the CEPMEIP study. For diesel use, emission factors for TSP was derived from measurement results within a recently reported European project (Whall et al 2002), while the relations of particle sizes were calculated as suggested in the CEPMEIP project. The same emission factors have been used for the whole time period 1980-2001 (Table 8.9).

Table 8.9 Emission factors for for particles from navigation

Fuel	Emission factor TSP	Emission factor PM_{10}	Emission factor $PM_{2.5}$	unit
Heavy oil	146.3	139.0	132.1	g/GJ
Diesel and EO1	33.6	32.0	30.4	g/GJ

Particle emissions from off-road machinery (NFR 1A3e)

Emissions of particles from off-road vehicles and machinery have been estimated in national studies (Persson and Kindbom, 1999, ÅF Industriteknik AB, 1990, 3K Engineering AB, 1989, Andersson, 2000). Information on the total emissions of TSP for diesel are available for the years 1990, 1995, 1997, 2000 and 2001, and for gasoline 1995, 1997, 2000 and 2001. For gasoline the same emission value was assigned for 1990 as was available for 1995. A linear interpolation has been made for missing years. The assumed distribution of emissions of particles between the different sectors of off-raod machinery has been performed according to Andersson (2000).

The size distribution of particles as TSP, PM_{10} and $PM_{2.5}$ was made according to the relations given in the CEPMEIP study for gasoline and diesel use respectively (Table 8.10).

Table 8.10 Particle size relations from the CEPMEIP study

	TSP	PM_{10}	$PM_{2.5}$
Diesel	100%	95%	90%
Gasoline	100%	100%	100%

8.2.2. Metal emissions from mobile sources, combustion of fuel

The only metal considered in the emissions from combustion of fuels from road traffic is lead (Pb), which formerly was emitted from combustion of leaded gasoline. The Pb-emissions have been calculated with the national EMV model, where the amount of gasoline used is the basis for the estimates. The use of leaded gasoline in Sweden was phased out in 1995 as a result of legisative measures.

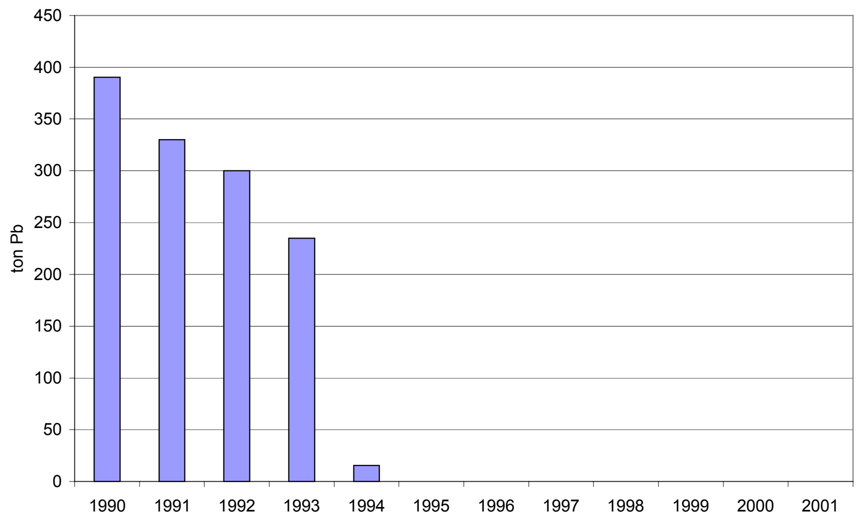

Figure 8.6 Estimated emissions of Lead (Pb) from road traffic combustion of leaded gasoline (ton).

8.2.3. Dioxin emissions from road traffic

Dioxin emission from road traffic is mainly associated with leaded gasoline, although the possible contribution from diesel vehicles appears uncertain. The Swedish phaseout of gasoline lead started in the late 1980´s and was complete in 1994. The total consumption of gasoline and diesel, as well as the fraction of leaded gasoline, was taken from the Swedish EMV model for traffic emissions.

Different emission factors are found in the literature (Table 8.11), the variation of which is not surprising since representative emission measurements are difficult to perform. We have chosen to follow the selection of Finstad et al. (2002). Fuel consumption and the associated emissions are presented in Table 8.12, showing that emissions have declined strongly over the period.

Table 8.11 Emission factors for dioxins from road traffic. Mass units are in g TEQ.

Leaded gasoline	Unleaded gasoline	Diesel	Reference
		0.01-0.023 ng/vkm ≈ ca 0.04-0.07 µg/ton	Gullett och Ryan (2002) *original measurements*
2.2 µg/ton		0.5 µg/ton	UNEP (2001)
0.01-1.1 µg/ton		0.024-0.05 µg/ton	European Dioxin Inventory
2 µg/ton	0.1 µg/ton	0.1 µg/ton	Finstad et al. (2002)

Table 8.12 Fuel consumption and dioxin emissions (g TEQ/yr) from road traffic during 1980-2001.

Year	Leaded gasoline, 10^6 ton	Unleaded gasoline, 10^6 ton	Diesel, 10^6 ton	Dioxin, leaded gasoline	Dioxin, unleaded gasoline	Dioxin, Diesel	Total emission
1980	3.11	0.00	1.27	6.22	0.00	0.13	6.35
1981	3.12	0.00	1.28	6.24	0.00	0.13	6.37
1982	3.13	0.00	1.30	6.26	0.00	0.13	6.39
1983	3.14	0.00	1.31	6.29	0.00	0.13	6.42
1984	2.84	0.32	1.32	5.68	0.03	0.13	5.84
1985	2.85	0.32	1.34	5.71	0.03	0.13	5.87
1986	2.58	0.65	1.36	5.16	0.06	0.14	5.36
1987	2.01	1.34	1.39	4.02	0.13	0.14	4.29
1988	2.10	1.40	1.46	4.19	0.14	0.15	4.48
1989	2.19	1.46	1.56	4.39	0.15	0.16	4.69
1990	1.98	1.62	1.55	3.96	0.16	0.16	4.28
1991	1.81	1.81	1.54	3.62	0.18	0.15	3.96
1992	1.64	2.01	1.55	3.29	0.20	0.15	3.64
1993	0.88	2.65	1.53	1.76	0.26	0.15	2.18
1994	0.00	3.53	1.61	0.00	0.35	0.16	0.51
1995	0.00	3.58	1.65	0.00	0.36	0.17	0.52
1996	0.00	3.58	1.70	0.00	0.36	0.17	0.53
1997	0.00	3.48	1.80	0.00	0.35	0.18	0.53
1998	0.00	3.42	2.13	0.00	0.34	0.21	0.55
1999	0.00	3.42	2.13	0.00	0.34	0.21	0.55
2000	0.00	3.37	2.25	0.00	0.34	0.23	0.56
2001	0.00	3.35	2.33	0.00	0.33	0.23	0.57

8.2.4. PAH emissions from road traffic

Road traffic is often reported to be one of the dominant sources for PAH emissions. SOU (1996:124) states that it is particularly important on a local scale, in urban areas as a potential source for human exposure. Determining the importance of road traffic for emissions of PAH-4 to air on a national scale requires an estimate of the total traffic load combined with emission factors, which relate to the emissions specifically to air. There are, however, several ways to derive emission factors from traffic. Some studies have attempted to derive emissions from various sub-sources such as exhaust, road abrasion, different types of vehicles etc. Ahlbom and Duus (1994) studied the rubber tyre wear in Sweden, and derived emission factors for PAH emissions from tyres. As these factors were based on tyre wear, they reflect the total emissions of PAH to the environment, rather than just emissions to air. As many particles, which are released from tyre wear, are large and heavy, these are likely to remain close to or on the road, instead of being dispersed via the atmosphere. The Swedish National Road Administration uses the so-called TCT-model in order to calculate emissions to air. The TCT-model concerns total PAH and benzo(a)pyrene, and are not specified for the other substances of intererst here. Also, it only includes gaseous PAH and not the particle-bound substances.

Another way to estimate emissions from traffic is to derive emission factors from tunnel studies, where the emission of a certain substance from all passing traffic is measured during a certain period of time. The advantage of this method is that it can provide a general idea of total emissions to air, including road abrasion, tyre and break wear, as well as exhaust emissions from a large variety of vehicles. They are thus useful for rough inventories, where the aim is to get an overall idea of the total emissions from traffic, regardless of vehicle type. Benner et al. (1989) derived emission factors from traffic by measuring emissions from a traffic tunnel in Baltimore and Wingfors et al. (2001) measured emissions of different PAH from traffic in two tunnels in central Gothenburg in the year 2000. The emission factors obtained in these two studies are shown in Table 8.13. A significant change in fuel use occurred in the time period 1994-1995, which led to a considerable change in environmental classes of cars. The change occurred gradually from the early 90's for diesel, whereas there was a distinct change in the turn of 1994/1995 for gasoline (Sjödin, Å. pers. comm.). The recent measurements by Wingfors et al. (2001), are thus likely to be representative for the years from 1995 and onwards, whereas the emission factors from Benner et al. (1989) were adopted for the years 1980-1994. It should be noted that the emission factors here only indicate "warm" emissions, they do not include increased emissions that might occur from e.g. cold starts. The TCT-model does take cold starts into account, but does not specify the emissons of individual substances, apart from BaP.

Table 8.13 Emission factors for PAH from traffic as observed in two different tunnel studies. Units are mg/km.

Substance	*Wingfors et al., 2002*	*Benner et al., 1989*
BaP	$5.70 \times 10^{-4} \pm 4.60 \times 10^{-4}$	2×10^{-3}
BbF	$6.70 \times 10^{-4} \pm 4.10 \times 10^{-4}$	3×10^{-3} (BbF + BkF)
BkF	$5.10 \times 10^{-5} \pm 7.00 \times 10^{-5}$	
Ind	$2.60 \times 10^{-4} \pm 2.20 \times 10^{-4}$	1×10^{-3}

The emissions of PAH-4, which were calculated based on the emission factors given above are presented in Figure 8.7. The sudden shift in emission levels that occurs between 1994/1995 is due to the different emission factors applied (see discussion above). It is likely, however, that this shift occurred more smoothly than indicated here. The annual emissions of BaP from traffic, as calculated by the TCT-model, are about ten times higher (300 kg/year) than the emissions calculated using the emission factors from Wingfors et al. (2001), thus of the same order of magnitude as the emissions based on factors from Benner et al. (1989).

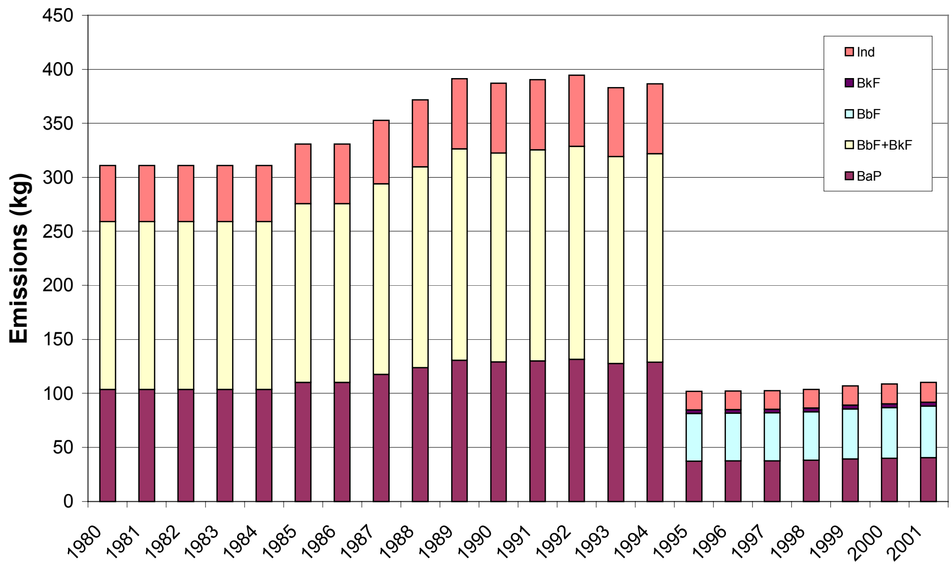

Figure 8.7 Emissions of PAH 4 from traffic calculated by using emission factors from Benner et al. (1989) and Wingfors et al. (2001).

PAH emissions from lawn mowers

Persson and Kindbom (1999) compiled emissions from "work tools" in Sweden. In 1995, the number of riding lawn mowers in use was about 120 000 and the number of walk-behind lawn mowers in use was approximately 1 000 000. The operation time for these varies from 20 h/year for the riding lawn mowers to about 10 h/year for walk-behind models (Persson and Kindbom, 1999). Christensen et al. (2001) measured emissions of PAH from motorised lawn mowers. Two different fuel types were included in the study and both catalytic and non-catalytic lawn mowers were used. According to Klippo, a major lawn mower sales company, approximately 5 % of the lawn mowers sold are equipped with a catalyst (Norén S. pers. comm). All of the lawn mowers may be run on alkyl fuel as well as gasoline. Adopting a worst case scenario, it was assumed that only gasoline was used, which yielded annual PAH-4 emissions of **2 kg**, which can be regarded as negligible when compared to other sources.

8.3. Emissions of particles and metals from road abrasion and tyre and brake wear

Emissions of road transport non-combustion particles have been estimated using emission factors that represent a sum of abrasion from brakes, tyres and the road (Table 8.14). However, these emission factors also include resuspended material, the contribution of which cannot be specified quantitatively with the current knowledge. Emissions of particles and metals have been calculated based on these emission factors and annual total traffic mileage. The activity rate, annual total traffic mileage, is the same total traffic activity rate as used in the EMV model. The emission factors are considered to be quite representative for Swedish urban conditions (Areskoug et al 2003, Sternbeck et al 2001, Sternbeck et al 2002). In Table 8.14 emission factors for TSP, PM_{10} and $PM_{2.5}$ suggested in the CEPMEIP project have been included for comparison. It has not been possible to separate the Swedish data according to those given in the CEPMEIP project, e.g. separate emission factors for tyre wear, brake wear and road abrasion, as well as separate factors for different types of vehicles. In order to make a comparison possible, the CEPMEIP factors have been summed for each vehicle type and weighted according to the CEPMEIP information on travelled mileage/vehicle type. The resulting emission factor for TSP is comparable (Table 8.14) whereas the measured Swedish emission factors for PM_{10} and $PM_{2.5}$ are considerably higher than the CEPMEIP factors.

The emissions of metals from road traffic have been calculated accordingly, using emission factors developed based on information from literature and measurement data from Swedish studies (Sternbeck et al., 2001, Sternbeck et al., 2002). Both Ni and Cr were reported as below detection limit in these studies.

The calculated non-combustion emissions of TSP, PM_{10}, $PM_{2.5}$ and the metals Pb, Cd, Cu and Zn from road traffic for the period 1980-2001 are presented in Table 8.15.

Table 8.14 Emission factors for road abrasion and tyre-and brakewear

Substance	Emission factor mg/vehicle*km	Reference	CEPMEIP, weighted emission factors (see text)
TSP	360	Calculated from Sternbeck et al (2001).	332
PM_{10}	200	Areskoug et. al (2002)	24
$PM_{2.5}$	25	Areskoug et. al (2002)	9
Pb	0.0351	Sternbeck et al (2001 and 2002)	
Cd	0.000244	Sternbeck et al (2001 and 2002)	
Cr	bd*	Sternbeck et al (2001 and 2002)	
Cu	0.147	Sternbeck et al (2001 and 2002)	
Ni	bd*	Sternbeck et al (2001 and 2002)	
Zn	0.205	Sternbeck et al (2001 and 2002)	

*bd, below detection limit at traffic tunnel measurements

Table 8.15 Traffic mileage and estimated emissions of particles and metals from road abrasion and tyre- and brake wear (ton).

Year	Total traffic mileage ($1x10^9$ vehicle*km)	TSP ton	PM_{10} ton	$PM_{2,5}$ ton	Pb ton	Cd ton	Cu ton	Zn ton
1980	51.8	18648	10360	1295	1.82	0.013	7.6	10.6
1985	55.1	19836	11020	1378	1.93	0.013	8.1	11.3
1987	58.8	21168	11760	1470	2.06	0.014	8.6	12.1
1988	62.0	22320	12400	1550	2.18	0.015	9.1	12.7
1989	65.3	23508	13060	1633	2.29	0.016	9.6	13.4
1990	64.5	23220	12900	1613	2.26	0.016	9.5	13.2
1991	65.1	23436	13020	1628	2.29	0.016	9.6	13.3
1992	65.7	23652	13140	1643	2.31	0.016	9.7	13.5
1993	63.8	22968	12760	1595	2.24	0.016	9.4	13.1
1994	64.4	23184	12880	1610	2.26	0.016	9.5	13.2
1995	65.6	23616	13120	1640	2.30	0.016	9.6	13.4
1996	65.9	23724	13180	1648	2.31	0.016	9.7	13.5
1997	66.1	23796	13220	1653	2.32	0.016	9.7	13.6
1998	66.8	24048	13360	1670	2.34	0.016	9.8	13.7
1999	68.9	24804	13780	1723	2.42	0.017	10.1	14.1
2000	70.0	25200	14000	1750	2.46	0.017	10.3	14.4
2001	71.0	25560	14200	1775	2.49	0.017	10.4	14.6

9. Industrial processes (NFR 2)

9.1. Activity data for industrial processes

The compilation of data concerning emissions from industrial processes has mainly been based on information in industrial companies legal Environmental Reports to the environmental authorities, direct contact with companies, trade associations, experts at county administrations and the Swedish EPA. Further information sources are the counties administrative board emissions database (EMIR), older reports on emissions made by the Swedish EPA, 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, as to the number of emitted substances that are reported as an emission figure. The database, 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 1980´s, usually nationwide information from official statistics or trade associations 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 and substances only sparse data have been available, e.g. from older reports or emission data compilations. This is the case especially for the 1980´s. In those cases interpolations have been done and in some cases data from adjoining years have been used.

In some cases emission data and activity data were available from facilities judged to be representative, and in those cases emission factors could be developed and used on a nationwide scale.

9.2. Emissions from industrial processes

Among the sources reported in the industrial processes sector, the largest contribution to particle emissions has been from processes in the pulp- and paper industry. Metal production and the group of activities reported as "mineral products, other" including e.g. sinter and pelletizing plants, construction activites, glass manufacture etc, also contribute significantly. The estimated emissions of TSP from the industrial processes sector are presented in Figure 9.1.

Metal emissions, as well as emissions of dioxins, from the industrial processes sector are dominated by emissions from the activities grouped into "metal production" (Table 9.1, Figure 9.2). Metal production, as reported to UNECE/LRTAP, includes primary and secondary iron and steel production, non-ferrous metal production and aluminium production. PAH-4 from industrial processes almost entirely originates from metal production, i.e. aluminium production. Minor quantities are also emitted from the pulp and paper industry.

Below the method of estimation as well as emissions from each source is described in more detail. The general development for many sources and substances has been of decreasing emissions over the last decade or decades. This is primarily due to more commonly used and improved abatement techniques.

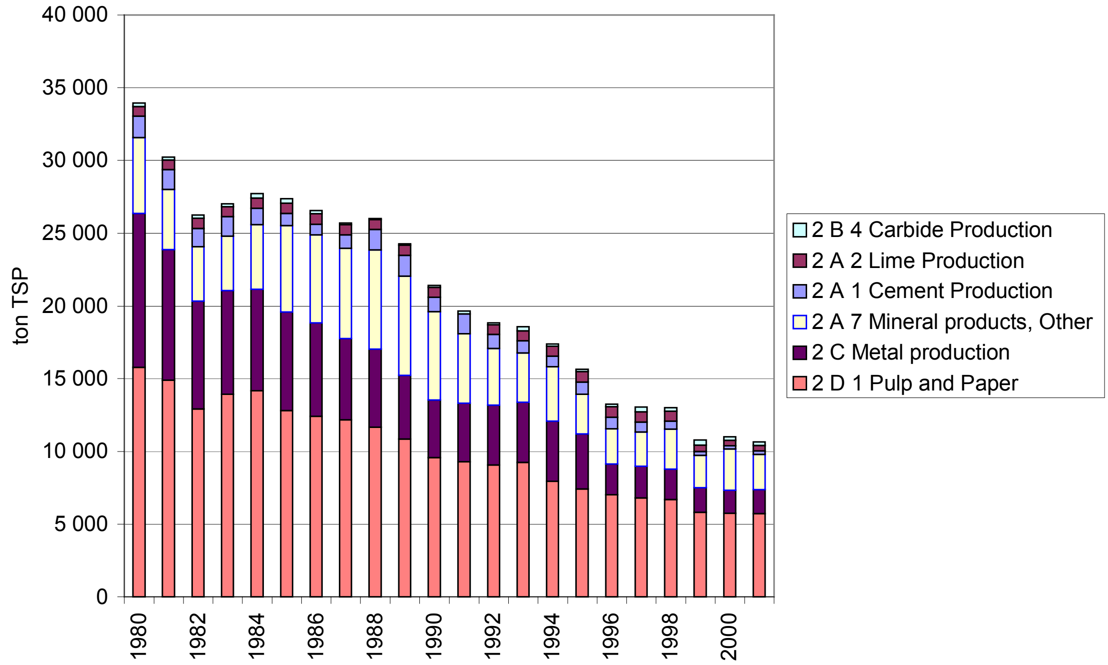

Figure 9.1 Emissions of TSP from industrial processes

Table 9.1 Metal emissions from industrial processes (ton).

	Mineral products	Metal production	Pulp and paper	Mineral products	Metal production	Pulp and paper	Mineral products	Metal production	Pulp and paper	Mineral products	Metal production	Pulp and paper	Chemical industry
		As			Cr			Pb			Hg		
1990	0.2	4.7	0.1	0.2	21	0.2	1.7	73	0.4	0.02	0.46	0.01	0.26
1991	0.3	3.2	0.1	0.2	17	0.2	1.7	57	0.4	0.02	0.33	0.01	0.26
1992	0.1	3.2	0.1	0.2	15	0.2	1.7	45	0.4	<0.1	0.31	0.01	0.25
1993	0.1	1.9	0.1	0.1	15	0.2	1.4	30	0.4	<0.1	0.29	0.01	0.16
1994	0.1	0.7	0.1	0.2	14	0.2	1.2	20	0.4	<0.1	0.28	0.01	0.18
1995	0.1	0.8	0.1	0.1	11	0.2	1.7	14	0.3	<0.1	0.29	0.01	0.13
1996	0.1	0.5	0.1	0.1	9	0.2	1.5	11	0.3	<0.1	0.29	0.01	0.14
1997	0.0	0.6	0.1	0.2	7	0.2	1.7	10	0.3	<0.1	0.26	0.02	0.11
1998	0.3	0.5	0.1	0.1	6	0.2	1.7	9	0.3	<0.1	0.24	0.02	0.14
1999	0.0	0.2	0.1	0.1	5	0.1	2.7	8	0.3	<0.1	0.36	0.02	0.11
2000	0.0	0.2	0.1	0.2	6	0.2	2.9	5	0.3	<0.1	0.27	0.02	0.09
2001	0.0	0.4	0.1	0.1	6	0.2	0.8	6	0.3	<0.1	0.17	0.02	0.07
		Cd			Cu			Ni			Zn		
1990	0.03	1.55	0.09	0.1	21	0.6	1.0	7.3	0.5	0.7	113	0.8	
1991	0.03	1.02	0.09	0.1	18	0.6	0.8	6.2	0.5	1.1	97	0.8	
1992	0.02	0.93	0.09	0.3	26	0.6	0.7	6.9	0.5	1.7	71	0.8	
1993	0.02	0.66	0.09	0.3	16	0.7	0.6	7.4	0.5	0.8	70	0.8	
1994	0.02	0.33	0.08	0.1	6	0.6	0.7	8.2	0.4	0.9	65	0.7	
1995	0.02	0.31	0.07	0.2	6	0.5	0.4	7.8	0.4	0.8	50	0.7	
1996	0.02	0.28	0.07	0.2	6	0.5	0.4	3.0	0.4	1.0	34	0.6	
1997	0.02	0.30	0.07	0.1	7	0.5	0.4	2.3	0.4	0.4	33	0.6	
1998	0.01	0.25	0.07	0.1	56	0.5	0.4	1.7	0.4	0.3	30	0.6	
1999	0.03	0.13	0.06	0.1	3	0.4	0.3	1.1	0.3	0.4	19	0.6	
2000	0.03	0.09	0.07	0.1	2	0.5	0.5	0.8	0.4	0.3	19	0.6	
2001	0.02	0.17	0.07	0.1	2	0.5	0.4	0.7	0.4	0.3	20	0.6	

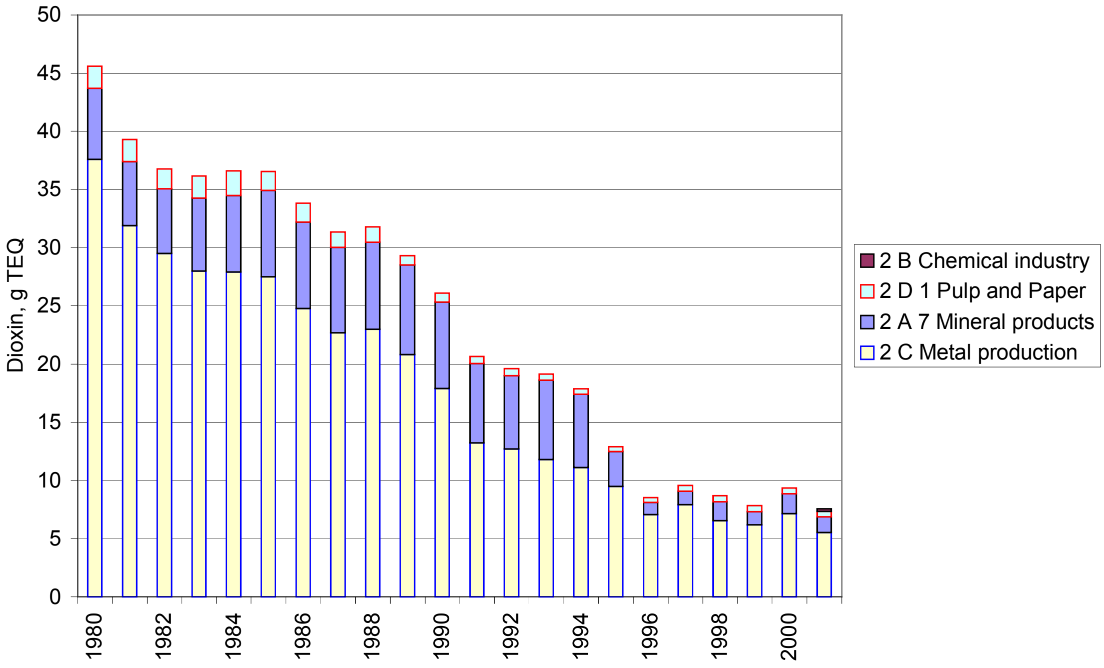

Figure 9.2 Dioxin emission from industrial processes (g TEQ).

9.3. Mineral products (2A)

9.3.1. Particles from cement production (2A1)

Cement production occurs at three facilities in Sweden, of which one is dominating. Emissions of particles have been estimated based on information from the industry. Emissions of heavy metals, PAH-4 and dioxins were calculated based on the energy statistics, since most of these substances originate from the fuels used. These emissions have been allocated to the energy sector and are included in the group called combustion in manufacturing industries.

In order to verify that cement production is not an important source for emissions of PAH-4, measurement data from the major cement industry in Sweden were used to roughly estimate the level of emissions. The results from measured emissions of different PAH substances in 1999 indicated very low emissions of BaP, BbF, BkF and Ind, representing emission factors $<1.4\times10^{-7}$ mg/ton produced cement. For illustrative reasons, we multiplied the activities reported from the cement industry by the emission factors given by the USEPA (1998), which were 3.96×10^{-5}, 2.3×10^{-5} and 8.68×10^{-6} mg/ton for BaP, BkF and Ind respectively. The results confirmed that PAH-4 emissions from cement production are likely to be negligible in Sweden, ($<2\times10^{-4}$ kg).

Emissions of TSP, PM_{10} and $PM_{2.5}$ were estimated for the time period 1980-2001 (Table 9.2, Figure 9.3). The activity data for all facilities are known. Emission factors for TSP were developed, based on information on TSP-emissions from two of the facilities. These emission factors were then used to calculate the emissions from the third facility. The particle size distribution of the emissions, the fractions of PM_{10} and $PM_{2.5}$, was done by expert judgement, based on a few measurement results and knowledge about abatement techniques installed.

Table 9.2 Annual production of cement (kton), emissions of TSP, PM_{10} and $PM_{2.5}$ (ton), calculated emission factor for TSP (kg/ton) and fraction of PM_{10} and $PM_{2.5}$ in relation to TSP.

Year	Production ton cement	Emissions TSP ton	Emissions PM_{10} ton	Emissions $PM_{2.5}$ ton	EF TSP kg/ton	Fraction PM_{10}/TSP	Fraction $PM_{2.5}$/TSP
1980	2528000	1459	1167	948	0.58	0.80	0.65
1981	2700000	1364	1091	886	0.51	0.80	0.65
1982	2450000	1271	1017	826	0.52	0.80	0.65
1983	2232000	1344	1075	874	0.60	0.80	0.65
1984	2307000	1148	918	746	0.50	0.80	0.65
1985	2175000	852	682	554	0.39	0.80	0.65
1986	2004000	721	577	469	0.36	0.80	0.65
1987	2225000	930	744	605	0.42	0.80	0.65
1988	2327000	1405	1124	913	0.60	0.80	0.65
1989	2395000	1423	1138	925	0.59	0.80	0.65
1990*	2521000	1003	803	652	0.40	0.80	0.65
1991	2295000	1358	1086	882	0.59	0.80	0.65
1992	2310000	949	806	664	0.41	0.85	0.70
1993	2190000	829	704	580	0.38	0.85	0.70
1994	2312000	705	599	493	0.30	0.85	0.70
1995	2476000	864	734	605	0.35	0.85	0.70
1996	2406000	801	681	561	0.33	0.85	0.70
1997	2321000	695	625	556	0.30	0.90	0.80
1998	2254000	541	487	433	0.24	0.90	0.80
1999	2286000	263	237	211	0.12	0.90	0.80
2000	2465000	216	194	172	0.09	0.90	0.80
2001	2602000	254	229	203	0.10	0.90	0.80

* Comparatively low emissions of particles as reported from the facilities

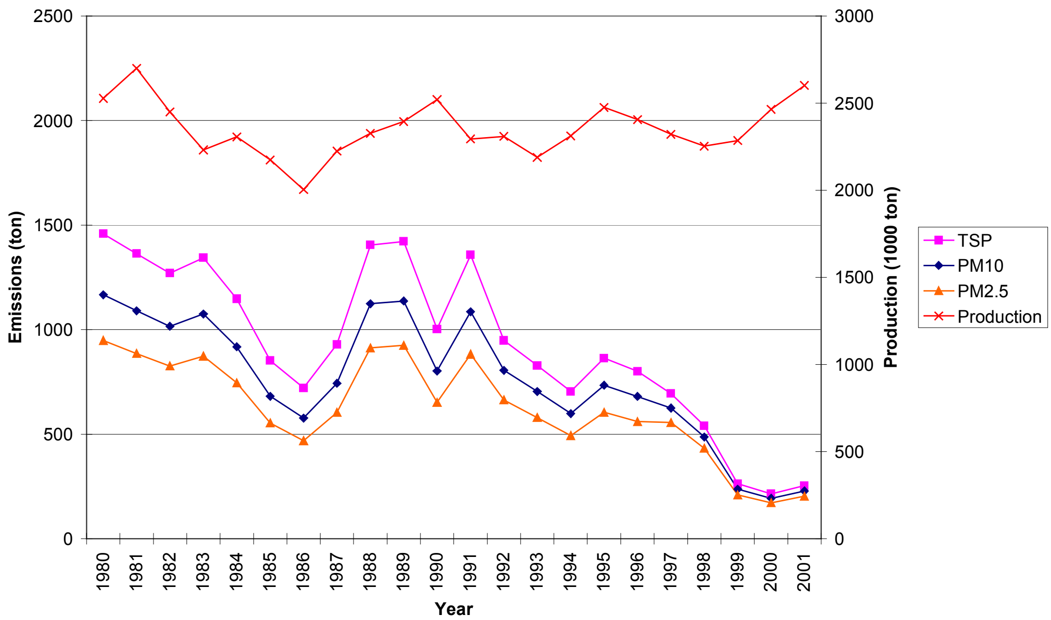

Figure 9.3 Time series of cement production (right axis) and emissions of TSP, PM_{10} and $PM_{2.5}$ (left axis), 1980-2001.

9.3.2. Particles and dioxins from lime production (2A2)

Lime production occurs at 15-20 facilities in Sweden. Emissions of particles have been estimated for production of carbonate products, including quarrying, crushing and grinding, and from production of quick lime. The activity data for production of lime was calculated from the sum of quarried amount of limestone and dolomite (Swedish Geological Survey, 2001), from which the use in cement production have been subtracted (calculated as 2 times the clinker production in the cement industry). The particle emissions from the lime used in cement production are included in the estimates for cement production, see above. The Swedish Association of Lime Manufacturers has provided the approximate figure on annual production of quick lime.

Emission factors for production of lime (Table 9.3) were taken from the CEPMEIP project and for quick lime from manufacturers and expert judgement on the size fractions. The estimated emissions of TSP, PM_{10} and $PM_{2.5}$ for 1980-2001 from lime and quick lime production are presented in Table 9.4.

Table 9.3 Emission factors for lime production

	Time period	TSP (kg/ton)	PM10 kg/ton	PM2.5 (kg/ton)	Reference
Lime prod	1980-2001	0.3	0.15	0.03	CEPMEIP
Quick-lime	1980-1998	1	0.9	0.8	*
	1999	0.58	0.522	0.5	*
	2000	0.43	0.387	0.3	*
	2001	0.41	0.369	0.3	*

*Based on information from the trade association (Kalkföreningen) and from individual facilities.

Table 9.4 Production figures and emissions of particles from lime production

			Total estimated emissions		
	Production of lime kton	Production of quick lime kton	TSP ton	PM_{10} ton	$PM_{2,5}$ ton
1980	2670	600	680	580	488
1981	2326	600	670	575	487
1982	2826	600	685	582	488
1983	3262	600	698	589	490
1984	3112	600	693	587	489
1985	3376	600	701	591	490
1986	3718	600	712	596	491
1987	3276	600	698	589	490
1988	3072	600	692	586	489
1989	2936	600	688	584	489
1990	2684	600	681	580	488
1991	3124	600	694	587	489
1992	2865	600	686	583	489
1993	2693	600	681	580	488
1994	3027	600	691	585	489
1995	3430	600	703	591	490
1996	3242	600	697	589	490
1997	3071	600	692	586	489
1998	3205	600	696	588	490
1999	2458	600	422	350	286
2000	3909	600	375	291	218
2001	4084	600	369	283	209

The European Dioxin Inventory, citing the previous Swedish inventory (de Wit, unpubl.), gives values on dioxin emissions from lime production for 1990 and 1993 of 9.8-18 and 2-2.5 g TEQ, respectively. The origin of the estimated dioxin emissions was however not specified. According to UNEP (2001) dioxin may be formed primarily originating from the use of waste as fuel in the high-temeperature process. In Sweden no waste is used in lime production, and thus these earlier estimates were not considered further. All emissions from the combustion of fuels are accounted for in the energy sector.

9.3.3. Metals from battery manufacture (2A7)

Heavy metal emissions from battery manufacture originate from three facilities in Sweden. One of these produces nickel-cadmium batteries and two facilities produce lead batteries. The time-series from 1990-2001 were compiled based on emission data reported from the individual facilities to the EMIR database (Table 9.5). For some years information on emissions was not available, and data have been interpolated.

Table 9.5 Emissions of heavy metals from battery manufacture (kg).

	Cd, kg	Ni, kg	Pb, kg
1990	23	27	240
1991	19	27	199
1992	7	40	157
1993	7	22	119
1994	7	14	140
1995	5	17	123
1996	4	9	91
1997	4	6	97
1998	4	10	87
1999	5	6	28
2000	2	8	28
2001	3	11	28

9.3.4. Particles, metals and dioxins from sinter and pelletizing plants (2A7)

Emission from iron ore mining and sinter/pellets production has been estimated for the time period 1980-2001 for particles and dioxins and for the time period 1990-2001 for metals. Data on production statistics as well as on emissions of TSP have been supplied from the facilities producing sinter/pellets for the entire time period.

Both pellets and sinter have been produced during the time period from 1980-1994, but since 1995 only pellets are produced (Figure 9.4). Separate emission factors for TSP from sinter and pellets production respectively, were calculated based on the information received from industry. The emission factors calculated for TSP are presented in Table 9.6, where also suggested emission factors from the CEPMEIP project are shown. The emission factors calculated using information from industry are considerably higher than those given in the CEPMEIP project, especially for the production of pellets. Information from the CEPMEIP-project on the particle size fractions, presented as relevant for conditions in 1995, was used as a basis when, in cooperation with industry, assigning the particle size distribution for the calculations of time series of emissions. In the estimated particle emissions (Table 9.7) also dressing (sifting) and concentrating plants are included, but the contributions from these are only minor in comparison to the actual sinter and pelletizing processes.

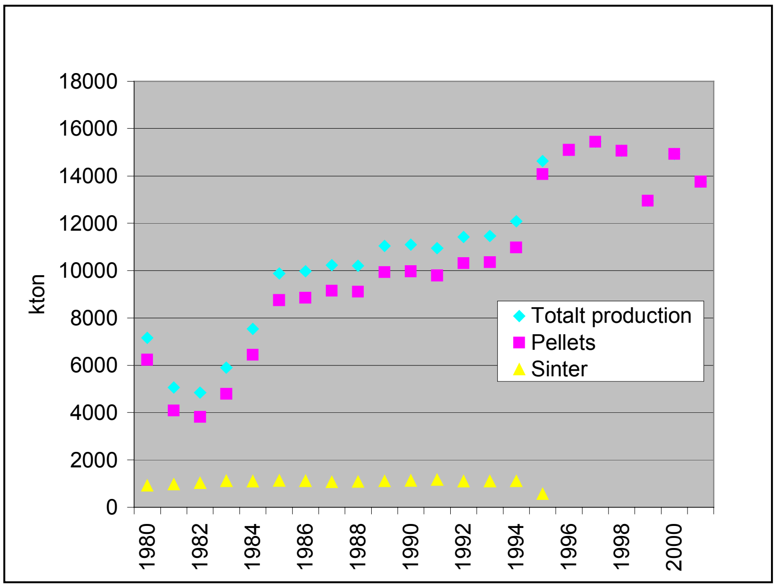

Figure 9.4 Production statistics for pellets and sinter production 1980-2001 (kton).

Table 9.6 Emission factors for TSP, PM_{10} and $PM_{2.5}$ from sinter and pelletizing plants.

	Sinter	Pellets	Unit	Comment
TSP	0.7-0.5	0.5-0.1	kg/ton	Calculated national EF, 1980-1995 (sinter), 1980-2001 (pellets)
	0.2	*0.03*	*kg/ton*	*CEPMEIP for 1995*
PM_{10}	50%	90%	fraction of TSP	Assigned values for 1980-1990
	50%	95%	-“-	Assigned values for 1991-1994
	NO*	100%	-“-	Assigned values for 1995-2001
	50%	*100%*	*-“-*	*CEPMEIP for 1995*
$PM_{2.5}$	40%	80%	fraction of TSP	Assigned values for 1980-1990
	40%	85%	-“-	Assigned values for 1991-1994
	NO*	100%	-“-	Assigned values for 1995-2001
	50%	*100%*	*-“-*	*CEPMEIP for 1995*

*NO, not occurring

Table 9.7 Production, calculated implied emission factor for TSP, and emissions of TSP, PM_{10} and $PM_{2.5}$ from sinter and pelletizing plants 1980-2001. Sinter production ended in 1994.

	Production	Calculated IEF* for TSP	Emissions		
			TSP	PM_{10}	$PM_{2,5}$
Year	kton totalt	kg/ton	ton	ton	ton
1980	7156	0.53	3826	3217	2834
1981	5056	0.56	2830	2279	1996
1982	4841	0.51	2458	1948	1703
1983	5903	0.42	2450	1976	1731
1984	7541	0.42	3147	2617	2303
1985	9872	0.47	4670	3962	3495
1986	9969	0.48	4759	4043	3567
1987	10225	0.48	4858	4144	3658
1988	10195	0.53	5417	4617	4075
1989	11042	0.48	5326	4555	4023
1990	11092	0.41	4499	3847	3397
1991	10944	0.30	3285	2945	2617
1992	11417	0.24	2709	2442	2172
1993	11456	0.21	2427	2189	1946
1994	12081	0.24	2872	2597	2310
1995	14633	0.12	1790	1754	1746
1996	15094	0.10	1505	1505	1505
1997	15443	0.10	1491	1491	1491
1998	15059	0.12	1843	1843	1843
1999	12953	0.10	1353	1353	1353
2000	14929	0.13	2005	2005	2005
2001	13752	0.11	1572	1572	1572

* Implied emission factor

The content of heavy metals in emitted particulate matter, used as emission factors in the calculations, originates from an analysis provided by industry (Table 9.8). The analyzed samples were from pellets production, but in the emission estimates the factors have been used on the sum of produced sinter and pellets. The time series of estimated emissions of metals from sinter and pelletizing plants are presented in Table 9.9.

Table 9.8 Metal content in emitted TSP from pelletizing plants (Ögren, 2002 pers comm).

Metal	kg/ton TSP
As	0.006
Cd	0.0002
Cr	0.044
Cu	0.01
Hg	0.00004
Ni	0.22
Pb	0.003
Zn	0.07

Table 9.9 Estimated emissions of metals from sinter and pelletizing plants (kg).

Year	As kg	Cd kg	Cr kg	Cu kg	Hg kg	Ni kg	Pb kg	Zn kg
1980	23	0.8	170	38	0.15	840	11	270
1981	17	0.6	120	28	0.11	620	8	200
1982	15	0.5	110	25	0.10	540	7	170
1983	15	0.5	110	24	0.10	540	7	170
1984	19	0.6	140	31	0.13	690	9	220
1985	28	0.9	200	47	0.19	1030	14	330
1986	29	1.0	210	48	0.19	1050	14	330
1987	29	1.0	210	49	0.19	1070	15	340
1988	33	1.1	240	54	0.22	1190	16	380
1989	32	1.1	230	53	0.21	1170	16	370
1990	27	0.9	200	45	0.18	990	13	320
1991	20	0.7	140	33	0.13	720	10	230
1992	16	0.5	120	27	0.11	600	8	190
1993	15	0.5	110	24	0.10	530	7	170
1994	17	0.6	130	29	0.11	630	9	200
1995	11	0.4	80	18	0.07	390	5	120
1996	9	0.3	70	15	0.06	330	5	100
1997	9	0.3	70	15	0.06	330	4	100
1998	11	0.4	80	18	0.07	410	6	130
1999	8	0.3	60	14	0.05	300	4	100
2000	12	0.4	90	20	0.08	440	6	140
2001	9	0.3	70	16	0.06	350	5	110

Sinter plants are very important dioxin emitters according to e.g. the European Dioxin Inventory. There are presently three pellet plants in operation, whereas a sinter plant was shut down in 1995.

Total emissions from the three pellets plants were measured during 2001 and amounted to 1.35 g TEQ, according to their Environmental Report. No major changes in their process have occurred during the period 1980-2001. We therefore assume that the formation rate of dioxins (µg/ton) has been constant. Thus, the concentration of dioxins in dust should also be constant, and emissions of dioxins should be proportional to those of dust. Dust emission data have been supplied from the pellets plants for the entire period, allowing for estimating dioxin emissions over time. This translates to calculated emission factors of slightly more than 0.3 µg/ton during the 1980´s. Following a sharp drop in the early 1990´s, calculated emission factors for dioxins vary in the range 0.07 to 0.11 µg/ton during 1995-2001 (Table 9.10).

Dioxin emissions from the sinter plant were measured in 1993 and 1995 and reached 5.4 and 2 g TEQ, respectively. This corresponds to emission factors of 4.9 and 3.5 µg/ton. In the absence of other data, it is assumed that an emission factor of 4.2 µg/ton is valid for the period 1980-1995. The total dioxin emissions from this activity were in the range 5.5-7.5 g TEQ/yr until 1994, and then dropped to slightly more than 1 g TEQ/yr following the closing of the sinter plant (Table 9.10).

Table 9.10 Dioxin emissions from the pellets and sinter plants. In the absence of other information, emission factors for the sinter plant is assumed to be invariant during the entire period.

Year	Pellets		Sinter		Total emissions
	Emissions g TEQ/yr	Calculated emission factor µg TEQ/ton	Emissions g TEQ/yr	Assumed emission factor µg TEQ/ton	g TEQ /yr
1980	2.2	0.36	3.9	4.2	6.1
1981	1.5	0.36	4.1	4.2	5.5
1982	1.3	0.33	4.3	4.2	5.6
1983	1.6	0.33	4.7	4.2	6.3
1984	2.0	0.31	4.6	4.2	6.6
1985	2.7	0.31	4.7	4.2	7.4
1986	2.7	0.31	4.7	4.2	7.4
1987	2.8	0.31	4.5	4.2	7.3
1988	2.9	0.32	4.6	4.2	7.5
1989	3.0	0.31	4.7	4.2	7.7
1990	2.7	0.27	4.7	4.2	7.4
1991	1.9	0.20	4.9	4.2	6.8
1992	1.6	0.16	4.6	4.2	6.3
1993	1.4	0.14	5.4	measured	6.8
1994	1.6	0.15	4.7	4.2	6.3
1995	1.0	0.07	2.0	measured	3.0
1996	1.1	0.07	-	-	1.1
1997	1.1	0.07	-	-	1.1
1998	1.7	0.11	-	-	1.7
1999	1.2	0.09	-	-	1.2
2000	1.7	0.11	-	-	1.7
2001	1.4	0.10	-	-	1.4

9.3.5. Particles and metals from glass production (2A7)

Emissions of particulate matter and heavy metals from production of float glass, container and manual glass have been compiled for the period 1990-2001. Data were obtained from industry and from legal Environmental Reports, and for earlier years in the time series from national reporting to HELCOM and from Bjärborg (1998). For manual glass production only emissions of lead and arsenic are reported. Data for missing years and parameters have been inserted or interpolated. The particle size distribution used in the emissions estimates was as suggested in the CEPMEIP- project (for production of flat glass, blown or drawn glass and container glass). The emissions factors provided by CEPMEIP translates for PM_{10} into 90% and for $PM_{2.5}$ into 80% of the TSP emissions.

Table 9.11 Emissions of particles and metals from glass production (ton)

Year	TSP ton	PM_{10} ton	$PM_{2.5}$ ton	Cd ton	Cr ton	Hg ton	Pb ton	As ton
1990	164	147	131	0.004	0.02	0.006	1.31	0.10
1991	147	132	117	0.004	0.02	0.00	1.28	0.26
1992	118	106	94	0.005	0.01	0.001	1.15	0.07
1993	131	118	105	0.005	0.01	0.002	1.14	0.06
1994	149	134	120	0.005	0.01	0.002	0.88	0.04
1995	167	151	134	0.009	0.02	0.001	1.49	0.02
1996	149	134	119	0.009	0.02	0.001	1.37	0.02
1997	153	138	123	0.008	0.01	0.001	1.57	0.01
1998	130	117	104	0.009	0.01	0.001	1.54	0.01
1999	87	78	69	0.025	0.03	0.002	2.69	0.01
2000	87	79	70	0.028	0.04	0.002	2.85	0.01
2001	49	44	39	0.013	0.02	<0.001	0.72	<0.01

9.3.6. Particles and metals from glass and mineral wool production (2A7)

Glass and mineral wool have been produced at approximately 5-7 facilities during the time period 1980-2001. Two have shut down since 1980. Presently the ownership is distributed on two companies. Emission and production data have been received from one company (four facilities 1980-1991 and three facilities 1992-2001) for the whole time series 1980-2001. The data provided for the 1990´s and 2000-2001 are primarily based on measurements whereas for earlier years estimates made by the company are based on different known circumstances influencing emissions. Concerning the particle emissions, only the TSP emissions were provided by industry, and the fraction of PM_{10}, 90%, and $PM_{2.5}$, 70% of TSP, was calculated from emission factors for production of glass fibres provided in the CEPMEIP study. The emission factor for TSP, according to CEPMEIP, is 0.3 kg TSP/ton, while the calculated implied emission factors from the data provided from industry range from 3 kg/ton in the early 1980´s, to approximately 0.9 kg/ton in 2000 and 2001. Estimated emissions of particles and metals from glass and mineral wool production are presented in Table 9.12.

Table 9.12 Emissions of particles and metals from glass- and mineral wool production (particles in ton, metals in kg)

Year	TSP	PM_{10}	$PM_{2.5}$	Pb	Cd	Hg	As	Cr	Cu	Ni	Zn
	ton	ton	ton	kg	kg	kg	kg	kg	kg	kg	kg
1980	457	411	320	10	0.4	<0.02	1	22	6	30	131
1981	431	388	302	10	0.4	<0.02	1	21	6	29	129
1982	417	375	292	8	0.3	<0.02	1	21	6	27	113
1983	396	356	277	8	0.3	<0.02	1	20	5	26	109
1984	369	332	258	7	0.3	<0.01	1	19	5	25	104
1985	358	322	251	6	0.2	<0.01	1	18	5	22	91
1986	376	338	263	6	0.2	<0.01	1	20	5	24	93
1987	394	355	276	6	0.2	<0.02	1	21	5	25	96
1988	397	357	278	6	0.2	<0.02	1	22	6	26	99
1989	433	390	303	7	0.3	<0.02	1	25	6	29	112
1990	413	372	289	7	0.3	<0.02	1	24	6	28	109
1991	407	366	285	7	0.3	<0.02	1	26	6	30	114
1992	169	152	118	7	0.3	<0.02	1	25	6	29	111
1993	124	112	87	5	0.2	<0.01	1	21	5	23	85
1994	135	122	95	1	0.1	<0.01	1	29	5	21	67
1995	157	141	110	6	0.2	<0.01	1	22	5	26	98
1996	137	123	96	6	0.2	<0.01	1	22	5	26	98
1997	131	118	92	6	0.2	<0.01	1	20	5	24	90
1998	165	149	116	7	0.3	<0.02	1	23	6	28	107
1999	156	140	109	8	0.3	<0.02	1	24	6	29	116
2000	93	84	65	7	0.3	<0.02	1	24	6	27	103
2001	84	76	59	7	0.3	<0.01	1	24	6	28	107

9.3.7. Particles and metals from mining and extraction of non-iron mineral ore (2A7)

For mining and the extraction of non-iron mineral ore, emissions of TSP and metals have been compiled for 1990-2001, based on data reported by the companies in their legal environmental reporting. Data for earlier years were not available. Also during the 1990´s data were not available for all years, so for missing years values have been interpolated or inserted. The particle size distribution of the particulate emissions was derived from the emission factors for copper and zinc ore mining given in the CEPMEIP study. According to those data PM_{10} is estimated to amount to 50% and $PM_{2.5}$ to 7% of the TSP-emissions. The compiled time series of emissions of TSP, PM_{10}, $PM_{2.5}$ and metals from non-iron ore mining and extraction are presented in Table 9.13.

Table 9.13 Emissions of particles and metals from non-iron ore mining and extraction, 1990-2001. Particles in ton, metals in kg.

Year	TSP	PM_{10}	$PM_{2.5}$	Cu	Pb	Zn	Cd	As	Ni	Hg
	ton	ton	ton	kg	kg	kg	kg	kg	kg	kg
1990	4.7	2.3	0.3	84	118	299	3	42	0.2	11
1991	6.1	3.0	0.4	84	218	789	3	42	0.2	11
1992	7.3	3.7	0.5	301	364	1408	3	40	0.2	4
1993	2.6	1.3	0.2	251	140	540	3	30	0.2	3
1994	3.2	1.6	0.2	91	160	650	3	30	0.2	3
1995	16	8.1	1.1	125	104	545	4	39	3.2	3
1996	9.1	4.6	0.6	146	62	848	2	29	3.4	2
1997	3.0	1.5	0.2	68	22	198	3	9	7.2	1
1998	1.2	0.6	0.1	43	28	71	<1	8	0.7	1
1999	1.1	0.5	0.1	42	27	149	1	11	4.0	1
2000	0.9	0.5	0.1	45	16	57	<1	7	1.7	2
2001	1.7	0.8	0.1	28	44	116	1	6	3.2	5

9.3.8. Particles from construction activities (2A7)

Time series of emissions of particles from construction work has been developed. The basis for the calculations is national data on construction activity. Emission factors from the CEPMEIP study was used, as presented in Table 9.14.

Table 9.14 Emission factors for construction-related activities (CEPMEIP)

	TSP	**PM_{10}**	**$PM_{2.5}$**	**Unit**
Dwellings	0.215	0.108	0.011	ton/1000 m^2/year
Utilities	0.123	0.061	0.006	ton/1000 m^2/year

The activity data that was chosen as a basis for the calculations, is economic statistics on annual investments in construction-related activities 1980-2001, obtained from The Swedish Construction Federation (Rydell, 2002). The data is divided into four sub-groups, dwellings, industries, other buildings and construction. The latter three are considered to be utilities and are treated as a sum. No consistent reliable statistics on activity in the form of "constructed area" or likewise are available. In order to transform this economic information into a unit where the suggested emission factors (Table 9.14) can be used, 1995, the inventory year in the CEPMEIP study, was used as a base year for transforming economics into constructed square meters.

The number of square meters of construction work in 1995 in Sweden, provided in the CEPMEIP study, together with data from The Swedish Construction Federation on investments in construction-related activities in 1995, were used to calculate an average cost per constructed square meter for dwellings and utilities respectively.

For the calculations of the time series of emissions, the economic information was normalised to the 1995 level, and the costs per square meter was assumed to be constant throughout the time series. Using the derived factor "costs per square meter", emissions for the whole time series were calculated from the emission factors and the magnitude of investments for each year (Table 9.15).

Table 9.15 Emissions of particles from construction-related activities

Year	TSP (ton)	PM_{10} (ton)	$PM_{2.5}$ (ton)
1980	936	468	47
1981	883	441	44
1982	865	433	43
1983	865	433	43
1984	923	462	46
1985	906	453	45
1986	916	458	46
1987	965	482	48
1988	1001	500	50
1989	1066	533	53
1990	1097	548	55
1991	1035	518	52
1992	982	491	49
1993	792	396	40
1994	717	359	36
1995	704	352	35
1996	718	359	36
1997	660	330	33
1998	678	339	34
1999	688	344	34
2000	722	361	36
2001	731	366	37

9.4. Chemical industry (2B)

Estimates of emissions of particles and mercury have been made from chemical industry. It is known that also dioxin emissions may occur from chemical industry, but reliable data have been difficult to obtain. A few indicative figures from Environmental Reports from later years are discussed below.

The mercury emissions reported originate from the chlor-alkali industry and from sulphuric acid production. Particle emissions have only been estimated from carbide production. Chemical industry in general is not expected to contribute significantly to particle emissions.

9.4.1. Particles from carbide production (2B4)

Calcium-carbide production is located at only one facility in Sweden, which has provided production statistics as well as information on particle emissions for the whole time series (Löfstrand, E. 2002). Based on this information, emission factors for TSP could be calulated (Table 9.16). There seems to be some inconsistencies in the time series from the mid 1980´s to the mid 1990´s, when considerably lower specific emissions of particles were reported from the facility. It has not been possible to clarify if this was caused by changes in the production process or if it is an effect of different ways of estimating the particle emissions. Considering other sources of particle emissions, carbide production cannot be considered to be a significant source.

The partitioning of particles between TSP, PM_{10} and $PM_{2,5}$ has been done by expert judgement, after discussions with the facility. PM_{10} was judged to amount to 90% and $PM_{2.5}$ to 80% of the TSP emissions. Carbide production is not specifically treated in the CEPMEIP project.

Table 9.16 Estimated emissions of particles from carbide production

Year	Production (ton)	Emissions of TSP (ton)	Emissions of PM_{10} (ton)	Emissions of $PM_{2.5}$ (ton)	Calculated emission factor for TSP (kg/ton)
1980	29700	215	194	172	7.2
1981	20700	205	185	164	9.9
1982	31600	220	198	176	7.0
1983	33000	200	180	160	6.1
1984	34800	310	279	248	8.9
1985	30400	290	261	232	9.5
1986	36600	230	207	184	6.3
1987	29200	94	85	75	3.2
1988	47100	60	54	48	1.3
1989	54800	120	108	96	2.2
1990	54900	120	108	96	2.2
1991	55500	199	179	159	3.6
1992	42500	124	112	99	2.9
1993	43700	278	250	222	6.4
1994	45600	150	135	120	3.3
1995	46100	153	138	122	3.3
1996	47000	198	178	158	4.2
1997	46600	337	303	270	7.2
1998	43100	232	209	186	5.4
1999	42800	372	335	298	8.7
2000	38100	241	217	193	6.3
2001	37300	263	237	210	7.1

9.4.2. Mercury from the chlor alkali industry (2B5)

In the past the chlor alkali industy has been a significant source of mercury emissions. Levander (1989, unpubl) has estimated that this source was one of the predominant sources of mercury in Sweden during the 1950´s with emissions in the order of 10 tons/year.

The estimated Swedish emissions 1990-2001, originating from approximately five facilities, are presented in Table 9.17. Reported emissions of mercury were derived from information in the EMIR database, from industries Environmental Reports or unpublished earlier estimates (Levander, 1989). Data were however, not available for all years and a few interpolations had to be made.

Table 9.17 Emissions of mercury (Hg) from the chlor alkali industry 1990-2001.

Year	Hg, ton
1990	0.20
1991	0.19
1992	0.16
1993	0.12
1994	0.13
1995	0.12
1996	0.11
1997	0.08
1998	0.06
1999	0.06
2000	0.05
2001	0.05

9.4.3. Mercury from sulphuric acid production (2B5)

Sulphuric acid production occurs at a large smelter, and all data on emissions of mercury from this process have been obtained from Environmental Reports from the facility. The production at this facility is complicated and involves a number of different processes. It has not been meaningful to try and find relevant activity data since the reporting of emissions as such is considered to be sufficient. Some data on emissons of mercury for years before 1990 exist, but they have only been sporadically reported. Earlier there were some more facilities producing sulphuric acid in Sweden.

Table 9.18 Emissions of mercury from sulphuric acid production 1990-2001.

Year	Hg (ton)
1990	0.063
1991	0.069
1992	0.095
1993	0.033
1994	0.051
1995	0.010
1996	0.031
1997	0.024
1998	0.074
1999	0.043
2000	0.047
2001	0.019

9.4.4. Dioxins from chemical industry (2B)

Hardly any information on dioxin emissions from chemical industry has been available, and it has not been possible to compile any time series of dioxin emissions from these sources. Reported emissions from a few Environmental Reports from later years are presented in Table 9.19.

Dioxins are formed during the production of ethylene dichloride (EDC) and vinyl chloride monomer (VCM). UNEP (2001) gives a default emission factor of 0.95 μg TEQ/ton. One Swedish facility has reported emissions for the more recent years (Table 9.19). Using their production of EDC and VCM during 2000, an average emission factor of 0.02 μg TEQ/ton is calculated, significantly lower than the UNEP default value.

There is also a single value on dioxin emissions from a major facility for production of pharmaceuticals from 2001 (Table 9.19).

Table 9.19 Dioxin emissions from chemical industry. Data were obtained from Environmental Reports from the facilities.

Subcategory	Year	Emission (g TEQ/yr)
Production of EDC and VCM	1998	0.015
Production of EDC and VCM	2000	0.005
Production of EDC and VCM	2001	0.003
Pharmaceutical industry	2001	0.2

9.5. Metal production (2C)

Processes that are included in this category are primary and secondary iron and steel production, non-ferrous metal production and aluminium production.

9.5.1. Particles, metals and dioxins from the iron and steel industry (2C)

There are three primary iron and steel facilities in Sweden and about ten steel plants equipped with electric arc furnaces. Totally, there are approximately 20 various facilities included in the estimates. Processes that occur besides the primary processes and secondary steel production are rolling mills, pickling and other steel related processes.

The estimated TSP emissions are based on data provided from the trade association (Jernkontoret, 2000) for almost all years 1980-1999 (for 2000 and 2001 companies' legal Environmental Reports). Data for some missing years have been interpolated. The PM size fractionation has been made according to expert judgement, based on knowledge about changes in production methods and abatement technology. The chosen time series in particle size distributions and the reported emissions are presented in Table 9.20.

Table 9.20 PM fractions in percent of TSP, and estimated emissions of TSP, PM_{10} and $PM_{2.5}$ for the iron and steel industry.

Year	PM_{10} (% of TSP)	$PM_{2,5}$ (% of TSP)	TSP (ton)	PM_{10} (ton)	$PM_{2.5}$ (ton)
1980	80	60	8866	7093	5320
1981	80	60	7333	5866	4400
1982	80	60	5800	4640	3480
1983	80	60	5600	4480	3360
1984	80	60	5400	4320	3240
1985	80	60	5200	4160	3120
1986	80	70	4996	3997	3497
1987	80	70	4856	3885	3399
1988	80	70	4716	3773	3301
1989	85	75	3700	3145	2775
1990	85	75	3300	2805	2475
1991	85	75	3450	2933	2588
1992	85	75	3600	3060	2700
1993	85	75	3665	3115	2749
1994	85	75	3730	3171	2798
1995	85	75	3365	2860	2524
1996	95	85	1768	1680	1503
1997	95	85	1788	1699	1520
1998	95	85	1575	1496	1339
1999	95	85	1282	1218	1090
2000	95	85	1169	1111	994
2001	95	85	1293	1228	1099

The estimated metal emissions from iron and steel processes are based on known activity data, i.e. total and primary production, published by the trade association (Jernkontoret, 2000). The secondary production has been calculated as total production minus primary production. The activity data are presented in Table 9.21. Calculated implied emission factors for metal emissions from primary and secondary production are based on compiled emissions in older trade specific reports made by the Swedish EPA for some years during the 1990's. Implied emission factors have been calculated for Cd, Cr; Cu, Hg, Ni, Pb and Zn. The emissions of As, arsenic, have not been covered due to lack of data. For years for which the Swedish EPA did not provide trade specific reports, or when the trade was not fully covered in the reports, emission factors have been interpolated. The emissions from primary and secondary production have been calculated as the product of the implied emission factor and the activity data for the whole time-series. The calculated implied emission factors that have been used are presented in Table 9.22. The annual total estimated emission of each metal (Table 9.23) has been calculated as emission from primary plus secondary production.

Table 9.21 Activity data for iron and steel production for 1980-2001.

Year	Total production (Gg= kton)	Primary production (Gg= kton)	Secondary production (Gg= kton)
1980	4237	2435	1801
1981	3770	1770	2000
1982	3900	1779	2121
1983	4210	2011	2199
1984	4705	2214	2492
1985	4813	2424	2389
1986	4716	2435	2280
1987	4595	2313	2282
1988	4779	2492	2287
1989	4692	2638	2054
1990	4454	2736	1718
1991	4252	2812	1440
1992	4359	2735	1623
1993	4591	2845	1746
1994	4967	3037	1930
1995	4953	3020	1934
1996	4910	3130	1780
1997	5148	3060	2088
1998	5153	3150	2004
1999	5067	3212	1855
2000	5229	3146	2083
2001	5229	3146	2083

Table 9.22 Calculated implied emission factors for primary and secondary iron and steel production for 1990-2001 (g/ton).

	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
Year	Cd	Cd	Cr	Cr	Cu	Cu	Hg	Hg	Ni	Ni	Pb	Pb	Zn	Zn
1990	0.04	0.07	0.10	6.98	0.37	0.58	0.01	0.15	0.15	4.00	4.75	4.66	4.8	37.8
1991	0.03	0.07	0.09	5.34	0.26	0.50	0.01	0.14	0.15	4.00	3.66	3.99	2.9	27.4
1992	0.03	0.06	0.07	3.70	0.15	0.50	0.00	0.13	0.15	4.00	2.56	3.33	3.3	21.6
1993	0.03	0.05	0.07	3.06	0.13	0.50	0.00	0.13	0.13	4.00	1.29	2.46	2.6	19.4
1994	0.03	0.03	0.06	2.43	0.11	0.50	0.00	0.12	0.15	4.00	1.19	1.59	2.3	17.3
1995	0.03	0.02	0.05	1.79	0.10	0.50	0.00	0.11	0.14	3.83	1.09	0.71	2.5	15.2
1996	0.03	0.02	0.03	1.00	0.09	0.45	0.00	0.10	0.10	1.50	0.85	0.69	1.0	10.0
1997	0.03	0.02	0.03	0.80	0.08	0.40	0.00	0.08	0.06	1.00	0.61	0.66	0.9	8.0
1998	0.03	0.02	0.03	0.80	0.08	0.34	0.00	0.08	0.03	0.80	0.37	0.64	0.8	7.0
1999	0.01	0.02	0.02	0.70	0.05	0.29	0.00	0.08	0.04	0.50	0.23	0.62	0.8	4.4
2000	0.00	0.01	0.02	0.60	0.02	0.10	0.00	0.08	0.04	0.30	0.08	0.42	0.5	4.6
2001	0.00	0.01	0.02	0.50	0.02	0.07	0.00	0.04	0.04	0.29	0.08	0.25	0.5	3.9

Table 9.23 Reported metal emissions from iron and steel production 1990-2001

Year	Cd (ton)	Cr (ton)	Cu (ton)	Hg (ton)	Ni (ton)	Pb (ton)	Zn(ton)
1990	0.22	12	2.0	0.27	7.3	21	78
1991	0.18	7.9	1.4	0.22	6.2	16	60
1992	0.17	6.2	1.2	0.23	6.9	12	44
1993	0.17	5.5	1.2	0.23	7.4	8.0	41
1994	0.15	4.9	1.3	0.23	8.2	6.7	40
1995	0.13	3.6	1.3	0.22	7.8	4.7	37
1996	0.13	1.9	1.1	0.19	3.0	3.9	21
1997	0.13	1.8	1.1	0.18	2.3	3.3	19
1998	0.13	1.7	0.93	0.17	1.7	2.5	17
1999	0.06	1.4	0.70	0.16	1.1	1.9	11
2000	0.03	1.3	0.27	0.17	0.75	1.1	11
2001	0.03	1.1	0.20	0.08	0.72	0.76	9.7

According to USEPA (1997), dioxin emissions from steel production are strongly dependent on a number of parameters that are likely to vary between steel plants. Whether steel is produced from primary metals or from scrap metal is one very important factor, with the latter giving much higher dioxin emissions. Plant specific data is therefore recommended, if available.

From Environmental Reports from the last two years, dioxin emission data for this activity have been compiled in Table 9.24. For the years 2000 and 2001, the sum of the reported dioxin emissions to air was 6.3 and 3.7 g TEQ, respectively. The calculated implied emission factors from the individual plants show a fairly wide scatter (0.07 –13 µg/ton;Table 9.24). This range is similar to the total range of emission factors presented by UNEP (2001), where high values represent contaminated scrap metal and low values represent virgin iron.

Table 9.24 Dioxin emissions from iron and steel plants during 2000 according to companies legal Environmental Reports, excl. iron ore sintering and aluminum.

Process details	Dioxin (g TEQ)	Calculated emission factor (µg/ton)
Primary steel	0.3	0.167
Sponge iron	0.0089	0.071
Electric arc furnace	0.2	0.470
Electric arc furnace	2.3	12.8
Electric arc furnace/steel plant	0.4	0.776
Electric arc furnace	0.015	0.109
Electric arc furnace	1	2.16
Electric arc furnace	2.1	8.14
Electric arc furnace/steel plant	0.023	0.334
Total	**6.3**	

Since the emission factors vary widely depending on several process factors, no straightforward calculations using an emission factor were made when compiling a time series of national dioxin emissions from the iron and steel industry. Instead, the estimates for the time period 1980-2001 are based on a combination of information concerning production data for scrap-based steel, results from dioxin measurements, earlier estimates and expert judgement in co-operation with the trade association (Jernkontoret). The result is presented in Figure 9.5. The estimated emissions range from approximately 30 g TEQ/year in the early 1980´s, to less than 5 g in 2001.

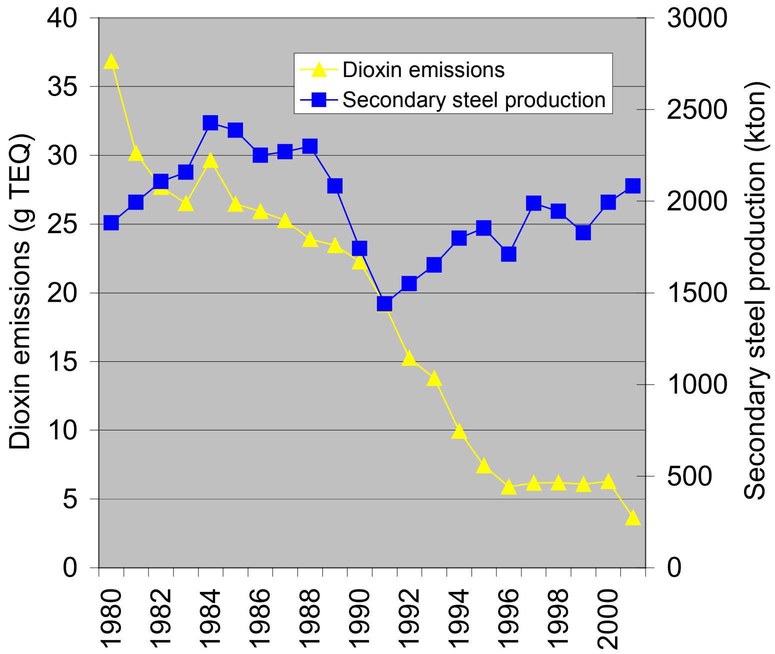

Figure 9.5 Estimated dioxin emissions from secondary steel production, and production statistics, 1980-2001.

Measurements of PAH emissions from electric arc furnaces in 1990 showed non-detectable levels of the four specified compounds of interest (Boström et al., 1993), thus the emissions of PAH-4 from the steel industry were assumed to be insignificant, and were not further considered.

9.5.2. Particles and metals from ferroalloys production (2C)

Ferroalloy production in Sweden occurs at one facility. The TSP emissions have been calculated based on activity data provided by the company (1980-2001) and emission factors derived from reported emissions of TSP in the company's legal Environmental Reports in later years. The calculated average emission factor has been used for all years during 1990's and was doubled for the period 1980-1989, as suggested by the company experts (Table 9.25). The estimated time series of TSP emissions is presented in Table 9.26. The size distribution of particulates between PM_{10} (95%) and $PM_{2,5}$ (75%) has been estimated by an expert who has performed measurements at the facility since the beginning of the 1980's (Peterson, 2002). The same particle size distribution was assumed for the whole time series.

Metals emitted to air from ferroalloy production are primarily Cr, Pb and Zn. Chromium emission have been reported by Environmental Reports to the EMIR database since 1992. The chromium (Cr) emissions in the database and the activity data obtained from the company have been used to calculate the emission factors. The mean implied emission factor for 1992-1994 has been calculated and used for 1990-1991, and the mean implied emission factor for 1990-2001 has been doubled and used for 1980-1989, see Table 9.25. Zinc and lead emissions have only been sporadically reported to the EMIR database during the 1990's, therefore data from older Swedish EPA reports (e.g Swedish EPA reports 3429 (1988), 1570 (1982), Monitor 1982, Monitor 1987) have been combined with the reported EMIR-data in order to calculate the emission factors for the 1990's. As for chromium the mean emission factor for zinc for 1990-2001 has been doubled and used for 1980-1989. The calculated zinc emissions for 1980's are much lower than formerly reported for 1984 and 1985 (Swedish EPA report 3429).

Table 9.25 Emission factors for particles and metals (kg/ton alloy) from ferro alloys production.

Year(s)	TSP	Pb	Zn	Cr
1980-1989	1.34	0.00035	0.017	0.10
1990-1995	0.67	0.00020	0.009	0.07-0.05
1996	0.67	0.00015	0.007	0.04
1997	0.67	0.00015	0.007	0.05
1998	0.67	0.00015	0.007	0.03
1999	0.68	0.00015	0.006	0.03
2000	0.66	0.00013	0.009	0.03
2001	0.66	0.00016	0.006	0.04

Table 9.26 Activity data for ferro alloys production, and emissions of particulate matter and metals, 1980-2001.

Year	Production, kton alloy	TSP (ton)	PM_{10} (ton)	$PM_{2.5}$ (ton)	Pb (ton)	Zn (ton)	Cr (ton)
1980	94.8	127	121	95	0.03	1.6	9.4
1981	113	151	144	113	0.04	1.9	11
1982	139	186	177	140	0.05	2.3	14
1983	107	143	136	107	0.04	1.8	11
1984	118	158	150	118	0.04	2.0	12
1985	123	164	156	123	0.04	2.0	12
1986	118	158	150	118	0.04	2.0	12
1987	122	164	156	123	0.04	2.0	12
1988	143	191	182	143	0.05	2.4	14
1989	124	166	158	125	0.04	2.1	12
1990	128	85	81	64	0.03	1.2	8.4
1991	136	91	86	68	0.03	1.3	8.9
1992	136	91	87	68	0.03	1.3	8.9
1993	136	91	86	68	0.03	1.3	9.7
1994	146	98	93	73	0.03	1.4	8.9
1995	147	99	94	74	0.03	1.4	7.0
1996	156	104	99	78	0.02	1.1	7.0
1997	120	80	76	60	0.02	0.9	5.5
1998	139	93	89	70	0.02	1.0	4.3
1999	133	91	86	68	0.02	0.8	3.8
2000	153	101	96	76	0.02	1.4	4.2
2001	128	85	81	64	0.02	0.8	4.8

9.5.3. Particles, metals and dioxins from primary and secondary non-ferrous metal smelters

One large non-ferrous smelter and seven smaller facilities have been studied in order to compile time series of emissions of particles and metals. Estimates of dioxin emissions have only been possible to obtain for the large facility in their annual Environmental Reports.

At the large smelter, a variety of processes occur, including both primary and secondary processes, and a number of products are produced. This facility has a long history of submitting environmental reports to the authorities, why emission estimates for all substances were readily available, except for the size fractions of emitted particles (Table 9.27).

Emission factors for PM_{10} and $PM_{2.5}$, as fractions of emitted TSP, have for the period before 1995 been assigned by expert judgement, in cooperation with company experts. Fractions range from 60-95% for PM_{10} from 1980-2001 and from 30-80% for $PM_{2.5}$ during the same period of time. The suggested emission factors from CEPMEIP correspond to a value of 90% for PM_{10} and 80% for $PM_{2.5}$, which were used for the later period, e.g. 1995-2001.

Table 9.27 Time series of emissions of particles and metals from a large non-ferrous smelter, 1980-2001.

Year	TSP (ton)	PM_{10} (ton)	$PM_{2.5}$ (ton)	Hg (ton)	Pb (ton)	Cd (ton)	Cu (ton)	Zn (ton)	As (ton)
1980	1585	951	476	0.64	213	3.20	137	142	56
1981	1480	888	444	0.74	173	3.00	108	169	37
1982	1411	847	423	0.74	198	4.30	77	170	35
1983	1400	840	420	0.64	186	6.50	80	192	47
1984	857	686	429	0.74	103	2.50	42	122	39
1985	997	798	499	0.54	101	2.70	41	145	40
1986	984	787	492	0.37	67	1.70	232	81	24
1987	450	383	270	0.26	73	1.40	46	62	12
1988	317	276	206	0.31	64	0.90	38	38	6.0
1989	250	218	163	0.19	48	0.90	20	31	5.3
1990	250	218	163	0.18	52	1.32	18	33	4.7
1991	230	200	150	0.11	40	0.81	17	35	3.2
1992	200	174	130	0.08	32	0.74	24	25	3.2
1993	167	145	109	0.06	22	0.48	14	27	1.9
1994	101	91	71	0.04	13	0.17	5.0	23	0.7
1995	63	60	50	0.06	8.6	0.16	4.5	11	0.8
1996	65	62	52	0.10	6.0	0.15	5.2	12	0.5
1997	97	92	78	0.08	7.2	0.17	6.2	13	0.6
1998	79	75	63	0.07	6.3	0.12	4.2	13	0.5
1999	67	64	54	0.20	5.6	0.07	2.3	7.8	0.2
2000	57	54	46	0.10	3.8	0.06	1.9	6.2	0.2
2001	57	54	45	0.09	5.0	0.14	1.6	9.0	0.4

Emissions of particles and metals from seven smaller secondary non-ferrous metal smelters have been compiled. Emissions, presented in Table 9.28, are for TSP and the metals as reported by the companies in Environmental Reports, and further into the EMIR database. The inclusion of data into EMIR has, unfortunately not been consistent, and several instances of missing values have had to be interpolated in order to complete the time series. Emissions, as a total from this category, are generally low, and no further attempts to track missing data were made. Estimates of the emissions of PM_{10} and $PM_{2.5}$ were made using the same assumptions concering particle size fractions as was applied for the large smelter, i.e PM_{10} and $PM_{2.5}$ from 90-95% and 70-80% of TSP respectively for the period 1990-2001.

Table 9.28 Emissions of particles and metals from small non-ferrous metal smelters, 1990-2001.

Year	TSP (ton)	PM_{10} (ton)	$PM_{2.5}$ (ton)	Pb (ton)	Cd (ton)	Cu (ton)	Zn (ton)	As (ton)	Cr (ton)	Hg (ton)	Ni (ton)
1990	8	7	6	0.465	0.013	0.038	0.623	0.001	0.017	0.005	0.002
1991	11	10	8	1.019	0.027	0.069	0.924	0.001	0.017	0.004	0.002
1992	9	8	6	0.454	0.017	0.058	0.744	0.001	0.017	0.007	0.002
1993	9	8	6	0.525	0.018	0.064	0.573	0.001	0.017	<0.001	0.001
1994	5	5	4	0.349	0.010	0.029	0.519	0.001	0.005	0.007	0.003
1995	5	5	4	0.190	0.011	0.021	0.208	0.001	0.018	0.004	0.011
1996	5	5	4	0.086	0.005	0.021	0.181	0.001	0.016	0.004	0.002
1997	5	5	4	0.065	0.005	0.008	0.170	0.002	0.014	0.003	0.002
1998	4	4	4	0.073	0.004	0.008	0.176	0.002	0.012	0.003	0.002
1999	4	4	3	0.082	0.004	0.008	0.151	0.001	0.010	0.002	0.002
2000	4	4	4	0.148	0.004	0.004	0.141	0.001	0.008	0.002	0.002
2001	5	4	4	0.224	0.006	0.005	0.132	0.001	0.006	0.002	0.002

Primary non-ferrous metal production is not associated with major dioxin emissions to air. From secondary processes, however, dioxin emissions are known to occur. No information has been available for the smaller secondary non-ferrous metal smelters, but data have been obtained from the large non-ferrous smelter mentioned above. Dioxin emissions during 2001, for different processes at the smelter, are displayed in Table 9.29. Emission measurements started ca 1985, but we have only been able to find emission data from 1990 onwards, displayed in Table 9.30 (pers. comm. with M. Borell). The major dioxin sources are metal recovery from electronic waste (associated with secondary production of several metals including copper) and secondary zinc production. These emissions display variations over time (Figure 9.6). While the decline in emission from electronic waste recovery is due to improved flue gas cleaning that was installed in November 1997, there is no obvious explanation for the increasing emissions from secondary zinc production.

Table 9.29 Dioxin emissions from the large metal smelting plant during 2001, according to their environmental report.

Activity	TEQ gram/yr
Clinker plant	0.14
Converter ventilation	0.022
Sulphuric acid production	0.002
Sulphur products	0.02
“Slagfuming” (secondary Zn)	1.48
Lead kaldo (recovery of electronic waste)	0.034
Sum	**1.698**

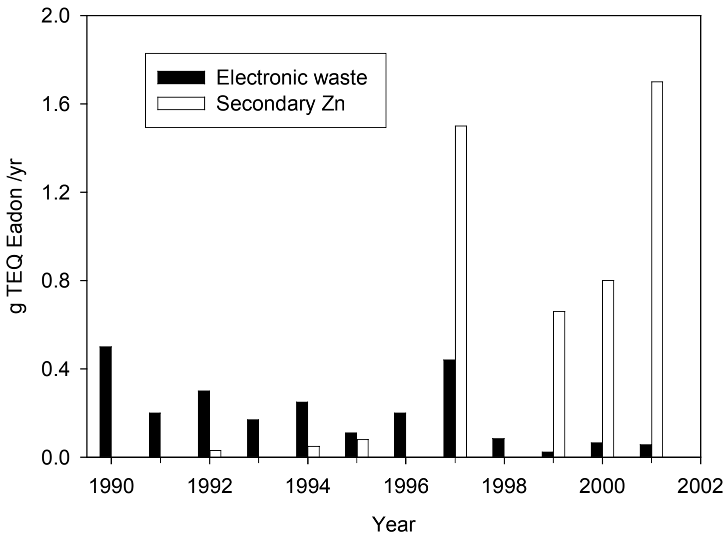

Figure 9.6 **Dioxin emissions from the large metal smelting plant during 1990-2001.**

Table 9.30 **Total dioxin emissions from the metal smelting plant 1990-2001**

Year	Dioxins
	g TEQ
1990	0.53
1991	0.23
1992	0.33
1993	0.21
1994	0.3
1995	0.19
1996	0.28
1997	1.94
1998	0.744
1999	0.684
2000	0.866
2001	1.756

9.5.4. Particles and PAH from primary aluminium production (2C)

There is only one primary aluminium production facility in Sweden. The facility consists of two plants. The first plant includes 56 closed pre-baked ovens, each of 150 kA. In the second plant, there are 3 pre-baked ovens and 259 open ovens with so-called Söderberg anodes. The anodes are produced in the electrode pulp factory. The time series of emissions that have been compiled from primary aluminium production include emissions of particles and PAH.

Information concerning production statistics and emissions of TSP and BaP were provided by industry, and only a few missing years have had to be interpolated.

The particle size fractions of PM_{10} and $PM_{2.5}$ have been assumed for the whole time period, as given in the CEPMEIP-project for primary aluminium production. The assumption is thus that PM_{10} constitutes 95% and $PM_{2.5}$ 43% of the reported TSP emissions.

Emissions of benzo(a)pyrene and “PAH” have been reported from the facility as far back as 1984. It is not known which compounds are included in the term “PAH”. In 1984 and 1986, BaP emissions occurred from plant 1 and 2. From 1987 and onwards, emissions were reported to occur only from plant 2, which represents the production of Söderberg anodes and anode baking in the so-called Söderberg ovens.

The reported BaP emissions were given in g/h, which was converted to g/year, given an annual operation time of 8760 h. Emission factors expressed in g/ton were then derived based on the annually produced amounts of Al. For some missing years, the emission factors were interpolated.

Table 9.31 shows derived emission factors for the four PAH substances, where the profile between BaP and the other three PAH substances was obtained from the Emission Inventory Guidebook (EEA, 2001).

Table 9.31 Emission factors (g/ton Al) for BaP, BkF+BbF and Ind for aluminium production in Sweden (Industrial information for BaP, profiles from EEA, 2001)

Year	*1984*	*1985**	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996**	*1997*	*1998*	*1999*	*2000*	*2001*
BaP	22.4	19.7	16.9	5.9	12.6	17.9	14.4	19.1	13	10.4	13	13.7	15.7	9	17.4	22.9	11.1	13.9
BkF + BbF	49.4	43.3	37.2	13	27.8	39.3	31.7	42	28.6	22.8	28.5	30.1	34.6	19.9	38.2	50.4	24.4	30.5
Ind	11.2	9.8	8.5	2.9	6.3	8.9	7.2	9.5	6.5	5.2	6.5	6.8	7.9	4.5	8.7	11.4	5.6	6.9

* Interpolated emission factors for BaP.

Time series of production statistics and of reported emissions of TSP and benzo(a)pyrene, as well as calulated emissions of PM_{10}, $PM_{2.5}$, benzo(b)fluoranthen +benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene and the resulting sum of PAH-4 are presented in Table 9.32. The estimated time series of PAH emissions are also presented in Figure 9.7.

Table 9.32 Total production and emissions of particles and PAH-species from primary aluminium production, 1980-2001.

	Production, of aluminium (kton)	TSP (ton)	PM_{10} (ton)	$PM_{2.5}$ (ton)	benso(a)pyrene,BaP (ton)	benso(b)fluoranthene+ benso(k)fluoranthene BbF+ BkF (ton)	Indeno(1,2,3-cd)pyrene ind (ton)	Total PAH-4 (ton)
1980	81.2	485	461	207	na*	na	na	na
1981	83.5	474	450	203	na	na	na	na
1982	78.6	447	424	191	na	na	na	na
1983	82.0	389	369	166	na	na	na	na
1984	82.8	535	508	229	1.8	4.1	0.9	6.87
1985	83.5	385	365	164	1.6	3.6	0.8	6.08
1986	77.7	287	273	123	1.3	2.9	0.6	4.86
1987	81.5	110	105	47	0.4	1.0	0.2	1.62
1988	99.2	148	141	63	1.0	2.1	0.5	3.56
1989	97.0	261	248	112	1.3	2.9	0.6	4.86
1990	96.3	325	309	139	1.0	2.3	0.5	3.89
1991	96.9	258	245	110	1.4	3.1	0.7	5.19
1992	77.2	216	206	92	0.7	1.5	0.4	2.59
1993	82.4	215	204	92	0.6	1.3	0.3	2.27
1994	83.9	203	193	87	0.8	1.7	0.4	2.92
1995	95.1	247	235	106	1.0	2.2	0.5	3.66
1996	98.7	190	181	81	1.2	2.6	0.6	4.40
1997	98.8	228	216	97	0.7	1.5	0.3	2.53
1998	96.3	344	327	147	1.3	2.8	0.6	4.70
1999	99.3	247	235	106	1.7	3.8	0.9	6.45
2000	101.3	223	212	95	0.9	1.9	0.4	3.21
2001	101.8	214	203	91	1.1	2.4	0.5	4.05

* na, not available

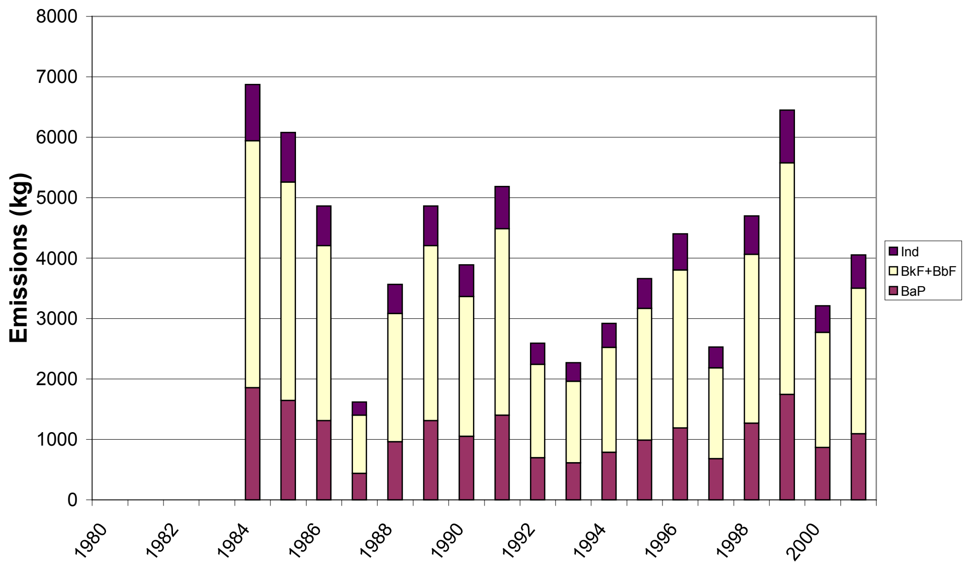

Figure 9.7 Estimated emissions of PAH-4 between 1984 and 2001 from primary aluminium production, based on reported BaP emissions.

According to UNEP (2001) primary production of aluminium has no significant emissions of dioxins to air. This was confirmed by mesurements made at the facility in the late 1970´s and early 1980´. The measurements in the early 1980´s did not result in any detectable amounts.

9.5.5. Dioxins from secondary aluminium production

The secondary production of aluminium in Sweden has amounted to ca 25 000 ton/yr during 1995-2000 (USGS, 2000). Compared to primary aluminium production, this process has a stronger potential for dioxin formation due to impurities, e.g. various plastics, in the metal source. The environmental report for 2001 from one of the major plants shows that 0.063 g TEQ was emitted to air and that 29 560 ton Al was produced. This translates to an emission factor of 2 µg TEQ/ton Al, compared to the range of 0.5-150 µg TEQ/ton Al presented in UNEP (2001). No emission data has been found for previous years. While considering the wide range of default emission factors and the apparently low contribution of this activity to the national total, no estimates for previous years have been done.

9.6. Other production (2D)

9.6.1. Particles, metals, PAH and dioxins from the pulp and paper industry (2D1)

Forty-two individual pulp and paper facilities are included in the estimates, as well as two manufacturers of board. The kraft process is dominating in Sweden but there are also six sulphite and 14 CTMP (Chemo Thermo Mechanical Pulp) or TMP (Thermo Mechanical Pulp) facilities.

Time series of emissions of TSP, PM_{10}, $PM_{2.5}$, metals, dioxins and PAH-4 for the period 1980-2001 have been compiled. Calculations were made based on production statistics, emission factors and for the size distribution of particles, expert judgement. Emission factors were derived based on reported data from different plants and on information from published reports (as referred below). Calculated emission factors are presented in Table 9.33 to Table 9.36.

The emission factors for particles have, when considered neccessary, been separately assigned for the sulfite and the Kraft process (Table 9.36). (EPA 1997, Moisio 1999, SSVL 24 Branschutredningar DP 8, SSVL 85-Rapport nr 53)

The emission factors for metals that are presented in Table 9.33 represent conditions during the 1980´s, and are primarily derived from actual measurement results (EPA 1997, SSVL Miljö 2000 Rapport nr 2, NCASI-reports and internal IVL material). These emission factors refer to emission per produced unit, and are used to estimate emissions during the 1980´s. From around 1990 abatement techniques were more widely introduced, resulting in a total lowering of particle emissions/unit produced, and also in a changed composition of the particle emissions towards a larger share of smaller particles. The emitted particle bound metals are to a large extent associated with the smaller particles. This fact has been considered in the estimates of metal emissions, in such a way that between 1991-2001 the metal emissions have been assumed to constitute a larger share of the calculated TSP-emissions see also chapter 7.5. (Table 9.34). For Hg, which primarily is emitted in gaseous form, the emission factor in Table

9.33 has been used for the whole time period. Arsenic (As) has been treated similarly, since it is emitted partly in gaseous form.

The emission factor for dioxin in Table 9.35 is valid for 1995-2001, when chlorine bleaching had been phased out. Between 1980-1994 the emission factor, 0.06 µg/ton, has been multiplied with a factor of 5 in the beginning of the 1980´s down to a factor of 1.2 in 1994.

Table 9.33 Emission factors for metals from pulp production, valid for the 1980´s (mg/t90[#]).

Substance	Emission factor, Kraft process 1980-1990	Emission factor, Sulfite process 1980-1990	Unit
As	0.02	0.002	mg/t90
Cd	0.013	*	mg/t90
Cr	0.032	0.01	mg/t90
Cu	0.060	0.1	mg/t90
Hg**	0.002	*	mg/t90
Ni	0.070	*	mg/t90
Pb	0.060	*	mg/t90
Zn	0.120	*	mg/t90

[#] t90, 90% of the production in ton, a measure of product to the market
*Emission factor for the Sulfite process is the same as for the Kraft process
** Valid for the whole time period, 1980-2001

Table 9.34 Calculated emission factors for metals in relation to emitted TSP for pulp and paper production.

	Cd	Cr	Cu	Ni	Pb	Zn
Year			kg/ton TSP			
1980	0.005	0.01	0.04	0.001	0.03	0.02
1985	0.007	0.02	0.05	0.001	0.04	0.03
1990	0.009	0.02	0.07	0.001	0.05	0.04
1995	0.010	0.02	0.07	0.002	0.05	0.05
2000	0.012	0.03	0.08	0.003	0.06	0.05

Table 9.35 Emission factors for PAH-4 (1980-2001) and for dioxins (1995-2001).

Substance	Emission factor	Unit
PAH(4)*	0.0022	g/t90
Dioxin**	0.06	µg/t90

* valid for the whole time period
** valid for 1995-2001

Table 9.36 Time series of emission factors for particles and dioxin, 1980-2001.

Year	Kraft process Black liqour recovery furnace	Kraft process Smelt dissolver	Kraft process Lime kiln	Sulfite process	Both processes		
	TSP	TSP	TSP	TSP	PM_{10}	$PM_{2.5}$	Dioxin
	kg/ton	kg/ton	kg/ton	kg/ton	fraction of TSP	fraction of TSP	factor*
1980	2.0	0.25	0.3	2.0	0.85	0.60	5*EF
1981	1.9	0.25	0.3	1.7	0.85	0.60	5*EF
1982	1.8	0.25	0.3	1.7	0.85	0.60	5*EF
1983	1.7	0.25	0.3	1.5	0.85	0.60	5*EF
1984	1.6	0.25	0.3	1.5	0.85	0.60	5*EF
1985	1.5	0.25	0.3	1.2	0.85	0.60	4*EF
1986	1.4	0.25	0.3	1.2	0.90	0.65	4*EF
1987	1.3	0.25	0.3	0.9	0.90	0.65	3*EF
1988	1.2	0.25	0.3	0.7	0.90	0.65	3*EF
1989	1.1	0.25	0.3	0.6	0.90	0.65	2*EF
1990	1.0	0.25	0.3	0.5	0.90	0.65	2*EF
1991	0.9	0.25	0.3	0.4	0.95	0.70	1.5*EF
1992	0.9	0.25	0.3	0.2	0.95	0.70	1.5*EF
1993	0.9	0.25	0.3	0.1	0.95	0.70	1.2*EF
1994	0.7	0.25	0.3	0.1	0.95	0.70	1.2*EF
1995	0.6	0.25	0.3	0.1	0.95	0.70	1*EF
1996	0.6	0.25	0.25	0.1	0.95	0.75	1*EF
1997	0.5	0.25	0.25	0.1	0.95	0.75	1*EF
1998	0.5	0.25	0.25	0.1	0.95	0.75	1*EF
1999	0.5	0.15	0.20	0.1	0.95	0.75	1*EF
2000	0.4	0.15	0.20	0.1	0.95	0.75	1*EF
2001	0.4	0.15	0.20	0.1	0.95	0.75	1*EF

* EF= emission factor for 1995-2001 (Table 9.35).

Estimated time series of emissions from the pulp and paper industry for 1980-2001 are presented in Table 9.37. The emissions of PAH 4 are very low (0.01-0.02 ton/year), and the dioxin emissions have decreased from this source from approximately 2 g TEQ/year in the early 1980´s to about 0.5 g TEQ/year in later years (Miljövänlig tillverkning av blekt massa. Rapport nr 96, SSVL85 Rapport nr 28, SSVL Miljö 90 Rapport nr 1, SSVL Miljö 90 Rapport nr 80). In Figure 9.8 the estimated particle emissions are shown, together with production statistics. The figure shows that the specific emissions of particles have decreased substantially over this period of time. The emissions of metals (Figure 9.9) have also declined but according to the discussion above not as much, relatively, as the decrease in TSP emissions. The smaller particles, which in later years constitutes a relatively larger share of the TSP emissions, contains proportionally more metals.

Table 9.37 Emissions from pulp and paper production 1980-2001.

Year	TSP ton	PM_{10} ton	$PM_{2.5}$ ton	PAH-4 ton	Dioxin g TEQ	As ton	Cd ton	Cr ton	Cu ton	Hg ton	Ni ton	Pb ton	Zn ton
1980	15770	13410	9460	0.01	1.9	0.11	0.08	0.18	0.60	0.01	0.45	0.38	0.77
1981	14890	12660	8940	0.01	1.9	0.12	0.08	0.18	0.60	0.01	0.45	0.38	0.76
1982	12930	10990	7760	0.01	1.7	0.11	0.07	0.17	0.54	0.01	0.40	0.34	0.69
1983	13930	11840	8360	0.01	1.9	0.12	0.08	0.19	0.61	0.01	0.45	0.39	0.78
1984	14190	12060	8520	0.02	2.1	0.13	0.09	0.20	0.65	0.01	0.48	0.41	0.82
1985	12830	10900	7700	0.01	1.6	0.12	0.09	0.19	0.63	0.01	0.46	0.39	0.79
1986	12420	11180	8070	0.01	1.6	0.13	0.09	0.20	0.64	0.01	0.46	0.40	0.80
1987	12170	10950	7910	0.02	1.3	0.13	0.09	0.21	0.67	0.01	0.49	0.42	0.83
1988	11660	10500	7580	0.02	1.3	0.14	0.09	0.21	0.68	0.01	0.50	0.43	0.85
1989	10850	9770	7050	0.02	0.8	0.13	0.09	0.21	0.68	0.01	0.49	0.42	0.85
1990	9580	8620	6230	0.01	0.8	0.13	0.09	0.20	0.64	0.01	0.47	0.40	0.80
1991	9290	8830	6500	0.02	0.6	0.13	0.09	0.20	0.65	0.01	0.48	0.42	0.83
1992	9060	8610	6340	0.02	0.6	0.13	0.09	0.19	0.63	0.01	0.47	0.40	0.81
1993	9250	8790	6480	0.02	0.5	0.13	0.09	0.20	0.67	0.01	0.49	0.42	0.85
1994	7940	7540	5550	0.02	0.5	0.11	0.08	0.17	0.57	0.01	0.42	0.36	0.72
1995	7420	7050	5200	0.02	0.4	0.11	0.07	0.17	0.54	0.01	0.40	0.34	0.68
1996	7020	6660	5260	0.02	0.4	0.10	0.07	0.15	0.50	0.01	0.37	0.32	0.63
1997	6800	6460	5100	0.02	0.5	0.11	0.07	0.16	0.52	0.02	0.38	0.33	0.65
1998	6710	6370	5030	0.02	0.5	0.10	0.07	0.15	0.50	0.02	0.37	0.32	0.63
1999	5820	5520	4360	0.02	0.5	0.09	0.06	0.14	0.44	0.02	0.32	0.28	0.56
2000	5760	5480	4320	0.02	0.5	0.10	0.07	0.15	0.49	0.02	0.36	0.31	0.61
2001	5720	5430	4290	0.02	0.5	0.10	0.07	0.15	0.48	0.02	0.35	0.30	0.60

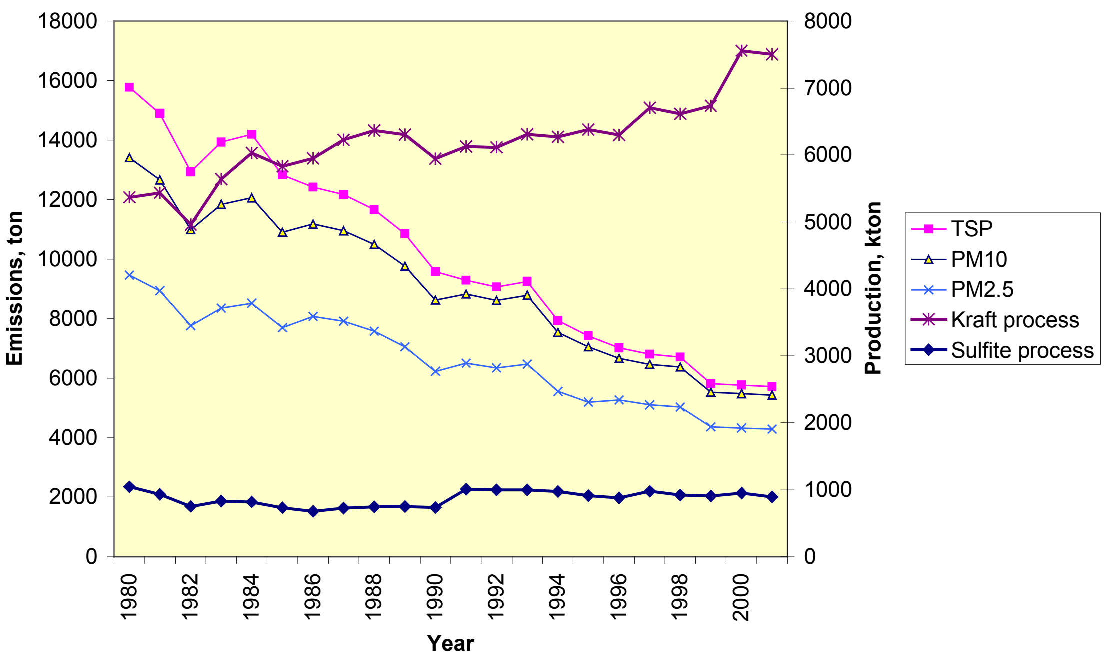

Figure 9.8 Emissions of particles from pulp production (ton) and production statistics for the Kraft process and Sulfite process (kton).

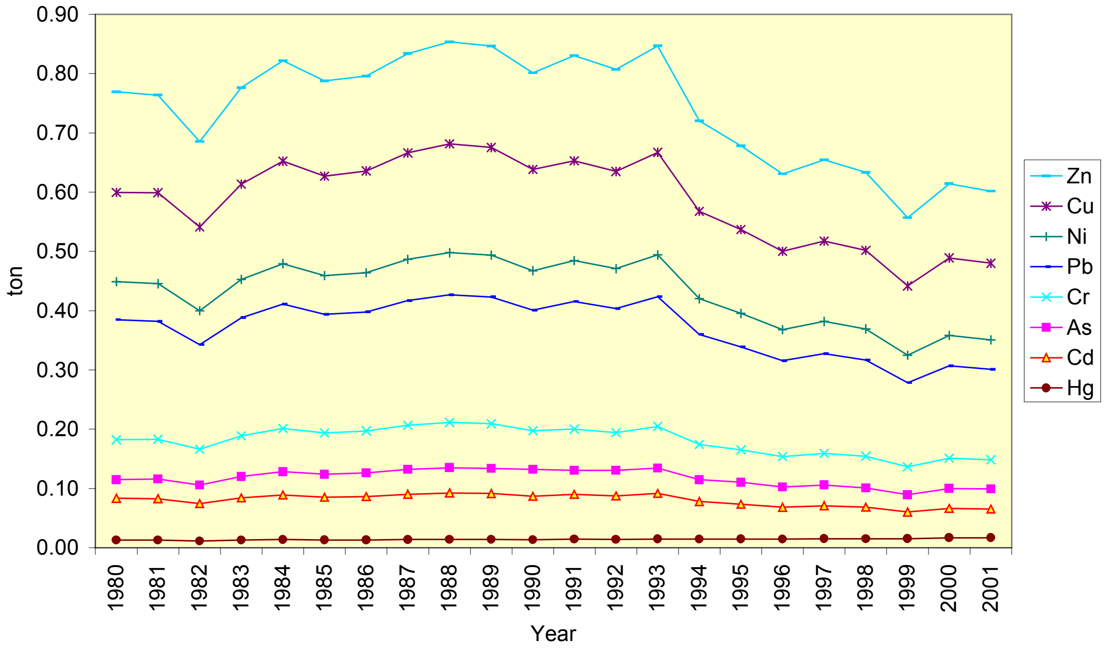

Figure 9.9 Emissions of metals from pulp- and paper production 1980-2001 (ton)

10. Solvent and product use (NFR 3)

Emissions from tobacco smoking, the use of fireworks and from the wood preservation industry were studied as sources to emissions from product use. From tobacco smoking, emissions of particles and PAH were estimated and from fireworks only the particle emissions. Dioxin emissions from the wood preservation industry are discussed and stated to be negligible.

The time series for particulate emissions have been compiled for 1980-2001. Calculations were based on activity data from statistics on sold amount of tobacco (Statistical yearbook of Sweden) and fireworks (Sweden´s Statistical Databases) respectively. Emission factors from the CEPMEIP study have been used. All particle emissions are considered to consist only of small particles, $PM_{2.5}$.There is also some information available on metal emissions from fireworks, and this issue will be studied further in teh future.

10.1. Emissions from solvent and product use

Particle emissions from product use presented in Figure 10.1. The sum of emissions from tobacco smoking and from the use of fireworks has been estimated to about 700 tons in later years. Emissions from tobacco smoking have decreased since less tobacco is sold, while emissions from the use of fireworks have increased, due to an increased use of fireworks.

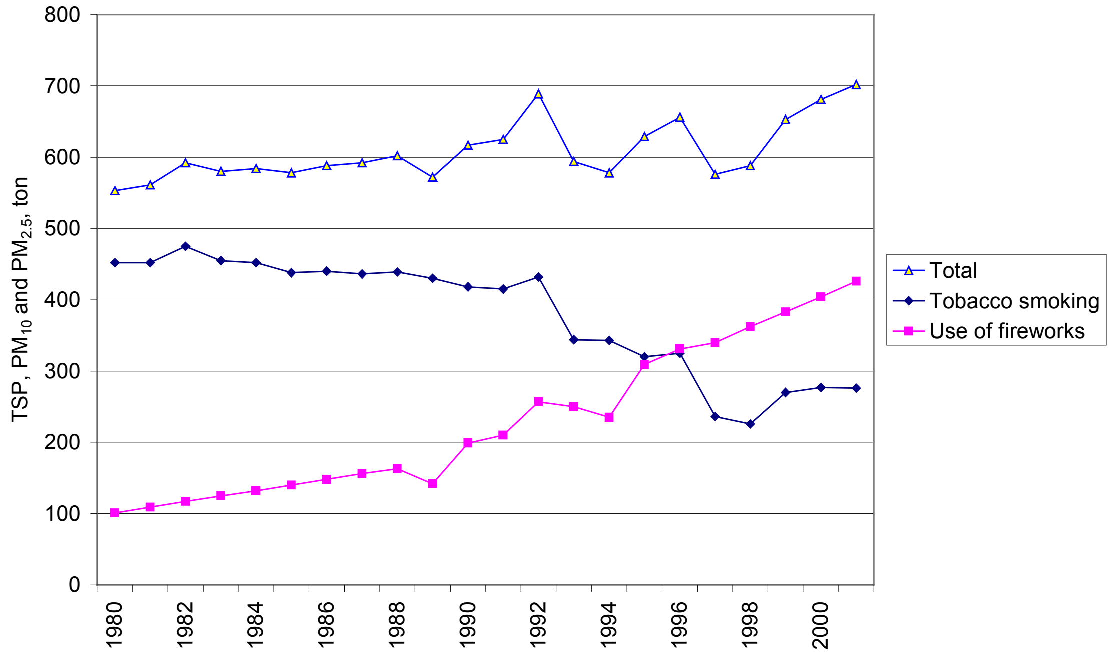

Figure 10.1 Emissions of particles from product use (ton). All particles are considered to be $PM_{2.5}$.

10.1.1. Particles and PAH from tobacco smoking (3D)

Emissions of particles from tobacco smoking were estimated based on official statistical sales figures and the emission factors suggested in the CEPMEIP project. According to CEPMEIP all particles are small and consequently the emission factor the same for TSP, PM_{10} and $PM_{2.5}$. Activity data and estimated emissions are presented in Table 10.1. The statistics on tobacco is given in number of cigars, cigarills and cigarettes. The figure for 1995 on ton tobacco consumed in Sweden according to the CEPMEIP project was used as a conversion factor to calculate tons of tobacco each year from the available statistics.

Rogge et al. (1994) measured emissions of organic substances from cigarette smoking. Several PAH substances were identified in the smoke, however, only one of the four PAHs investigated here was found, at an emission rate of 5.4×10^{-4} mg/cigarette. Multiplied by the total number of cigarettes sold, this yields an annual emission of PAH-4 of **0.8 g**, which can be regarded as negligible. Although a significant additional number of cigarettes is likely to be consumed, as a result of smuggling, the emissions are assumed to be insignificant in comparison to other sources. Cigarettes were thus not further considered as emission source for PAHs in this inventory.

Table 10.1 Activity data, emission factor and emissions of particles from tobacco smoking.

Year	ton tobacco	Emission factor for TSP, PM_{10} and $PM_{2.5}$ ton/ton	Emissions of TSP, PM_{10} and $PM_{2.5}$ ton
1980	11300*	0.04	452
1981	11306	0.04	452
1982	11865	0.04	475
1983	11365	0.04	455
1984	11302	0.04	452
1985	10954	0.04	438
1986	11009	0.04	440
1987	10900	0.04	436
1988	10981	0.04	439
1989	10747	0.04	430
1990	10449	0.04	418
1991	10387	0.04	415
1992	10796	0.04	432
1993	8592	0.04	344
1994	8568	0.04	343
1995	7988	0.04	320
1996	8132	0.04	325
1997	5905	0.04	236
1998	5650	0.04	226
1999	6748	0.04	270
2000	6932	0.04	277
2001	6900*	0.04	276

* No data available, data have been assumed.

10.1.2. Particles from the use of fireworks (3D)

Particle emissions from the use of fireworks have been estimated based on sales statistics and emission factors from the CEPMEIP project. The sales statistics is available from 1988-2001, given as ton fireworks sold. In the CEPMEIP project an emission factor is suggested as ton particulate matter/inhabitant. Using the information for 1995 on this emission factor, number of inhabitants and tons of fireworks sold an emission factor of 0.156 ton PM/ton fireworks could be calculated. According to CEPMEIP all particles emitted are $PM_{2.5}$. The activity data for 1980-1987 have been assumed, based on the available data for the later period, which show an increasing trend in the use of fireworks. An increasing tendency has been applied also to the years where activity data are lacking. In Table 10.2 activity data and calculated emissions are presented. The particle emissions from this source are small compared to most other national sources.

Table 10.2 Activity data and emissions of particles for the use of fireworks. Activity data for 1980-1987 have been assumed.

Year	Import (ton)	Emissions of TSP, PM_{10} and $PM_{2.5}$ (ton)
1980	650	101
1981	700	109
1982	750	117
1983	800	125
1984	850	132
1985	900	140
1986	950	148
1987	1000	156
1988	1045	163
1989	909	142
1990	1276	199
1991	1350	210
1992	1652	257
1993	1606	250
1994	1512	235
1995	1985	309
1996	2123	331
1997	2184	340
1998	2322	362
1999	2460	383
2000	2598	404
2001	2736	426

10.1.3. Dioxin from the wood preservation industry

In the European Dioxin Inventory (EDI) it is estimated that ca 8 g TEQ/yr is emitted from wood preservation with pentachlorophenol in Sweden. This is based on an uncorrect assumption, because the use of PCP has not been permitted since 1978 in Sweden. The conclusion is that there is no reason to believe that wood preservation in Sweden is associated with significant dioxin emissions.

11. Agriculture (NFR 4)

Included in the estimates of particles from agricultural activities for 1980-2001 are emissions from handling of fertilisers, from handling of crops and particulate emissions from livestock farming. All emission factors are as suggested in the CEPMEIP study, and no changes in emission factors over time have been assumed.

The calulated emissions of TSP from the agricultural sector are substantial, where the major part according to the calculations arises from livestock farming (Figure 11.1). In later years estimated TSP emissions from livestock farming contribute approximately 8% of the calculated national total emissions of TSP. Unlike most other sources, the fraction of large particles is comparatively high from these sources (Figure 11.2). The contribution to the national totals of PM_{10} and $PM_{2.5}$ is thus lower, relatively, than for TSP.

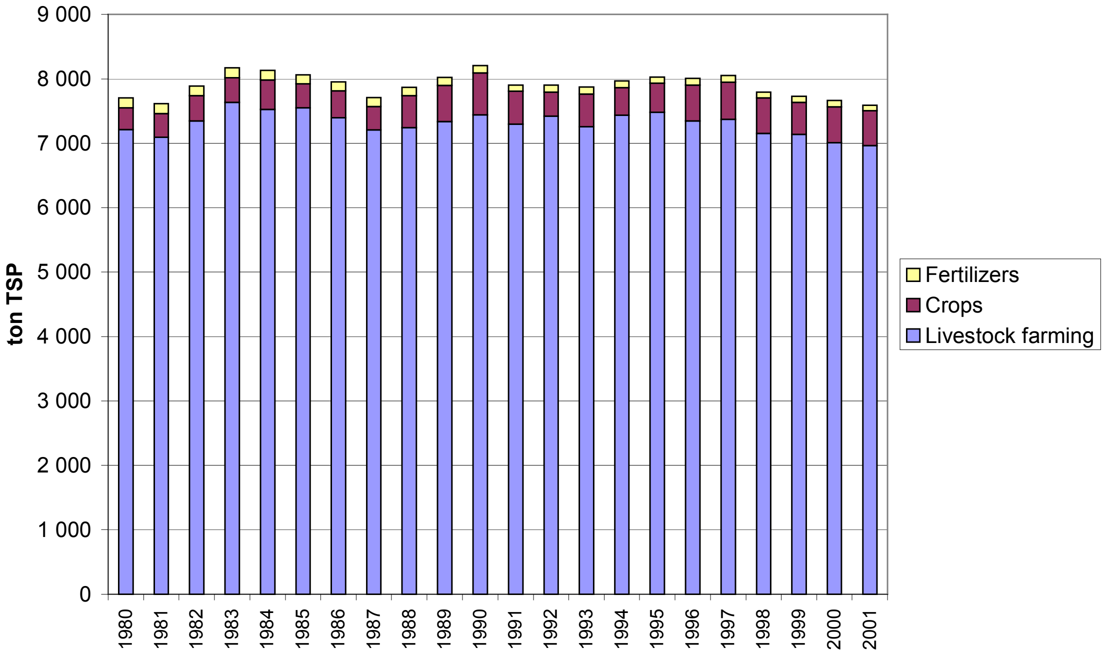

Figure 11.1 Estimated emissions of TSP from the agricultural sector, ton TSP.

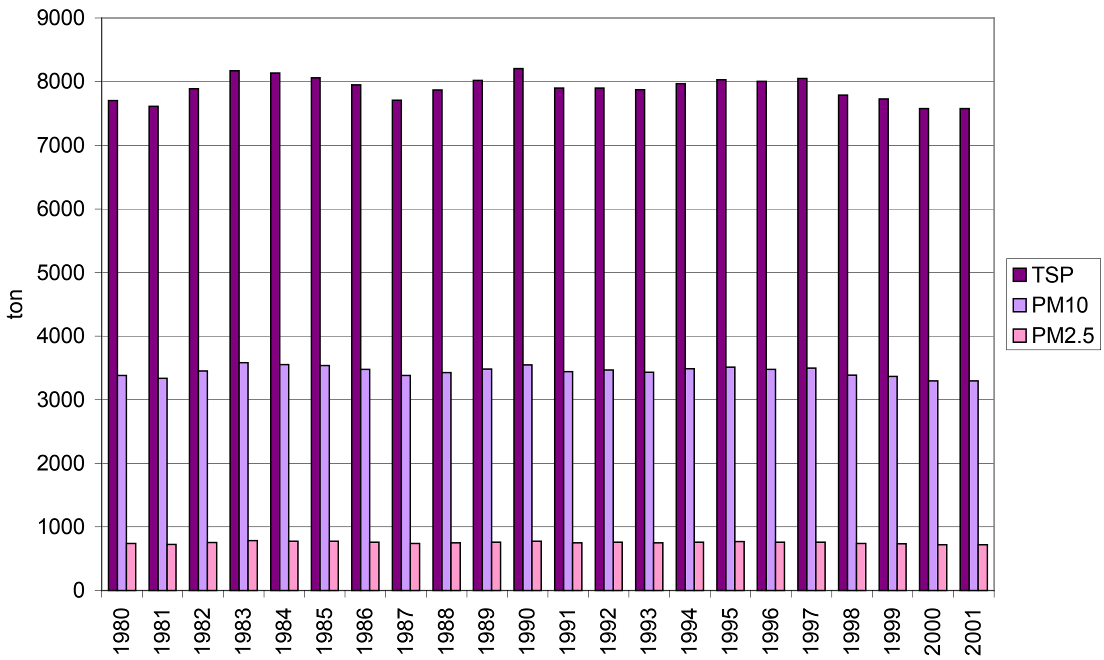

Figure 11.2 Calcualted emissions of TSP, PM_{10} and $PM_{2.5}$ from the agricultural sector.

11.1. Activity data for the agricultural sector

Estimates of emissions from fertilizer use are based on activity data from official statistics on sold amount of commercial fertilizer to agriculture and horticulture

(Yearbook of Agricultural Statistics). The fertilizers taken into consideration are both single and combined fertilizers.

Particle emissions from handling of crop have been estimated based on official statistics where activity data have been aggregated and include figures on harvested and imported amounts of wheat, oat, barley, rye, sorghum, buckwheat, maize and leguminous plants.

Activity data used to estimate particle emissions from livestock farming were from statistics on the number of animals, using the sub-groups cattle (including horses), pigs, chicken and other poultry.

11.2. Emissions of from the agricultural sector (4G)

11.2.1. Particles from storage and handling of fertilizers

Emissions of particles from storage and handling of fertilizers have been estimated based on national sales statistics on single and combined artificial fertilizers, and emission factors suggested by the CEPMEIP project (Table 11.1). The results of the calculation, as well as the activity data as sold amount of fertilizer are presented in Table 11.2.

Table 11.1 Emission factors for particles from storage and handling of fertilizers (from the CEPMEIP project).

TSP	PM_{10}	$PM_{2.5}$	
0.0001	0.000032	0.000004	ton/ton

Table 11.2 Sold amount of fertilizers and calculated particle emissions from storage and handling of fertilizers 1980-2001.

Year	Sold amount of fertilizer	Emission TSP	Emission PM_{10}	Emission $PM_{2.5}$
	kton	ton	ton	ton
1980	1495	150	48	6
1981	1523	152	49	6
1982	1542	154	49	6
1983	1571	157	50	6
1984	1498	150	48	6
1985	1404	140	45	6
1986	1380	138	44	6
1987	1341	134	43	5
1988	1314	131	42	5
1989	1247	125	40	5
1990	1131	113	36	5
1991	900	90	29	4
1992	1047	105	33	4
1993	1105	111	35	4
1994	1051	105	34	4
1995	967	97	31	4
1996	1028	103	33	4
1997	1036	104	33	4
1998	882	88	28	4
1999	954	95	31	4
2000	950*	95	30	4
2001	950*	95	30	4

* Data for 2000 and 2001 were not available and have been assumed

11.2.2. Particles from storage and handling of agricultural crops

Particle emissions from storage and handling of agricultural crops (and products) were calculated based on official statistics on production and import. Crops considered were wheat, oat, barley, rye, sorghum, buckwheat, maize and leguminous plants. Emission factors from CEPMEIP were used for the entire time period 1980-2001. No distinction between emission factors for different crops is made by CEPMEIP, and all crops are assigned the same emission factors (Table 11.3). The sum of the amounts of produced (harvested) and imported crop as well as calculated emissions of particles is presented in Table 11.4.

Table 11.3 Emissions factors for particles from storage and handling of crops (from CEPMEIP).

TSP (ton/ton)	PM_{10} (ton/ton)	$PM_{2.5}$ (ton/ton)
0.0001	0.000025	0.000004

Table 11.4 Total amount of crop, imported and produced, and emissions of particles 1980-2001.

Year	Amount of crop (kton)	Emissions		
		TSP (ton)	PM_{10} (ton)	$PM_{2.5}$ (ton)
1980	3415	342	85	14
1981	3669	367	92	15
1982	3916	392	98	16
1983	3822	382	96	15
1984	4585	459	115	18
1985	3718	372	93	15
1986	4148	415	104	17
1987	3683	368	92	15
1988	4932	493	123	20
1989	5602	560	140	22
1990	6490	649	162	26
1991	5157	516	129	21
1992	3764	376	94	15
1993	5060	506	126	20
1994	4276	428	107	17
1995	4494	449	112	18
1996	5600	560	140	22
1997	5754	575	144	23
1998	5493	549	137	22
1999	4969	497	124	20
2000	5604	560	140	22
2001	5604	560	140	22

*Activity data for 2001 were not available and have been assumed to equal 2000

11.2.3. Particle emissions from livestock farming

Statistics on the number of cattle, pigs, chicken (slaughter chicken from The Swedish Poultry Meat Association), other poultry and horses (information from the Riding Association) was used together with emission factors from the CEPMEIP project (Table 11.5) to estimate particle emissions from livestock farming. Emission factors are based on measurements from North European stables (Takai et al, 1998) and are considered primarily to arise from feeding activities, faecal material and from bedding, with lesser contributions from skin, hair, mould, pollen grains and insect parts (Klimont et al 2002). No national information concerning particle emissions from this source is available. The calculated time series of emissions is presented in Table 11.6. According to the calculations it constitutes quite a large part of the total national emissions, especially of TSP.

Table 11.5 Emission factors for particle emissions from livestock farming.

CEPMEIP	EF TSP	EF PM_{10}	EF $PM_{2.5}$	
poultry, chickens	8.3093E-05	3.7429E-05	8.3093E-06	ton/year/animal
poultry, other poultry	0.00055395	0.00024953	5.5395E-05	ton/year/animal
live stock, pigs	0.00060628	0.0002731	6.0628E-05	ton/year/animal
stock, cattle	0.00088825	0.00040011	8.8825E-05	ton/year/animal

Table 11.6 Estimated emissions of particles from livestock farming 1980-2001.

Year	TSP ton	PM_{10} ton	$PM_{2.5}$ ton
1980	7211	3248	721
1981	7094	3195	709
1982	7343	3308	734
1983	7634	3439	763
1984	7524	3389	752
1985	7549	3400	755
1986	7397	3332	740
1987	7204	3245	720
1988	7242	3262	724
1989	7334	3304	733
1990	7441	3352	744
1991	7294	3286	729
1992	7418	3342	742
1993	7256	3269	726
1994	7433	3348	743
1995	7482	3370	748
1996	7343	3308	734
1997	7371	3320	737
1998	7152	3222	715
1999	7136	3214	714
2000	7005	3155	701
*2001	7005	3155	701

*Data on number of animals for 2001 have been assumed equal to 2000, no new information available.

12. Waste (NFR 6)

Emission estimates from the waste sector include incineration of hazardous waste (including also cremation) and also various types of fires such as forest fires, landfill fires, bonfires and open burning of garden waste. Combustion of municipal waste is accounted for in the energy sector, since it is used as fuel for energy production (Chapter 7).

The emitted substances that were covered in the waste sector are mercury (Hg), dioxins, PAH-4 and particles.

For accidental fires, activity data as to annual forested area affected by forest fires, has been obtained from the Swedish Rescue Services Agency (Räddningsverket) for the period 1996-2000. Information on forest volume and species corresponding to this area was obtained from "ForestSweden on the Internet" (www.skogssverige.se). In order to estimate emission of PAH, emission factors from USEPA were used, while emission factors for open burning of waste suggested by CEPMEIP were used to estimate emissions of TSP, PM_{10} and $PM_{2.5}$.

12.1. Emissions from incineration of hazardous waste (6C)

12.1.1. Mercury, PAH and dioxins from cremation

Estimated emissions of mercury, Hg, (1990-2001), PAH-4 (1980-2001) and dioxin (1980-2001) from cremation have been calculated based on emission factors and statistics on number of annual cremations. For mercury, from the late 1990´s abatement techniques have been considered in the estimations of mercury emission. An expert (Åkesson, regional county administration, Skåne) has provided emission estimates for Hg, given for each year as an interval. Reported emissions are the average of the intervals. In Table 12.1 the calculated implied emission factors for mercury are presented. Emission factors used to calculate PAH-emissions from cremation are from USEPA and for dioxin a suggested emission factor from the European Dioxin Inventory was used.

UNEP presents emission factors for dioxins in the range 0.4 – 90 µg TEQ/cremation, while the earlier Swedish Inventory (deWit, unpubl) suggested 6-12 µg TEQ/cremation, referred in the European Dioxin Inventory. An average of 9 µg TEQ/cremation has been selected in the present emission estimates (Table 12.1). This agrees with a recent experimental study (6-13 µg TEQ/cremation; Wang et al., 2003). The number of annual cremations has increased from 47 000 to 65 000 over the period, and associated dioxin emissions have thus increased from 0.42 g TEQ in 1980 to 0.58 g TEQ during 2001.

For PAH, only benzo(a)pyrene is considered to be emitted from cremation according to USEPA (1998). Calculated emissions of BaP from cremation are presented in Table 12.2, from which it is clear that the emissions of benzo(a)pyrene are very small.

Table 12.1 Emission factors for dioxins, benso(a)pyrene and mercury from cremation.

Substance	Time period	Emission factor	Unit	Reference
Dioxin	1980-2001	9	µg TEQ/cremation	derived from EDI
B(a)P	1980-2001	0.0001	mg/cremation	US EPA
Hg	1980-1991	0.004	kg/cremation	Calculated implied emission factor
Hg	1992-1995	0.005	kg/cremation	-"-
Hg	1996-1997	0.004	kg/cremation	-"-
Hg	1998-1999	0.003	kg/cremation	-"-
Hg	2000-2001	0.002	kg/cremation	-"-

Table 12.2 Time series of annual estimated emissions of mercury (Hg), dioxins and benzo(a)pyrene from cremation 1980-2001.

		Emissions		
Year	Number of cremations	Hg ton	Dioxin g TEQ	benzo(a)pyrene ton
1980	47 130	0.20	0.42	4.71E-09
1981	48 286	0.20	0.43	4.83E-09
1982	48 930	0.20	0.44	4.89E-09
1983	49 426	0.21	0.44	4.94E-09
1984	49 866	0.21	0.45	4.99E-09
1985	52 828	0.22	0.48	5.28E-09
1986	53 307	0.23	0.48	5.33E-09
1987	54 689	0.23	0.49	5.47E-09
1988	56 366	0.24	0.51	5.64E-09
1989	56 201	0.25	0.51	5.62E-09
1990	58 093	0.26	0.52	5.81E-09
1991	59 607	0.27	0.54	5.96E-09
1992	60 385	0.28	0.54	6.04E-09
1993	61 237	0.29	0.55	6.12E-09
1994	60 221	0.29	0.54	6.02E-09
1995	60 824	0.29	0.55	6.08E-09
1996	61 734	0.28	0.56	6.17E-09
1997	62 953	0.27	0.57	6.3E-09
1998	63 273	0.22	0.57	6.33E-09
1999	64 814	0.18	0.58	6.48E-09
2000	64 867	0.12	0.58	6.49E-09
2001	*65 000	0.12	0.58	6.52E-09

* Activity data was not available, 2001 was assumed to equal 2000.

12.1.2. Dioxin emissions from other hazardous waste

Hazardous waste, other than cremation, is incinerated at nine plants in Sweden. There is no information on the total activity of hazardous waste incineration in Sweden. Two of these plants, however, are reported in the category municipal waste. There is a major plant for handling and destruction of hazarduous waste, which is the only one for which we have emission data. The facility was operated with an electric precipitator from the start in 1983 until 1990, from when a textile filter with coal injection replaced the electric precipitator. During 2000, wet flue gas cleaning was installed after the textile filter. Dioxins in flue gases have been measured by spot tests, but are continously measured since June 2001. The plant combusted 31 000 ton of hazardous waste during 2001; the activity has increased over time and was ca 22 000 ton during 1995. Emission data (Table 12.3) were obtained from the facility for the time period 1990-2001. According to their Environmental Report for 2001, dioxin emissions to air were 0.093 g TEQ, which does not corrrespond to the information obtained in direct contact with experts the facility. This difference has not been possible to clarify.

Concerning incineration of medical waste, we are not aware of any national activity data for this source category.

Table 12.3 Dioxin emissions from combustion of hazardous waste at a major plant. This is not the total Swedish activity in this category, but probably a major share.

Year	Emissions (g TEQ/yr)
1990	3.6E-03
1991	3.6E-03
1992	7.2E-04
1993	2.5E-03
1994	3.6E-04
1995	2.1E-03
1996	3.6E-02
1997	3.6E-02
1998	3.6E-02
1999	3.6E-02
2000	5.2E-02
2001	1.4E-02

12.2. Other waste (6D)

12.2.1. PAH from cooking processes (barbecuing, frying)

Most barbecues are driven by charcoal or coal briquettes. Swedish charcoal is mainly based on deciduous wood such as aspen and birch, but to our knowledge, no studies concerning PAH emissions from these have been performed. In a recent Finnish study the total amount of charcoal consumed at barbecuing in Finland was estimated to 18 tonnes per year (Karveosenoja et al. 2002). Assuming similar barbecue habits in Sweden and Finland and scaled on a population basis, that yields a total annual consumption of 33 tonnes charcoal in Sweden. Oanh et al. (1999) have measured emissions of PAH from combustion of Vietnamese coal briquettes and mangrove charcoal. For illustrative purposes, due to lack of data on Swedish charcoal emissions, and to evaluate the possible impact of this source we used the emission factors derived by Oanh et al. (1999; see Table 12.4). Based on the assumptions mentioned above, the total emissions of PAH-4 from barbecuing turn out to be as low as **0.1 kg/year**. Therefore, this source was not further considered in the inventory.

Table 12.4 Emission factors for four PAHs from charcoal burning (Oanh et al. 1999)

Substance	*Charcoal (mangrove)*	*Coal briquettes (from Vietnam)*
	mg/kg fuel	mg/kg fuel
BaP	0.3	0.2
BkF	1.7	0.9
BbF	1.7	0.02
Ind	nd	nd

PAH have also been reported to be emitted from frying processes. This emission source, however, mainly influence the indoor environment. The extent of dispersion to the outdoor environment of these pollutants is difficult to estimate, since there are so many factors involved. In order to assess the PAH emissions to outdoor air from households this source should be investigated in a separate study.

12.2.2. Particles and PAH from garden burning, bonfires and forest fires

Open burning of garden waste could be a significant source of PAH emissions. This combustion process is relatively uncontrolled which can lead to significant emissions. USEPA (1998) specifies emission factors for BaP from uncontrolled burning of garden waste, based on controlled laboratory experiments. The emission factor for BaP is 0.35 g/ton combusted material. There are no national statistics regarding the extent of garden burning and bon fires, although several municipalities have restrictions concerning this kind of activities (Nilsson, J. pers. comm.). A rough estimate can be done, however, in order to investigate the importance of this source category.

A first assumption is that garden burning only occurs in areas with freestanding houses. Furthermore, we assume that about 50 % of these households actually burn their garden waste (which probably is not an underestimate, rather the opposite), and that this takes place three times a year on the average. According to Statistics Sweden, the number of freestanding houses is about 2.2 millions (SCB, 2002). Assuming an average weight of 10 kg of the combusted material, this yields a total combustion of 3.3×10^4 tonnes garden waste.

The basic assumption in the calculation of the contribution of bonfires to PAH emissions, is that each municipality has five bonfires/year on the average. The average mass is assumed to be one ton, which gives a total mass of 1445 ton combusted material, given 289 municipalities.

The total amount of material combusted at garden burning and bon fires is estimated to be 34 700 ton in the year 2000. Multiplied by the emission factor for BaP and the profiles given by EEA (2001) yields a total emission of PAH 4 of **28 kg** in 2000.

Considering forest fires, USEPA specifies emission factors for PAH from combustion of coniferous trees. As the Swedish forest largely consists of coniferous forest (ca 85 %; SLU, 2002), we consider these factors as useable. The average density of a pine is roughly 400 kg/m^3 and the total volume of spruce and pine in Sweden is about 2.45×10^9 m^3 (SLU, 2002), which gives a total mass of about 9.8×10^{11} kg. The total forested area is about 2.3×10^7 ha (SLU, 2002), and according to the Swedish Rescue Services Agency (Räddningsverket) the total forest area burnt in 2000 was 1113 ha, i.e. 0.005 % of the total forest area (Nilsson, J. pers. comm.). Assuming that spruce and pine dominated the burnt forest, the total mass burnt can be calculated as:

$$m_{burnt} = 0.00005 \times 9.8 \times 10^{11} = 47\,500 \text{ ton}$$

Table 12.5 Emission factors for PAH species from forest fires and for particles for open burning of waste.

Substance	*Emission factor*	*Unit*	*Reference*
BaP	0.74	g/ton	*U.S.EPA (1998)(g/ton)*
BbF + BkF	2.57	g/ton	*U.S.EPA (1998)(g/ton)*
Ind	1.7	g/ton	*U.S.EPA (1998)(g/ton)*
TSP	0.008	ton/ton	*CEPMEIP, open burning of waste*
PM10	0.006	ton/ton	*CEPMEIP, open burning of waste*
PM2.5	0.006	ton/ton	*CEPMEIP, open burning of waste*

The Swedish Rescue Services Agency has during the later years acknowledged the environmental impact of fires and suggested a sampling program in connection to fires. A pilot study showed that high levels of PAH were found in smoke and in water that had been used to control the fires, but emission factors and detailed studies concerning emissions from fires are still lacking (Rosén et al., 2001.).

The estimated emissions of particles and PAH from forest fires and garden burning of waste are presented in Table 12.6. As obvious from the discussions above, the data should be considered as indicative levels of emissions from these sources.

Table 12.6 Estimated emissions of particles and PAH from forest fires and garden burning of waste, 1996-2001.

	Forest fires and garden waste	Emissions							
		TSP	PM_{10}	$PM_{2.5}$	BaP	BbF	BkF	Ind	PAH-4
Year	kton burnt	ton	ton	ton	ton	ton	ton	ton	ton
1996	86	687	515	515	0.05	0.14	0.00	0.09	0.29
1997	243	1946	1460	1460	0.17	0.55	0.00	0.36	1.08
1998	43	344	258	258	0.02	0.03	0.00	0.02	0.07
1999	81	647	485	485	0.05	0.13	0.00	0.08	0.26
2000	82	657	493	493	0.05	0.13	0.00	0.09	0.27
2001	244	1953	1464	1256	0.17	0.55	0.00	0.36	1.08

12.2.3. Dioxin emissions from landfill fires

The potential for dioxin formation in landfill fires is obvious, and consequently it has been suggested as a major source in previous inventories (e.g. EDI). A few measurements of dioxin in air during landfill fires have been performed in Sweden. A study performed in 1989 gave concentrations of 220 ng TEQ/m^3 (Bergström och Björner, 1992). With a gas production rate of 5000 m^3/ton waste that was burnt, this translates to an emission factor of 1100 µg TEQ/ton waste. A similar study gave an interval of 50-900 µg TEQ/ton waste that was burnt (Peterson et al., 1996). The higher value was obtained when the waste contained large amounts of chlorinated plastics.

As a comparison, burning of household waste in open barrels resulted in average dioxin emissions of 840 - 3300 µg TEQ/ton (Lemieux et al., 2000). Considering the inherent experimental uncertainties in all these studies, it must be concluded that the studies agree well.

For the purpose of this inventory, a value of 500 µg TEQ/ton waste is selected. It has been estimated that ca 25 000 ton waste burns annually on Swedish landfills (Bergström och Björner, 1992; Ahlgren and Marklund, 2001). There is no temporal resolution of these estimates, why the emission is estimated to 13 g TEQ/yr for the entire period. In agreement with the initial assumptions, landfill fires is a major dioxin source in Sweden at present.

13. Conclusions and suggestions for further work

This study represents a first attempt to compile and estimate emissions of particles, metals, PAHs and dioxins from Sweden, according to the international requirements for reporting of national emissions.

In many cases, for particles, national information did not exist, especially for PM_{10} and $PM_{2.5}$, why international information on emission factors had to be used. The estimates probably do not lack important emission sources, since the CEPMEIP project, even if the suggested emission factors were not always used, provided a comprehensive list of emission sources for particles that should be considered in national emission estimates.

For metals, no comparable international guidance was available, but since metals have been more of a concern for a longer period of time, earlier national studies provided information, especially concerning emission sources that have been considered to be important contributors to metal emissions. All important emission sources are thus probably considered in the estimates.

For dioxins, through the European Dioxin Inventory and guidelines from UNEP (2001), good international guidance on important sources is available, and since these were considered in the current national inventory, the coverage is good. The main problem with dioxins is, generally, the wide intervals given on emission factors, which introduces uncertanties in the emission estimates.

All important sources for emissions of PAH-4, except emissions from mobile sources, were covered in the current estimates, according to information in international background documents (e.g. USEPA, 1998).

Further work should, generally, be directed towards verifying the reported emission levels, especially for sources with substantial contributions to the estimated national emissions of the different substances. Specific issues of further concern are PAH-emissions from mobile sources, which were not reported in the Swedish submission to UNECE/LRTAP in 2003, and also the problem of correctly allocating information from the Energy Statistics to the code system required for international reporting.

A more thorough work, especially on estimating particle emissions, can be expected in many countries in the near future as a result of increasing international attention. Results and experiences from efforts in individual countries and in international bodies such as UNECE would presumably result in more information on emissions and emission factors for different sources, which would justify and facilitate a review and an improvement of the current Swedish estimates.

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15. Appendix 1 Emission factors

TSP stationary combustion

Fuel type	Area of consumption	kg/GJ 1980-81	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Gas/diesel oil	Power plants, district heating, industry	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002
Gas/diesel oil	Other consumption	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003
Residual fuel oil	Power plants, district heating, industry	0.035	0.03	0.02	0.02	0.015	0.015	0.015	0.015	0.015	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Residual fuel oil	Other consumption	0.035	0.03	0.02	0.02	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
LPG	Power plants, district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
LPG	Other consumption	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Gas works gas	Power plants, district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Gas works gas	Other consumption	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Natural Gas	Power plants, district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Natural Gas	Other consumption	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Coke oven gas	All consumption	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Blast furnace gas	All consumption	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Steel converter gas	All consumption	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Coking coal, other bituminous coal	Power plants, district heating	0.045	0.045	0.045	0.045	0.04	0.04	0.04	0.04	0.04	0.035	0.035	0.035	0.035	0.035	0.03	0.03	0.025	0.025	0.02	0.02	0.02
Coking coal, other bituminous coal	Industry	0.055	0.055	0.055	0.055	0.05	0.05	0.05	0.05	0.05	0.045	0.045	0.045	0.045	0.045	0.04	0.04	0.035	0.035	0.03	0.03	0.03
Coking coal, other bituminous coal	Other consumption	0.2	0.18	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.12	0.12	0.11	0.1	0.1	0.1	0.1	0.1
Coke	Power plants, district heating	0.045	0.045	0.045	0.045	0.04	0.04	0.04	0.04	0.04	0.035	0.035	0.035	0.035	0.035	0.03	0.03	0.025	0.025	0.02	0.02	0.02
Coke	Industry	0.055	0.055	0.055	0.055	0.05	0.05	0.05	0.05	0.05	0.045	0.045	0.045	0.045	0.045	0.04	0.04	0.035	0.035	0.03	0.03	0.03
Coke	Other consumption	0.2	0.18	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.12	0.12	0.11	0.1	0.1	0.1	0.1	0.1
Wood	Power plants, district heating	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035
Wood	Industry	0.11	0.11	0.11	0.11	0.08	0.08	0.08	0.08	0.08	0.065	0.065	0.06	0.06	0.055	0.055	0.05	0.045	0.045	0.045	0.04	0.04
Wood	Households	2.2	2.2	2.1	2.1	2.1	2	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1	0.9	0.8	0.7	0.65	0.65
Wood	Other consumption	0.11	0.11	0.11	0.11	0.08	0.08	0.08	0.08	0.08	0.065	0.065	0.06	0.06	0.055	0.055	0.05	0.045	0.045	0.045	0.045	0.045
Peat	Power plants, district heating, industry	0.075	0.075	0.075	0.075	0.075	0.075	0.07	0.07	0.065	0.065	0.06	0.06	0.055	0.05	0.05	0.045	0.045	0.045	0.035	0.035	0.035
Municipal Solid Waste	Power plants, district heating, industry	0.04	0.04	0.038	0.038	0.038	0.03	0.02	0.015	0.01	0.005	0.003	0.003	0.0025	0.0025	0.0014	0.0017	0.0017	0.0011	0.0014	0.0012	0.0009
Black liquor	Industry	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Tall oil	All consumption	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002

TSP stationary combustion, cont.

Fuel type	Area of consumption	kg/GJ																				
		1980-81	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Kerosene	Power plants, district heating, industry	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002
Kerosene	Other consumption	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003
Landfill gas	Power plants, district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Landfill gas	Other consumption	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Petroleum coke	Power plants, district heating	0.045	0.045	0.045	0.045	0.04	0.04	0.04	0.04	0.04	0.035	0.035	0.035	0.035	0.035	0.03	0.03	0.025	0.025	0.02	0.02	0.02
Petroleum coke	Industry	0.055	0.055	0.055	0.055	0.05	0.05	0.05	0.05	0.05	0.045	0.045	0.045	0.045	0.045	0.04	0.04	0.035	0.035	0.03	0.03	0.03
Petroleum coke	Other consumption	0.2	0.18	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.14	0.14	0.13	0.13	0.12	0.12	0.11	0.1	0.1	0.1	0.1	0.1
Other biomass	Industry	0.11	0.11	0.11	0.11	0.08	0.08	0.08	0.08	0.08	0.065	0.065	0.06	0.06	0.055	0.055	0.05	0.045	0.045	0.045	0.04	0.04
Other biomass	Other consumption	0.11	0.11	0.11	0.11	0.08	0.08	0.08	0.08	0.08	0.065	0.065	0.06	0.06	0.055	0.055	0.05	0.045	0.045	0.045	0.045	0.045
Other petroleum fuels	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035
Other solid fuels	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035
Other not specified fuels	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035
Refinery gases	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035

For all other fuels emissions are assumed to be not occuring.

Source: IVL Environmental Research Institute Ltd

PM_{10}, Stationary combustion

Fuel type	Area of consumption	kg/GJ 1980-81	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Gas/diesel oil	Power plants, district heating, industry	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002
Gas/diesel oil	Other consumption	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003
Residual fuel oil	Power plants, district heating, industry	0.035	0.03	0.02	0.02	0.015	0.015	0.015	0.015	0.015	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Residual fuel oil	Other consumption	0.035	0.03	0.02	0.02	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
LPG	Power plants, district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
LPG	Other consumption	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Gas works gas	Power plants, district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Gas works gas	Other consumption	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Natural Gas	Power plants, district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Natural Gas	Other consumption	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Coke oven gas	All consumption	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Blast furnace gas	All consumption	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Steel converter gas	All consumption	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Coking coal, other bituminous coal	Power plants, district heating	0.04275	0.04275	0.04275	0.04275	0.038	0.038	0.038	0.038	0.038	0.03325	0.03325	0.03325	0.03325	0.03325	0.0285	0.0285	0.02375	0.02375	0.019	0.019	0.019
Coking coal, other bituminous coal	Industry	0.0385	0.0385	0.0385	0.0385	0.035	0.035	0.035	0.035	0.035	0.0315	0.0315	0.0315	0.0315	0.0315	0.028	0.028	0.0245	0.0245	0.021	0.021	0.021
Coking coal, other bituminous coal	Other consumption	0.1	0.09	0.09	0.085	0.085	0.08	0.08	0.075	0.075	0.07	0.07	0.065	0.065	0.06	0.06	0.055	0.05	0.05	0.05	0.05	0.05
Coke	Power plants, district heating	0.04275	0.04275	0.04275	0.04275	0.038	0.038	0.038	0.038	0.038	0.03325	0.03325	0.03325	0.03325	0.03325	0.0285	0.0285	0.02375	0.02375	0.019	0.019	0.019
Coke	Industry	0.04565	0.04565	0.04565	0.04565	0.0415	0.0415	0.0415	0.0415	0.0415	0.03735	0.03735	0.03735	0.03735	0.03735	0.0332	0.0332	0.02905	0.02905	0.0249	0.0249	0.0249
Coke	Other consumption	0.1	0.09	0.09	0.085	0.085	0.08	0.08	0.075	0.075	0.07	0.07	0.065	0.065	0.06	0.06	0.055	0.05	0.05	0.05	0.05	0.05
Wood	Power plants, district heating	0.086	0.086	0.086	0.086	0.0675	0.0675	0.0675	0.0675	0.0675	0.0558	0.057	0.05225	0.05225	0.0475	0.0475	0.04275	0.04275	0.033	0.03325	0.03325	0.03325
Wood	Industry	0.088	0.088	0.088	0.088	0.0664	0.0664	0.0664	0.0664	0.0664	0.05395	0.0559	0.0516	0.0516	0.0473	0.0473	0.043	0.0387	0.0387	0.0387	0.03825	0.0344
Wood	Households	1.98	1.98	1.89	1.89	1.89	1.8	1.71	1.62	1.53	1.44	1.35	1.26	1.17	1.08	0.99	0.9	0.81	0.72	0.63	0.585	0.585
Wood	Other consumption	0.0825	0.0825	0.0825	0.0825	0.064	0.064	0.064	0.064	0.064	0.052	0.052	0.048	0.048	0.04675	0.04675	0.0425	0.03825	0.03825	0.03825	0.03825	0.03825
Peat	Power plants, district heating, industry	0.06	0.06	0.06	0.06	0.06	0.06375	0.0595	0.0595	0.05525	0.05525	0.054	0.054	0.0495	0.045	0.045	0.0405	0.0405	0.0405	0.0315	0.0315	0.0315
Municipal Solid Waste	Power plants, district heating	0.034	0.034	0.0323	0.0323	0.0342	0.027	0.018	0.0135	0.009	0.0045	0.00285	0.00285	0.002375	0.002375	0.00133	0.001615	0.001615	0.001045	0.00133	0.00114	0.000855
Municipal Solid Waste	Industry	0.04	0.04	0.038	0.038	0.038	0.03	0.02	0.015	0.01	0.005	0.003	0.003	0.0025	0.0025	0.0014	0.0017	0.0017	0.0011	0.0014	0.0012	0.0009
Black liquor	Industry	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Tall oil	All consumption	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002

PM_{10}, Stationary combustion, cont.

Fuel type	Area of consumption	kg/GJ																				
		1980-81	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Kerosene	Power plants, district heating, industry	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002
Kerosene	Other consumption	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003
Landfill gas	Power plants, district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Landfill gas	Other consumption	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Petroleum coke	Power plants, district heating	0.04275	0.04275	0.04275	0.04275	0.038	0.038	0.038	0.038	0.038	0.03325	0.03325	0.03325	0.03325	0.03325	0.0285	0.0285	0.02375	0.02375	0.019	0.019	0.019
Petroleum coke	Industry	0.04565	0.04565	0.04565	0.04565	0.0415	0.0415	0.0415	0.0415	0.0415	0.03735	0.03735	0.03735	0.03735	0.03735	0.0332	0.0332	0.02905	0.02905	0.0249	0.0249	0.0249
Petroleum coke	Other consumption	0.1	0.09	0.09	0.085	0.085	0.08	0.08	0.075	0.075	0.07	0.07	0.065	0.065	0.06	0.06	0.055	0.05	0.05	0.05	0.05	0.05
Other biomass	Power plants, district heating	0.086	0.086	0.086	0.086	0.0675	0.0675	0.0675	0.0675	0.0675	0.0558	0.057	0.05225	0.05225	0.0475	0.0475	0.04275	0.04275	0.033	0.03325	0.03325	0.03325
Other biomass	Industry	0.088	0.088	0.088	0.088	0.0664	0.0664	0.0664	0.0664	0.0664	0.05395	0.0559	0.0516	0.0516	0.0473	0.0473	0.043	0.0387	0.0387	0.0387	0.03825	0.0344
Other biomass	Other consumption	0.0825	0.0825	0.0825	0.0825	0.064	0.064	0.064	0.064	0.064	0.052	0.052	0.048	0.048	0.04675	0.04675	0.0425	0.03825	0.03825	0.03825	0.03825	0.03825
Other petroleum fuels	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035
Other solid fuels	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035
Other not specified fue	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035
Refinery gases	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035

For all other fuels emissions are assumed to be not occuring.

Source: IVL Environmental Research Institute Ltd

PM 2.5, Stationary combustion

Fuel type	Area of consumption	kg/GJ 1980-81	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Gas/diesel oil	district heating, industry	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002
Gas/diesel oil	Other consumption	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.006	0.005	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003
Residual fuel oil	district heating, industry	0.02905	0.0249	0.0166	0.0166	0.01245	0.01245	0.01245	0.01245	0.01245	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083
Residual fuel oil	Other consumption	0.02905	0.0249	0.0166	0.0166	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245	0.01245
LPG	district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
LPG	Other consumption	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Gas works gas	district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Gas works gas	Other consumption	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Natural Gas	district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Natural Gas	Other consumption	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Coke oven gas	All consumption	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Blast furnace gas	All consumption	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Steel converter gas	All consumption	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Coking coal, other bituminous coal	Power plants, district heating	0.03735	0.03735	0.03735	0.03735	0.0332	0.0332	0.0332	0.0332	0.0332	0.02905	0.02905	0.02905	0.02905	0.02905	0.0249	0.0249	0.02075	0.02075	0.0166	0.0166	0.0166
Coking coal, other bituminous coal	Industry	0.0165	0.0165	0.0165	0.0165	0.015	0.015	0.015	0.015	0.015	0.0135	0.0135	0.0135	0.0135	0.0135	0.012	0.012	0.0105	0.0105	0.009	0.009	0.009
Coking coal, other bituminous coal	Other consumption	0.05	0.045	0.045	0.0425	0.0425	0.04	0.04	0.0375	0.0375	0.035	0.035	0.0325	0.0325	0.03	0.03	0.0275	0.025	0.025	0.025	0.025	0.025
Coke	Power plants, district heating	0.03735	0.03735	0.03735	0.03735	0.0332	0.0332	0.0332	0.0332	0.0332	0.02905	0.02905	0.02905	0.02905	0.02905	0.0249	0.0249	0.02075	0.02075	0.0166	0.0166	0.0166
Coke	Industry	0.0385	0.0385	0.0385	0.0385	0.035	0.035	0.035	0.035	0.035	0.0315	0.0315	0.0315	0.0315	0.0315	0.028	0.028	0.0245	0.0245	0.021	0.021	0.021
Coke	Other consumption	0.05	0.045	0.045	0.0425	0.0425	0.04	0.04	0.0375	0.0375	0.035	0.035	0.0325	0.0325	0.03	0.03	0.0275	0.025	0.025	0.025	0.025	0.025
Wood	Power plants, district heating	0.06	0.06	0.06	0.06	0.04875	0.04875	0.04875	0.04875	0.04875	0.042	0.042	0.0385	0.0385	0.035	0.035	0.0315	0.0315	0.0245	0.0245	0.0245	0.0245
Wood	Industry	0.066	0.066	0.066	0.066	0.052	0.052	0.052	0.052	0.052	0.0455	0.0455	0.042	0.042	0.0385	0.0385	0.035	0.0315	0.0315	0.0315	0.028	0.028
Wood	Households	1.76	1.76	1.68	1.68	1.68	1.6	1.52	1.44	1.36	1.28	1.2	1.12	1.04	0.96	0.88	0.8	0.72	0.64	0.56	0.52	0.52
Wood	Other consumption	0.066	0.066	0.066	0.066	0.052	0.052	0.052	0.052	0.052	0.0455	0.0455	0.042	0.042	0.0385	0.0385	0.035	0.0315	0.0315	0.0315	0.0315	0.0315
Peat	district heating, industry	0.045	0.045	0.045	0.045	0.045	0.04875	0.0455	0.0455	0.04225	0.04225	0.042	0.042	0.0385	0.035	0.035	0.0315	0.0315	0.0315	0.0245	0.0245	0.0245
Municipal Solid Waste	district heating, industry	0.03	0.03	0.0285	0.0285	0.0285	0.024	0.016	0.012	0.008	0.004	0.00255	0.00255	0.002125	0.002125	0.00119	0.00153	0.00153	0.00099	0.00126	0.00108	0.00081
Black liquor	Industry	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
Tall oil	All consumption	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002

PM 2.5, Stationary combustion, cont.

Fuel type	Area of consumption	kg/GJ 1980-81	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Kerosene	All consumption	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.002
Landfill gas	district heating, industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Landfill gas	Other consumption	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Petroleum coke	Power plants, district heating	0.03735	0.03735	0.03735	0.03735	0.0332	0.0332	0.0332	0.0332	0.0332	0.02905	0.02905	0.02905	0.02905	0.02905	0.0249	0.0249	0.02075	0.02075	0.0166	0.0166	0.0166
Petroleum coke	Industry	0.0385	0.0385	0.0385	0.0385	0.035	0.035	0.035	0.035	0.035	0.0315	0.0315	0.0315	0.0315	0.0315	0.028	0.028	0.0245	0.0245	0.021	0.021	0.021
Petroleum coke	Other consumption	0.05	0.045	0.045	0.0425	0.0425	0.04	0.04	0.0375	0.0375	0.035	0.035	0.0325	0.0325	0.03	0.03	0.0275	0.025	0.025	0.025	0.025	0.025
Other biomass	Power plants, district heating	0.06	0.06	0.06	0.06	0.04875	0.04875	0.04875	0.04875	0.04875	0.042	0.042	0.0385	0.0385	0.035	0.035	0.0315	0.0315	0.0245	0.0245	0.0245	0.0245
Other biomass	Industry	0.066	0.066	0.066	0.066	0.052	0.052	0.052	0.052	0.052	0.0455	0.0455	0.042	0.042	0.0385	0.0385	0.035	0.0315	0.0315	0.0315	0.028	0.028
Other biomass	Other consumption	0.066	0.066	0.066	0.066	0.052	0.052	0.052	0.052	0.052	0.0455	0.0455	0.042	0.042	0.0385	0.0385	0.035	0.0315	0.0315	0.0315	0.0315	0.0315
Other petroleum fuels	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035
Other solid fuels	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035
Other not specified fuel	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035
Refinery gases	All consumption	0.1	0.1	0.1	0.1	0.075	0.075	0.075	0.075	0.075	0.06	0.06	0.055	0.055	0.05	0.05	0.045	0.045	0.035	0.035	0.035	0.035

For all other fuels emissions are assumed to be not occuring.

Source: IVL Environmental Research Institute Ltd

As

Stationary combustion

				kg/GJ
Kod	Bränsleslag	Fuel type	Area of consumption	1990-2001
01, 21	Eldningsolja 1	Gas/diesel oil	All consumption	0.0000004
02, 03	Eldningsolja 2-5	Residual fuel oil	All consumption	0.0000012
07	Koksugnsgas	Coke oven gas	All consumption	0.000003
08	Masugnsgas	Blast furnace gas	All consumption	0.000003
10	Kol	Coking coal, other bituminous coal	All consumption	0.000003
11	Koks	Coke	All consumption	0.000003
12	Trädbränsle	Wood	All consumption	0.0000004
13	Torv	Peat	Power plants, district heating, industry	0.000006
14	Sopor	Municipal Solid Waste	Power plants, district heating, industry	0.0000012
16	Tallolja	Tall oil	All consumption	0.0000004
20	Fotogen	Kerosene	All consumption	0.0000004
24	Petroleumkoks	Petroleum coke	All consumption	0.000003
91	Övriga biobränslen	Other biomass	All consumption	0.0000004

For all other fuels emissions are assumed to be not occuring.

Source: IVL Swedish Environmental Research Institute Ltd

Cd

Stationary combustion

Fuel type	Area of consumption	kg/GJ								
		1990	1991	1992	1993	1994	1995	1996	1997	1998-2001
Gas/diesel oil	All consumption	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002
Residual fuel oil	All consumption	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004	0.0000004
Coking coal, other bituminous coal	Power plants, district heating, industry	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005
Coking coal, other bituminous coal	Other consumption	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004
Coke	Power plants, district heating, industry	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005
Coke	Other consumption	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004
Wood	Power plants, district heating, industry	0.0000015	0.0000015	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Wood	Other consumption	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003
Peat	Power plants, district heating, industry	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Municipal Solid Waste	Power plants, district heating, industry	0.000037	0.000002	0.000002	0.0000014	0.0000008	0.0000006	0.0000006	0.0000008	0.0000003
Black liquor	Industry	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06
Kerosene	All consumption	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002	0.0000002
Petroleum coke	Power plants, district heating, industry	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005
Petroleum coke	Other consumption	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004
Other biomass	Power plants, district heating, industry	0.0000015	0.0000015	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
Other biomass	Other consumption	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003

For all other fuels emissions are assumed to be not occuring.

Source: IVL Environmental Research Institute Ltd

Cr

Stationary combustion

Fuel type	Area of consumption	kg/GJ 1990-91	1992-93	1994	1995	1996-2001
Gas/diesel oil	All consumption	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005
Residual fuel oil	All consumption	0.0000007	0.0000007	0.0000007	0.0000007	0.0000007
Coking coal, other bituminous coal	All consumption	0.00001	0.00001	0.00001	0.00001	0.00001
Coke	All consumption	0.00001	0.00001	0.00001	0.00001	0.00001
Wood	Households	0.000002	0.000002	0.000002	0.000001	0.000001
Wood	Other consumption	0.0000033	0.0000033	0.0000033	0.0000033	0.0000033
Peat	Power plants, district heating, industry	0.000006	0.000006	0.000006	0.000006	0.000006
Municipal Solid Waste	Power plants, district heating, industry	0.00006	0.00003	0.00002	0.000008	0.000016
Kerosene	All consumption	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005
Petroleum coke	All consumption	0.00001	0.00001	0.00001	0.00001	0.00001
Other biomass	All consumption	0.0000033	0.0000033	0.0000033	0.0000033	0.0000033

For all other fuels emissions are assumed to be not occuring.

Source: IVLSwedish Environmental Research Institute Ltd

Cu

Stationary combustion

Fuel type	Area of consumption	kg/GJ 1990-91	1992-93	1994	1995	1996-2001
Gas/diesel oil	All consumption	0.000002	0.000002	0.000002	0.000002	0.000002
Residual fuel oil	All consumption	0.000005	0.000005	0.000005	0.000005	0.000005
Coking coal, other bituminous coal	All consumption	0.00001	0.00001	0.00001	0.00001	0.00001
Coke	All consumption	0.00001	0.00001	0.00001	0.00001	0.00001
Wood	Households	0.00001	0.00001	0.00001	0.00001	0.00001
Wood	Other consumption	0.000015	0.000015	0.000015	0.00001	0.00001
Peat	Power plants, district heating, industry	0.00001	0.00001	0.00001	0.00001	0.00001
Municipal Solid Waste	Power plants, district heating, industry	0.00006	0.00003	0.00002	0.000008	0.000016
Black liquor	Industry	0.07	0.07	0.06	0.06	0.06
Kerosene	All consumption	0.000002	0.000002	0.000002	0.000002	0.000002
Petroleum coke	All consumption	0.00001	0.00001	0.00001	0.00001	0.00001
Other biomass	All consumption	0.000015	0.000015	0.000015	0.00001	0.00001

For all other fuels emissions are assumed to be not occuring.

Source: IVL Environmental Research Institute Ltd

Hg

Stationary combustion

Fuel type	Area of consumption	kg/GJ									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999-2001
Gas/diesel oil	All consumption	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
Residual fuel oil	All consumption	0.00000006	0.00000006	0.00000006	0.00000006	0.00000006	0.00000006	0.00000006	0.00000006	0.00000006	0.00000006
Coke oven gas	All consumption	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003
Blast furnace gas	All consumption	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003
Coking coal, other bituminous coal	Power plants, district heating, industry	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003
Coking coal, other bituminous coal	Other consumption	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004
Coke	Power plants, district heating, industry	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003
Coke	Other consumption	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004
Wood	Power plants, district heating, industry	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
Wood	Other consumption	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005
Peat	Power plants, district heating, industry	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002	0.000002
Municipal Solid Waste	Power plants, district heating, industry	0.00025	0.0000116	0.0000064	0.0000055	0.0000064	0.000005	0.000004	0.0000033	0.0000028	0.0000014
Kerosene	All consumption	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
Petroleum coke	Power plants, district heating, industry	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003	0.000003
Petroleum coke	Other consumption	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004	0.000004
Other biomass	Power plants, district heating, industry	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
Other biomass	Other consumption	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005	0.0000005

For all other fuels emissions are assumed to be not occuring.

Source: IVL Swedish Environmental Research Institute Ltd

Ni

Stationary combustion

		kg/GJ						
Fuel type	Area of consumption	1990	1991-92	1993	1994	1995-96	1997	1998-2001
Gas/diesel oil	All consumption	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008
Residual fuel oil	All consumption	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024	0.00024
Coking coal, other bituminous coal	All consumption	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008
Coke	All consumption	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008
Wood	Households	0.0000045	0.000004	0.000004	0.000004	0.000003	0.000003	0.0000025
Wood	Other consumption	0.0000045	0.0000045	0.0000045	0.0000045	0.0000045	0.0000045	0.0000045
Peat	Power plants, district heating, industry	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Municipal Solid Waste	Power plants, district heating, industry	0.00006	0.0000046	0.000003	0.000002	0.0000011	0.000002	0.0000005
Tall oil	All consumption	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008
Kerosene	All consumption	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008
Petroleum coke	All consumption	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008	0.000008
Other biomass	All consumption	0.0000045	0.0000045	0.0000045	0.0000045	0.0000045	0.0000045	0.0000045

For all other fuels emissions are assumed to be not occuring.
Source: IVL Swedish Environmental Research Institute Ltd

Pb

Stationary combustion

Fuel type	Area of consumption	kg/GJ									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999-2001
Gas/diesel oil	All consumption	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024
Residual fuel oil	All consumption	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015	0.000015
Coking coal, other bituminous coal	All consumption	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024
Coke	All consumption	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024
Wood	Power plants, district heating, industry	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013
Wood	Other consumption	0.00002	0.00002	0.00002	0.00002	0.00002	0.000015	0.000015	0.000015	0.000015	0.000015
Peat	Power plants, district heating, industry	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004	0.00004
Municipal Solid Waste	Power plants, district heating	0.0001	0.000045	0.000035	0.000027	0.000019	0.0000075	0.000011	0.0000138	0.0000158	0.0000014
Municipal Solid Waste	Industry	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Kerosene	All consumption	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024	0.0000024
Petroleum coke	All consumption	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024	0.000024
Other biomass	Power plants, district heating, industry	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013	0.000013
Other biomass	Other consumption	0.00002	0.00002	0.00002	0.00002	0.00002	0.000015	0.000015	0.000015	0.000015	0.000015

For all other fuels emissions are assumed to be not occuring.

Source: IVL Environmental Research Institute Ltd

Se

Stationary combustion

Fuel type	Area of consumption	kg Se/GJ
Gas/diesel oil	All consumption	1.6E-07
Residual fuel oil	All consumption	1.5E-06
Coking coal, other bituminous coal	All consumption	3E-06
Coke	All consumption	3E-06
Wood	All consumption	2.2E-06
Peat	Power plants, district heating, industry	5.6E-06
Kerosene	All consumption	1.6E-07
Petroleum coke	All consumption	3E-06
Other biomass	All consumption	2.2E-06

For all other fuels emissions are assumed to be not occuring.

Source: IVL Swedish Environmental Research Institute Ltd

Zn

Stationary combustion

Fuel type	Area of consumption	kg/GJ 1990	1991	1992	1993	1994	1995-96	1997	1998-2001
Gas/diesel oil	All consumption	0.0000016	0.0000016	0.0000016	0.0000016	0.0000016	0.0000016	0.0000016	0.0000016
Residual fuel oil	All consumption	0.000012	0.000012	0.000012	0.000012	0.000012	0.000012	0.000012	0.000012
Coking coal, other bituminous coal	Power plants, district heating, industry	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Coking coal, other bituminous coal	Other consumption	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021
Coke	Power plants, district heating, industry	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Coke	Other consumption	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021
Wood	Power plants, district heating, industry	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Wood	Households	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Wood	Other consumption	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Peat	Power plants, district heating, industry	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Municipal Solid Waste	Power plants, district heating	0.0003	0.000176	0.0000046	0.000003	0.000002	0.0000011	0.000002	0.0000005
Municipal Solid Waste	Industry	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Tall oil	All consumption	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008	0.0000008
Kerosene	All consumption	0.0000016	0.0000016	0.0000016	0.0000016	0.0000016	0.0000016	0.0000016	0.0000016
Petroleum coke	Power plants, district heating, industry	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Petroleum coke	Other consumption	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021
Other biomass	Power plants, district heating, industry	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048	0.00048
Other biomass	Other consumption	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

For all other fuels emissions are assumed to be not occuring.

Source: IVL Swedish Environmental Research Institute Ltd

PAH-4, stationary combustion

Fuel type	Area of consumption	µg/MJ = mg/GJ = g/TJ																		
		1980	1981-82	1983-84	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000-2001
Gas/diesel oil	All consumption	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Residual fuel oil	All consumption	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Coking coal, other bituminous coal	Power plants, district heating, industry	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Other consumption	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Coke	Power plants, district heating, industry	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Other consumption	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Wood	Power plants, district heating, industry	100	75	60	50	50	30	30	20	20	15	15	10	10	5	5	5	3	3	3
	Households	1100	1100	1050	1050	1000	950	900	850	800	750	700	650	600	550	500	450	400	350	325
	Other consumption	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Peat	Power plants, district heating, industry	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	Other consumption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Municipal Solid Waste	Power plants, district heating, industry	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	1	1	1	1	1	1	1	1	1	1	1
	Other consumption	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tall oil	All consumption	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Kerosene	All consumption	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Petroleum coke	Power plants, district heating, industry	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Other consumption	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Other biomass	Power plants, district heating, industry	100	75	60	50	50	30	30	20	20	15	15	10	10	5	5	5	3	3	3
	Other consumption	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500

For all other fuels emissions are assumed to be not occuring.
Source: IVL Swedish Environmental Research Institute Ltd

Dioxin

Stationary combustion

Fuel type	Area of consumption	ng/MJ = µg/GJ = mg/TJ														
		1980 - 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999 - 2001
Coking coal, other bituminous coal	All consumption	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Coke	All consumption	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Wood	Households	0.07	0.07	0.07	0.07	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Wood and other biomass	All other consumption	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Peat	Power plants, district heating, industry	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Municipal Solid Waste	Power plants and district heating	8.3	6	4	2	1	0.7	0.55	0.35	0.25	0.11	0.12	0.11	0.15	0.12	0.12
Municipal Solid Waste	Industry	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Petroleum coke	All consumption	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

For all other fuels emissions are assumed to be not occuring.
Source: IVL Swedish Environmental Research Institute Ltd

TSP, mobile combustion

				kg TSP/GJ									
Fuel type	Sector	Subsector	Region	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Aviation Gas	Aviation	Domestic		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
		Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Biogas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Diesel oil	Military abroad	Bunkers		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Navigation/Shipping			0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
	Off Road Vehicles and Working Machinery			NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Railways	Railways		0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106
	Road Traffic	Bus	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Passenger C	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck 16t-	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck 3,5-16t	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck -3,5t	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Diesel oil*	Navigation/Shipping			0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
Etanol				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Gasoline	Navigation/Shipping			0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
	Off Road Vehicles and Working Machinery	Farming		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Forestry		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Households		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Industry		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Other		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Road Traffic	Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Moped	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Motorcycel	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Passenger C	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck -3,5t	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Jet Gasoline				0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Kerosene	Aviation	Bunkers		0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Domestic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Natural Gas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Residual Fuel Oil				0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146
RME				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

- = Not occuring, NE= Not estimated

Sources: Swedish National Road Administration, IPCC, IVL Swedish Environmental Research Institute Ltd

* In Sweden often called domestic heating oil

** Emissions in the inventory are not based on fuel consumption at all.

Note that the figures above are to a large extent Implied Emission Factors. Emissions in the Swedish inventory are estimated by models where fuel consumption is only one of all used input parameters.

TSP, mobile combustion, cont.

				kg TSP/GJ											
Fuel type	Sector	Subsector	Region	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aviation Gas	Aviation	Domestic		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
		Military		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Biogas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Diesel oil	Military abroa	Bunkers		0.022	0.020	0.018	0.018	0.017	0.016	0.015	0.014	0.014	0.013	0.012	0.016
	Navigation/Shipping			0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
	Off Road Vehicles and Working Machine			**	**	**	**	**	**	**	**	**	**	0.094	0.094
	Railways	Railways		0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106	0.106
	Road Traffic	Bus	Country	0.039	0.038	0.030	0.027	0.025	0.024	0.023	0.020	0.018	0.017	0.016	0.015
			Urban	0.083	0.078	0.058	0.052	0.047	0.046	0.040	0.035	0.030	0.028	0.025	0.022
		Military		0.022	0.020	0.018	0.018	0.017	0.016	0.015	0.014	0.014	0.013	0.012	0.011
		Passenger C	Country	0.008	0.007	0.007	0.007	0.006	0.007	0.007	0.006	0.006	0.006	0.006	0.005
			Urban	0.015	0.014	0.013	0.013	0.012	0.010	0.010	0.010	0.009	0.009	0.009	0.007
		Truck 16t-	Country	0.047	0.049	0.041	0.039	0.035	0.034	0.030	0.025	0.022	0.020	0.018	0.015
			Urban	0.028	0.029	0.024	0.023	0.022	0.021	0.018	0.015	0.013	0.012	0.011	0.009
		Truck 3,5-16t	Country	0.098	0.094	0.075	0.069	0.064	0.065	0.063	0.060	0.056	0.055	0.054	0.050
			Urban	0.074	0.070	0.055	0.051	0.049	0.050	0.047	0.044	0.041	0.040	0.039	0.037
		Truck -3,5t	Country	0.022	0.020	0.019	0.019	0.019	0.021	0.019	0.019	0.018	0.018	0.018	0.018
			Urban	0.031	0.030	0.028	0.028	0.028	0.026	0.025	0.025	0.026	0.027	0.028	0.029
Diesel oil*	Navigation/Shipping			0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
Etanol				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Gasoline	Navigation/Shipping			0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
	Off Road Veh	Farming		**	**	**	**	**	**	**	**	**	**	0.000	0.000
		Forestry		**	**	**	**	**	**	**	**	**	**	0.093	0.093
		Households		**	**	**	**	**	**	**	**	**	**	0.093	0.093
		Industry		**	**	**	**	**	**	**	**	**	**	0.093	0.093
		Other		**	**	**	**	**	**	**	**	**	**	0.093	0.093
	Road Traffic	Military		0.022	0.020	0.018	0.018	0.017	0.016	0.015	0.014	0.014	0.013	0.012	0.011
		Moped	Country	0.223	0.214	0.213	0.219	0.227	0.240	0.243	0.225	0.257	0.255	0.256	0.251
			Urban	0.356	0.358	0.357	0.351	0.354	0.326	0.314	0.332	0.295	0.293	0.294	0.289
		Motorcycel	Country	0.049	0.049	0.048	0.049	0.049	0.051	0.055	0.055	0.054	0.053	0.053	0.052
			Urban	0.040	0.038	0.038	0.040	0.039	0.035	0.035	0.036	0.034	0.035	0.035	0.035
		Passenger C	Country	0.008	0.007	0.007	0.007	0.006	0.007	0.007	0.006	0.006	0.006	0.006	0.005
			Urban	0.015	0.014	0.013	0.013	0.012	0.010	0.010	0.010	0.009	0.009	0.009	0.007
		Truck -3,5t	Country	0.022	0.020	0.019	0.019	0.019	0.021	0.019	0.019	0.018	0.018	0.018	0.018
			Urban	0.031	0.030	0.028	0.028	0.028	0.026	0.025	0.025	0.026	0.027	0.028	0.029
Jet Gasoline				0.010	0.010	0.010	0.010	-	-	-	-	-	-	-	-
Kerosene	Aviation	Bunkers		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Domestic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Military		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Natural Gas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Residual Fuel Oil				0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146
RME				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

** Emissions in the inventory are not based on fuel consumption at all.

Sources: Swedish National Road Administration, IPCC, IVL Swedish Environmental Research Institute Ltd

PM10, mobile combustion

				kg TSP/GJ									
Fuel type	Sector	Subsector	Region	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Aviation Gas	Aviation	Domestic		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
		Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Biogas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Diesel oil	Military abroad	Bunkers		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Navigation/Shipping			0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
	Off Road Vehicles and Working Machinery			NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Railways	Railways		0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
	Road Traffic	Bus	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Passenger C	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck 16t-	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck 3,5-16t	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck -3,5t	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Diesel oil*	Navigation/Shipping			0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
Etanol				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Gasoline	Navigation/Shipping			0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
	Off Road Vehicles and Working Machinery	Farming		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Forestry		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Households		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Industry		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Other		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Road Traffic	Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Moped	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Motorcycel	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Passenger C	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck -3,5t	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Jet Gasoline				0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Kerosene	Aviation	Bunkers		0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Domestic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Natural Gas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Residual Fuel Oil				0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139
RME				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

- = Not occuring, NE= Not estimated

Sources: Swedish National Road Administration, IPCC, IVL Swedish Environmental Research Institute Ltd

* In Sweden often called domestic heating oil

Note that the figures above are to a large extent Implied Emission Factors. Emissions in the Swedish inventory are estimated by models where fuel consumption is only one of all used input parameters.

PM10, mobile combustion, cont.

				kg TSP/GJ											
Fuel type	Sector	Subsector	Region	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aviation Gas	Aviation	Domestic		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
		Military		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Biogas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Diesel oil	Military abroa	Bunkers		0.022	0.020	0.018	0.018	0.017	0.016	0.015	0.014	0.014	0.013	0.012	0.016
	Navigation/Shipping			0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
	Off Road Vehicles and Working Machine			**	**	**	**	**	**	**	**	**	**	0.089	0.089
	Railways	Railways		0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101
	Road Traffic	Bus	Country	0.039	0.038	0.030	0.027	0.025	0.024	0.023	0.020	0.018	0.017	0.016	0.015
			Urban	0.083	0.078	0.058	0.052	0.047	0.046	0.040	0.035	0.030	0.028	0.025	0.022
		Military		0.022	0.020	0.018	0.018	0.017	0.016	0.015	0.014	0.014	0.013	0.012	0.011
		Passenger C	Country	0.008	0.007	0.007	0.007	0.006	0.007	0.007	0.006	0.006	0.006	0.006	0.005
			Urban	0.015	0.014	0.013	0.013	0.012	0.010	0.010	0.010	0.009	0.009	0.009	0.007
		Truck 16t-	Country	0.047	0.049	0.041	0.039	0.035	0.034	0.030	0.025	0.022	0.020	0.018	0.015
			Urban	0.028	0.029	0.024	0.023	0.022	0.021	0.018	0.015	0.013	0.012	0.011	0.009
		Truck 3,5-16t	Country	0.098	0.094	0.075	0.069	0.064	0.065	0.063	0.060	0.056	0.055	0.054	0.050
			Urban	0.074	0.070	0.055	0.051	0.049	0.050	0.047	0.044	0.041	0.040	0.039	0.037
		Truck -3,5t	Country	0.022	0.020	0.019	0.019	0.019	0.021	0.019	0.019	0.018	0.018	0.018	0.018
			Urban	0.031	0.030	0.028	0.028	0.028	0.026	0.025	0.025	0.026	0.027	0.028	0.029
Diesel oil*	Navigation/Shipping			0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
Etanol				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Gasoline	Navigation/Shipping			0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
	Off Road Veh	Farming		**	**	**	**	**	**	**	**	**	**	0.000	0.000
		Forestry		**	**	**	**	**	**	**	**	**	**	0.093	0.093
		Households		**	**	**	**	**	**	**	**	**	**	0.093	0.093
		Industry		**	**	**	**	**	**	**	**	**	**	0.093	0.093
		Other		**	**	**	**	**	**	**	**	**	**	0.093	0.093
	Road Traffic	Military		0.022	0.020	0.018	0.018	0.017	0.016	0.015	0.014	0.014	0.013	0.012	0.011
		Moped	Country	0.223	0.214	0.213	0.219	0.227	0.240	0.243	0.225	0.257	0.255	0.256	0.251
			Urban	0.356	0.358	0.357	0.351	0.354	0.326	0.314	0.332	0.295	0.293	0.294	0.289
		Motorcycel	Country	0.049	0.049	0.048	0.049	0.049	0.051	0.055	0.055	0.054	0.053	0.053	0.052
			Urban	0.040	0.038	0.038	0.040	0.039	0.035	0.035	0.036	0.034	0.035	0.035	0.035
		Passenger C	Country	0.008	0.007	0.007	0.007	0.006	0.007	0.007	0.006	0.006	0.006	0.006	0.005
			Urban	0.015	0.014	0.013	0.013	0.012	0.010	0.010	0.010	0.009	0.009	0.009	0.007
		Truck -3,5t	Country	0.022	0.020	0.019	0.019	0.019	0.021	0.019	0.019	0.018	0.018	0.018	0.018
			Urban	0.031	0.030	0.028	0.028	0.028	0.026	0.025	0.025	0.026	0.027	0.028	0.029
Jet Gasoline				0.010	0.010	0.010	0.010	-	-	-	-	-	-	-	-
Kerosene	Aviation	Bunkers		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Domestic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Military		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Natural Gas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Residual Fuel Oil				0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139
RME				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

** Emissions in the inventory are not based on fuel consumption at all.

Sources: Swedish National Road Administration, IPCC, IVL Swedish Environmental Research Institute Ltd

PM2.5, mobile combustion

				kg TSP/GJ									
Fuel type	Sector	Subsector	Region	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Aviation Gas	Aviation	Domestic		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
		Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Biogas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Diesel oil	Military abroad	Bunkers		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Navigation/Shipping			0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
	Off Road Vehicles and Working Machinery			NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Railways	Railways		0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096
	Road Traffic	Bus	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Passenger C	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck 16t-	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck 3,5-16t	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck -3,5t	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Diesel oil*	Navigation/Shipping			0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Etanol				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Gasoline	Navigation/Shipping			0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
	Off Road Vehicles and Working Machinery	Farming		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Forestry		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Households		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Industry		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Other		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Road Traffic	Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Moped	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Motorcycel	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Passenger C	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		Truck -3,5t	Country	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
			Urban	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Jet Gasoline				0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Kerosene	Aviation	Bunkers		0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Domestic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Military		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Natural Gas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Residual Fuel Oil				0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132
RME				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

- = Not occuring, NE= Not estimated

Sources: Swedish National Road Administration, IPCC, IVL Swedish Environmental Research Institute Ltd

* In Sweden often called domestic heating oil

Note that the figures above are to a large extent Implied Emission Factors. Emissions in the Swedish inventory are estimated by models where fuel consumption is only one of all used input parameters.

PM2.5, mobile combustion, cont.

				kg TSP/GJ											
Fuel type	Sector	Subsector	Region	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Aviation Gas	Aviation	Domestic		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
		Military		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Biogas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Diesel oil	Military abroa	Bunkers		0.021	0.019	0.017	0.017	0.016	0.016	0.015	0.014	0.013	0.012	0.012	0.015
	Navigation/Shipping			0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
	Off Road Vehicles and Working Machine			**	**	**	**	**	**	**	**	**	**	0.085	0.085
	Railways	Railways		0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096
	Road Traffic	Bus	Country	0.037	0.036	0.028	0.026	0.023	0.023	0.021	0.019	0.017	0.016	0.016	0.014
			Urban	0.078	0.074	0.056	0.050	0.045	0.044	0.038	0.034	0.029	0.026	0.024	0.021
		Military		0.021	0.019	0.017	0.017	0.016	0.016	0.015	0.014	0.013	0.012	0.012	0.011
		Passenger C	Country	0.008	0.007	0.007	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.005	0.005
			Urban	0.014	0.013	0.012	0.012	0.012	0.010	0.010	0.009	0.009	0.009	0.008	0.007
		Truck 16t-	Country	0.045	0.047	0.039	0.037	0.034	0.032	0.028	0.024	0.021	0.019	0.017	0.014
			Urban	0.026	0.027	0.023	0.022	0.021	0.020	0.017	0.014	0.012	0.011	0.010	0.009
		Truck 3,5-16t	Country	0.093	0.090	0.071	0.066	0.061	0.062	0.060	0.057	0.053	0.052	0.051	0.048
			Urban	0.071	0.067	0.052	0.049	0.046	0.047	0.045	0.042	0.039	0.038	0.037	0.035
		Truck -3,5t	Country	0.020	0.019	0.018	0.018	0.018	0.020	0.018	0.018	0.017	0.017	0.017	0.017
			Urban	0.030	0.028	0.027	0.027	0.026	0.024	0.024	0.024	0.025	0.025	0.026	0.028
Diesel oil*	Navigation/Shipping			0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
Etanol				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Gasoline	Navigation/Shipping			0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
	Off Road Veh	Farming		**	**	**	**	**	**	**	**	**	**	0.000	0.000
		Forestry		**	**	**	**	**	**	**	**	**	**	0.093	0.093
		Households		**	**	**	**	**	**	**	**	**	**	0.093	0.093
		Industry		**	**	**	**	**	**	**	**	**	**	0.093	0.093
		Other		**	**	**	**	**	**	**	**	**	**	0.093	0.093
	Road Traffic	Military		0.021	0.019	0.017	0.017	0.016	0.016	0.015	0.014	0.013	0.012	0.012	0.011
		Moped	Country	0.212	0.203	0.202	0.208	0.216	0.228	0.231	0.214	0.244	0.243	0.243	0.239
			Urban	0.338	0.340	0.339	0.333	0.336	0.309	0.298	0.315	0.280	0.279	0.279	0.275
		Motorcycel	Country	0.047	0.046	0.045	0.046	0.046	0.049	0.053	0.052	0.051	0.050	0.050	0.049
			Urban	0.038	0.036	0.036	0.038	0.037	0.033	0.033	0.034	0.033	0.033	0.033	0.033
		Passenger C	Country	0.008	0.007	0.007	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.005	0.005
			Urban	0.014	0.013	0.012	0.012	0.012	0.010	0.010	0.009	0.009	0.009	0.008	0.007
		Truck -3,5t	Country	0.020	0.019	0.018	0.018	0.018	0.020	0.018	0.018	0.017	0.017	0.017	0.017
			Urban	0.030	0.028	0.027	0.027	0.026	0.024	0.024	0.024	0.025	0.025	0.026	0.028
Jet Gasoline				0.010	0.010	0.010	0.010	-	-	-	-	-	-	-	-
Kerosene	Aviation	Bunkers		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Domestic		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Military		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Natural Gas				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Residual Fuel Oil				0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132
RME				NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

** Emissions in the inventory are not based on fuel consumption at all.

Sources: Swedish National Road Administration, IPCC, IVL Swedish Environmental Research Institute Ltd

16. Appendix 2 Estimated emissions 1980-2001

		TSP	TSP	TSP	TSP	TSP	TSP	TSP	TSP	TSP	TSP
	TSP (metric ton)	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
1	**ENERGY**										
1 A 1 a	Public Electricity and Heat Production	4176	3599	3632	2977	3651	4073	4137	4011	3513	2928
1 A 1 b	Petroleum refining	515	402	376	251	206	179	213	2	192	221
1 A 1 c	Manufacture of Solid Fuels and Other Energy	3	3	3	2	2	2	2	6	2	2
1 A 2	Manufacturing Industries and Construction	10171	5484	13299	12353	9312	7786	6977	6731	6781	6956
1 A 3 a ii (i)	Civil Aviation (Domestic, LTO)	8	9	9	8	9	8	10	8	9	9
1 A 3 a ii (ii)	Civil Aviation (Domestic, Cruise)	25	26	27	25	26	25	29	25	26	28
1 A 3 b	Road Transportation	23920	24135	24350	24564	24779	24994	25650	26305	27470	28693
1 A 3 c	Railways	146	145	152	150	165	169	160	162	158	140
1 A 3 d ii	National Navigation	618	540	562	755	959	1078	1158	1000	994	911
1 A 3 e ii	Other mobile sources and machinery	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 A 4 a	Commercial / Institutional	NE	NE	NE	645	579	474	372	412	429	374
1 A 4 b i	Residential plants	NE	NE	NE	79018	89378	103584	93586	81514	73184	66526
1 A 4 b ii	Household and gardening (mobile)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 A 4 c i	Stationary, agriculture, forestry and fishing	NE	NE	NE	235	274	324	318	378	359	338
1 A 4 c ii	Off-road Vehicles and Other Machinery	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 A 5 b	Other, Mobile (Including military)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 B 1 b	Solid fuel transformation	2	3	1	1	2	2	2	NE	2	2
1 B 1 c	Other	329	313	444	465	598	734	676	603	581	560
1 B 2 a	Oil	0.1	0.2	0.2	0.2	0.2	0.2	0.2	NE	0	0
1 B 2 a i	Exploration Production, Transport	NE	NE	NE	NE	NE	NE	NE	NE	0.1	0.1
1 B 2 a iv	Refining / Storage	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 B 2 b	Natural gas	0.0	0.1	0.1	0.1	0.1	0.1	0.1	NE	0.0	0
2	**INDUSTRIAL PROCESSES**										
2 A 1	Cement Production	1459	1364	1271	1344	1148	852	721	930	1405	1423
2 A 2	Lime Production	680	670	685	698	693	701	712	698	692	688
2 A 7	Other including Non Fuel Mining & Construction	5218	4143	3740	3711	4439	5934	6051	6217	6815	6825
2 B 4	Carbide Production	215	205	220	200	310	290	230	94	60	120
2 C	METAL PRODUCTION	10578	8964	7397	7143	6950	6746	6425	5580	5372	4377
2 D 1	Pulp and Paper	15774	14893	12932	13930	14192	12830	12418	12170	11664	10851
3	**SOLVENT AND PRODUCT USE**										
3 D	OTHER including products containing HMs and POPs	601	608	603	569	556	537	535	523	504	510
4	**AGRICULTURE**										
4 G	OTHER	7703	7613	7889	8173	8133	8061	7950	7706	7866	8019
5	**WASTE**										
6 D	OTHER WASTE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	National Total	82142	73119	77592	157218	166363	179383	168330	155077	148078	140501

		TSP	TSP	TSP	TSP	TSP	TSP	TSP	TSP	TSP	TSP	TSP	TSP
	TSP (metric ton)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
1	**ENERGY**												
1 A 1 a	Public Electricity and Heat Production	2944	3332	3284	3616	3886	3821	5267	3774	3473	3073	2858	3500
1 A 1 b	Petroleum refining	183	171	246	239	220	219	219	257	253	221	1044	1010
1 A 1 c	Manufacture of Solid Fuels and Other Energy	0	36	0	0	0	0	0	0	0	0	0	0
1 A 2	Manufacturing Industries and Construction	9370	9586	8867	9392	9899	9519	8954	8018	7795	7342	6831	7093
1 A 3 a ii (i)	Civil Aviation (Domestic, LTO)	3	3	3	2	3	3	2	3	3	3	3	3
1 A 3 a ii (ii)	Civil Aviation (Domestic, Cruise)	8	8	8	7	8	8	8	8	8	9	8	8
1 A 3 b	Road Transportation	27774	28050	28027	27068	27232	28056	27354	27197	27315	27980	28180	28318
1 A 3 c	Railways	149	134	126	122	114	114	92	88	95	103	111	111
1 A 3 d ii	National Navigation	718	614	582	452	419	438	401	520	579	618	624	645
1 A 3 e ii	Other mobile sources and machinery	386	383	380	377	375	372	370	369	368	368	367	367
1 A 4 a	Commercial / Institutional	1438	1269	838	777	694	621	644	590	562	505	469	533
1 A 4 b i	Residential plants	63361	59485	55751	52212	45239	44606	41388	35287	30731	25363	23576	26922
1 A 4 b ii	Household and gardening (mobile)	441	441	440	440	439	439	439	439	458	476	494	494
1 A 4 c i	Stationary, agriculture, forestry and fishing	614	573	524	476	271	243	212	194	174	142	23	29
1 A 4 c ii	Off-road Vehicles and Other Machinery	1537	1525	1514	1502	1490	1479	1473	1467	1460	1452	1445	1444
1 A 5 b	Other, Mobile (Including military)	45	44	42	40	43	44	37	32	28	24	31	22
1 B 1 b	Solid fuel transformation	3	3	2	2	4	3	3	2	3	3	3	3
1 B 1 c	Other	539	479	462	491	469	543	512	516	482	466	478	451
1 B 2 a	Oil	42	42	42	42	42	41	39	37	35	35	36	33
1 B 2 a i	Exploration Production, Transport	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	NE	0.0	0.0
1 B 2 a iv	Refining / Storage	42	42	42	42	42	41	39	37	35	35	36	33
1 B 2 b	Natural gas	NE	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1	NE	NE	0.1
2	**INDUSTRIAL PROCESSES**												
2 A 1	Cement Production	1003	1358	949	829	705	864	801	695	541	263	216	254
2 A 2	Lime Production	681	NE	686	681	691	703	697	692	696	422	375	369
2 A 7	Other including Non Fuel Mining & Construction	6060	4779	3907	3386	3769	2719	2424	2330	2733	2236	2862	2416
2 B 4	Carbide Production	120	199	124	278	150	153	198	337	232	372	241	263
2 C	METAL PRODUCTION	3960	4028	4107	4138	4132	3774	2127	2193	2091	1687	1550	1649
2 D 1	Pulp and Paper	9580	9290	9063	9249	7935	7425	7016	6802	6707	5815	5763	5718
3	**SOLVENT AND PRODUCT USE**												
3 D	OTHER including products containing HMs and POPs	668	696	730	640	587	629	628	596	611	600	624	646
4	**AGRICULTURE**												
4 G	OTHER	8203	7900	7900	7873	7966	8028	8006	8 050	7789	7728	7575	7575
5	**WASTE**												
6 D	OTHER WASTE	NE	NE	NE	NE	NE	NE	415	1674	69	371	380	1674
	National Total	139870	134468	128645	124375	116822	114906	109768	102205	95326	87711	86202	91582

		PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}
	PM_{10} (metric ton)	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
1	**ENERGY**										
1 A 1 a	Public Electricity and Heat Production	3750	3538	3470	2818	3396	3824	3869	3738	3257	2695
1 A 1 b	Petroleum refining	515	402	376	251	206	179	213	2	192	221
1 A 1 c	Manufacture of Solid Fuels and Other Energy	3	3	3	2	2	2	2	4	2	2
1 A 2	Manufacturing Industries and Construction	9001	5064	12245	11422	8165	6729	6027	5893	6167	6200
1 A 3 a ii (i)	Civil Aviation (Domestic, LTO)	8	9	9	8	9	8	10	8	9	9
1 A 3 a ii (ii)	Civil Aviation (Domestic, Cruise)	25	26	27	25	26	25	29	25	26	28
1 A 3 b	Road Transportation	15632	15741	15850	15960	16069	16178	16538	16897	17550	18245
1 A 3 c	Railways	139	138	145	142	156	160	152	154	150	133
1 A 3 d ii	National Navigation	597	523	544	728	922	1034	1112	962	956	878
1 A 3 e ii	Other mobile sources and machinery	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 A 4 a	Commercial / Institutional	NE	NE	NE	629	557	467	363	408	422	370
1 A 4 b i	Residential plants	NE	NE	NE	71210	80521	93299	84288	73430	65928	59931
1 A 4 b ii	Household and gardening (mobile)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 A 4 c i	Stationary, agriculture, forestry and fishing	NE	NE	NE	159	175	196	192	222	210	193
1 A 4 c ii	Off-road Vehicles and Other Machinery	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 A 5 b	Other, Mobile (Including military)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 B 1 b	Solid fuel transformation	2	3	1	1	2	2	2	NE	2	2
1 B 1 c	Other	329	125	178	186	239	294	270	241	232	224
1 B 2 a	Oil	0.1	0.2	0.2	0.2	0.2	0.2	0.2	NE	0.1	0.1
1 B 2 a i	Exploration Production, Transport	NE	NE	NE	NE	NE	NE	NE	NE	0.1	0.1
1 B 2 a iv	Refining / Storage	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 B 2 b	Natural gas	0.0	0.1	0.1	0.1	0.1	0.1	0.1	NE	0.0	0.0
2	**INDUSTRIAL PROCESSES**										
2 A 1	Cement Production	1167	1091	1017	1075	918	682	577	744	1124	1138
2 A 2	Lime Production	580	575	582	589	587	591	596	589	586	584
2 A 7	Other including Non Fuel Mining & Construction	4096	3109	2756	2765	3411	4738	4839	4981	5475	5478
2 B 4	Carbide Production	194	185	198	180	279	261	207	85	54	108
2 C	METAL PRODUCTION	8165	6898	5664	5456	5664	5479	5207	4529	3773	3769
2 D 1	Pulp and Paper	13408	12659	10992	11840	12063	10905	11176	10953	10498	9766
3	**SOLVENT AND PRODUCT USE**										
3 D	OTHER including products containing HMs and POPs	601	608	603	569	556	537	535	523	504	510
4	**AGRICULTURE**										
4 G	OTHER	3381	3336	3455	3585	3552	3538	3480	3380	3427	3484
5	**WASTE**										
6 D	OTHER WASTE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	National Total	61593	54032	58116	129601	137476	149127	139683	127770	120545	113967

		PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}	PM_{10}
	PM_{10} (metric ton)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
1	**ENERGY**												
1 A 1 a	Public Electricity and Heat Production	2719	3150	3106	3426	3690	3616	5016	3578	3275	2916	2706	3317
1 A 1 b	Petroleum refining	183	171	246	239	220	219	219	257	253	221	1034	1001
1 A 1 c	Manufacture of Solid Fuels and Other Energy	0	36	0	0	0	0	0	0	0	0	0	0
1 A 2	Manufacturing Industries and Construction	7999	8236	7572	7894	8588	8181	7631	6695	6586	6093	6140	6383
1 A 3 a ii (i)	Civil Aviation (Domestic, LTO)	3	3	3	2	3	3	2	3	3	3	3	3
1 A 3 a ii (ii)	Civil Aviation (Domestic, Cruise)	8	8	8	7	8	8	8	8	8	9	8	8
1 A 3 b	Road Transportation	17454	17634	17515	16860	16928	17560	16810	16621	16627	16956	16980	16958
1 A 3 c	Railways	141	127	120	116	109	109	87	83	91	98	105	105
1 A 3 d ii	National Navigation	694	595	566	441	410	429	393	505	561	599	604	624
1 A 3 e ii	Other mobile sources and machinery	368	365	362	360	357	354	353	352	351	351	350	350
1 A 4 a	Commercial / Institutional	1324	1168	772	716	639	570	590	536	511	461	428	487
1 A 4 b i	Residential plants	57084	53587	50223	47030	40757	40185	37280	31786	27680	22845	21235	24247
1 A 4 b ii	Household and gardening (mobile)	438	438	437	437	437	436	436	437	455	473	491	491
1 A 4 c i	Stationary, agriculture, forestry and fishing	460	455	444	408	235	216	192	176	158	130	23	29
1 A 4 c ii	Off-road Vehicles and Other Machinery	1461	1450	1439	1428	1417	1406	1400	1395	1388	1381	1374	1373
1 A 5 b	Other, Mobile (Including military)	44	43	41	38	42	43	36	31	27	23	30	21
1 B 1 b	Solid fuel transformation	3	3	2	2	4	3	3	2	3	3	3	3
1 B 1 c	Other	215	192	185	196	188	217	205	206	193	186	191	181
1 B 2 a	Oil	40	40	40	40	40	39	37	35	33	33	34	31
1 B 2 a i	Exploration Production, Transport	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	NE	0.0	0.0
1 B 2 a iv	Refining / Storage	40	40	40	40	40	39	37	35	33	33	34	31
1 B 2 b	Natural gas	NE	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1	NE	NE	0.1
2	**INDUSTRIAL PROCESSES**												
2 A 1	Cement Production	803	1086	806	704	599	734	681	625	487	237	194	229
2 A 2	Lime Production	580	NE	583	580	585	591	589	586	588	350	291	283
2 A 7	Other including Non Fuel Mining & Construction	4810	3874	3125	2735	3117	2302	2042	1981	2372	1872	2488	2039
2 B 4	Carbide Production	108	179	112	250	135	138	178	303	209	335	217	237
2 C	METAL PRODUCTION	3413	3464	3527	3551	3548	3249	2022	2083	1987	1603	1473	1576
2 D 1	Pulp and Paper	8622	8826	8610	8787	7538	7054	6665	6462	6372	5525	5474	5432
3	**SOLVENT AND PRODUCT USE**												
3 D	OTHER including products containing HMs and POPs	668	696	730	640	587	629	628	596	611	600	624	646
4	**AGRICULTURE**												
4 G	OTHER	3550	3443	3469	3430	3489	3513	3481	3 497	3387	3369	3298	3298
5	**WASTE**												
6 D	OTHER WASTE	NE	NE	NE	NE	NE	NE	311	1256	51	278	285	1256
	National Total	113232	109309	104082	100359	93706	91844	87335	80133	74300	66982	66118	70639

		$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$
	$PM_{2.5}$ (metric ton)	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
1	**ENERGY**										
1 A 1 a	Public Electricity and Heat Production	3024	2943	2881	2338	2799	3149	3202	3081	2667	2182
1 A 1 b	Petroleum refining	427	334	312	208	171	148	177	2	160	183
1 A 1 c	Manufacture of Solid Fuels and Other Energy	3	2	3	2	2	2	2	3	2	1
1 A 2	Manufacturing Industries and Construction	7994	4095	10705	9841	7300	6170	5540	5435	5929	5598
1 A 3 a ii (i)	Civil Aviation (Domestic, LTO)	8	9	9	8	9	8	10	8	9	9
1 A 3 a ii (ii	Civil Aviation (Domestic, Cruise)	25	26	27	25	26	25	29	25	26	28
1 A 3 b	Road Transportation	6303	6298	6293	6288	6283	6278	6314	6350	6443	6558
1 A 3 c	Railways	132	131	137	135	149	152	145	147	142	126
1 A 3 d ii	National Navigation	577	507	527	702	887	994	1067	926	920	846
1 A 3 e ii	Other mobile sources and machinery	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 A 4 a	Commercial / Institutional	NE	NE	NE	562	497	426	335	381	386	339
1 A 4 b i	Residential plants	NE	NE	NE	63339	71616	82977	74969	65325	58653	53323
1 A 4 b ii	Household and gardening (mobile)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 A 4 c i	Stationary, agriculture, forestry and fishing	NE	NE	NE	113	118	126	124	139	132	118
1 A 4 c ii	Off-road Vehicles and Other Machinery	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 A 5 b	Other, Mobile (Including military)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 B 1 b	Solid fuel transformation	2	3	1	1	2	2	2	NE	2	2
1 B 1 c	Other	329	13	18	19	24	29	27	24	23	22
1 B 2 a	Oil	0.1	0.2	0.2	0.2	0.2	0.2	0.2	NE	0.1	0.1
1 B 2 a i	Exploration Production, Transport	NE	NE	NE	NE	NE	NE	NE	NE	0.1	0.1
1 B 2 a iv	Refining / Storage	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1 B 2 b	Natural gas	0.0	0.1	0.1	0.1	0.1	0.1	0.1	NE	0.0	0.0
2	**INDUSTRIAL PROCESSES**										
2 A 1	Cement Production	948	886	826	874	746	554	469	605	913	925
2 A 2	Lime Production	488	487	488	490	489	490	491	490	489	489
2 A 7	Other including Non Fuel Mining & Construction	3201	2342	2038	2052	2706	3791	3876	3982	4403	4379
2 B 4	Carbide Production	172	164	176	160	248	232	184	75	48	96
2 C	METAL PRODUCTION	5891	4989	4043	3887	4016	3906	4230	3839	3301	3175
2 D 1	Pulp and Paper	9465	8936	7759	8358	8515	7698	8072	7910	7582	7053
3	**SOLVENT AND PRODUCT USE**										
3 D	OTHER including products containing HMs and POPs	601	608	603	569	556	537	535	523	504	510
4	**AGRICULTURE**										
4 G	OTHER	741	730	756	785	776	776	762	740	749	760
5	**WASTE**										
6 D	OTHER WASTE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	National Total	40332	33503	37601	100757	107934	118470	110561	100010	93483	86725

		$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$	$PM_{2.5}$
	$PM_{2.5}$ (metric ton)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
1	**ENERGY**												
1 A 1 a	Public Electricity and Heat Production	2226	2575	2548	2758	2961	2827	3955	2776	2574	2247	2072	2536
1 A 1 b	Petroleum refining	152	142	204	199	182	182	182	220	214	184	1022	989
1 A 1 c	Manufacture of Solid Fuels and Other Energy	0	35	0	0	0	0	0	0	0	0	0	0
1 A 2	Manufacturing Industries and Construction	6791	6882	6455	6775	7236	7074	6599	5794	5697	5324	5181	5550
1 A 3 a ii (i)	Civil Aviation (Domestic, LTO)	3	3	3	2	3	3	2	3	3	3	3	3
1 A 3 a ii (ii	Civil Aviation (Domestic, Cruise)	8	8	8	7	8	8	8	8	8	9	8	8
1 A 3 b	Road Transportation	5939	6011	5799	5490	5455	5858	5096	4884	4774	4739	4581	4395
1 A 3 c	Railways	134	121	114	110	103	103	83	79	86	93	100	100
1 A 3 d ii	National Navigation	671	577	550	431	401	419	386	492	545	581	585	605
1 A 3 e ii	Other mobile sources and machinery	351	348	346	343	341	338	337	336	335	335	334	334
1 A 4 a	Commercial / Institutional	1186	1046	694	643	576	515	531	480	459	415	385	437
1 A 4 b i	Residential plants	50795	47677	44687	41840	36263	35755	33167	28280	24622	20324	18893	21570
1 A 4 b ii	Household and gardening (mobile)	436	435	435	434	434	434	434	434	452	471	489	489
1 A 4 c i	Stationary, agriculture, forestry and fishing	363	374	380	352	203	190	170	156	139	116	21	26
1 A 4 c ii	Off-road Vehicles and Other Machinery	1389	1379	1368	1358	1347	1337	1331	1326	1320	1313	1307	1306
1 A 5 b	Other, Mobile (Including military)	42	41	39	37	40	41	34	29	25	22	29	20
1 B 1 b	Solid fuel transformation	3	3	2	2	4	3	3	2	3	3	3	3
1 B 1 c	Other	22	19	18	20	19	22	20	21	19	19	19	18
1 B 2 a	Oil	36	36	36	36	36	35	33	31	30	30	31	28
1 B 2 a i	Exploration Production, Transport	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	NE	0.0	0.0
1 B 2 a iv	Refining / Storage	36	36	36	36	36	35	33	31	30	30	31	28
1 B 2 b	Natural gas	NE	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1	NE	NE	NE
2	**INDUSTRIAL PROCESSES**												
2 A 1	Cement Production	652	882	664	580	493	605	561	556	433	211	172	203
2 A 2	Lime Production	488	NE	489	488	489	490	490	489	490	286	218	209
2 A 7	Other including Non Fuel Mining & Construction	3778	2991	2372	2105	2474	1935	1681	1652	2029	1527	2139	1690
2 B 4	Carbide Production	96	159	99	222	120	122	158	270	186	298	193	210
2 C	METAL PRODUCTION	2841	2916	2990	3018	3029	2754	1714	1755	1619	1318	1211	1299
2 D 1	Pulp and Paper	6227	6503	6344	6475	5554	5197	5262	5101	5030	4362	4322	4289
3	**SOLVENT AND PRODUCT USE**												
3 D	OTHER including products containing HMs and POPs	668	696	730	640	587	629	628	596	611	600	624	646
4	**AGRICULTURE**												
4 G	OTHER	775	754	761	750	764	770	761	764	741	738	724	724
5	**WASTE**												
6 D	OTHER WASTE	NE	NE	NE	NE	NE	NE	311	1256	51	278	285	1256
	National Total	86105	82647	78170	75150	69158	67681	63970	57821	52526	45874	44981	48969

	As (metric ton)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	ENERGY												
1 A 1 a	Public Electricity and Heat Production	0.38	0.42	0.42	0.40	0.35	0.40	0.39	0.36	0.46	0.34	0.32	0.35
1 A 1 b	Petroleum refining	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.01
1 A 2	Manufacturing Industries and Construction	0.14	0.22	0.21	0.23	2.64	0.26	0.25	0.17	0.17	0.16	0.23	0.19
1 A 4 a	Commercial / Institutional	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1 A 4 b i	Residential plants	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04
1 A 4 c i	Stationary, agriculture, forestry, fishing	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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
2	INDUSTRIAL PROCESSES												
2 A	MINERAL PRODUCTS	0.17	0.32	0.13	0.11	0.09	0.07	0.05	0.03	0.30	0.03	0.03	0.02
2 C	METAL PRODUCTION	4.70	3.24	3.22	1.90	0.66	0.78	0.49	0.55	0.49	0.23	0.17	0.36
2 D 1	Pulp and Paper	0.13	0.13	0.13	0.13	0.11	0.11	0.10	0.10	0.10	0.09	0.10	0.10
	NATIONAL TOTAL	5.63	4.44	4.21	2.87	3.96	1.71	1.39	1.31	1.61	0.94	0.91	1.09

	Cd (metric ton)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	ENERGY												
1 A 1 a	Public Electricity and Heat Production	0.16	0.17	0.17	0.17	0.15	0.19	0.24	0.20	0.22	0.20	0.18	0.22
1 A 1 b	Petroleum refining	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.01
1 A 2	Manufacturing Industries and Construction	0.24	0.30	0.31	0.33	0.39	0.37	0.36	0.27	0.28	0.26	0.28	0.28
1 A 3 b vi	R.T., Automobile tyre and brake wear	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1 A 4 a	Commercial / Institutional	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1 A 4 b i	Residential plants	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.13	0.13	0.12	0.12	0.13
1 A 4 c i	Stationary, agriculture, forestry, fishing	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	INDUSTRIAL PROCESSES												
2 A	MINERAL PRODUCTS	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.01
2 C	METAL PRODUCTION	1.55	1.02	0.93	0.66	0.33	0.31	0.28	0.30	0.25	0.13	0.09	0.17
2 D 1	Pulp and Paper	0.09	0.09	0.09	0.09	0.08	0.07	0.07	0.07	0.07	0.06	0.07	0.07
	NATIONAL TOTAL	2.24	1.78	1.71	1.46	1.15	1.15	1.16	1.04	1.01	0.86	0.80	0.91

	Cr (metric ton)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	ENERGY												
1 A 1 a	Public Electricity and Heat Production	1.13	1.21	0.78	0.78	0.46	0.45	0.67	0.59	0.63	0.34	0.31	0.35
1 A 1 b	Petroleum refining	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03
1 A 2	Manufacturing Industries and Construction	0.48	0.71	0.71	0.72	0.77	0.79	0.78	0.47	0.47	0.43	0.66	0.40
1 A 4 a	Commercial / Institutional	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1 A 4 b i	Residential plants	0.12	0.12	0.12	0.12	0.11	0.08	0.08	0.07	0.07	0.06	0.06	0.07
1 A 4 c i	Stationary, agriculture, forestry, fishing	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	INDUSTRIAL PROCESSES												
2 A	MINERAL PRODUCTS	0.24	0.19	0.16	0.14	0.17	0.12	0.10	0.09	0.11	0.12	0.15	0.11
2 C	METAL PRODUCTION	20.70	16.87	15.12	15.25	13.76	10.61	8.89	7.27	6.02	5.18	5.53	5.91
2 D 1	Pulp and Paper	0.20	0.20	0.19	0.21	0.17	0.17	0.15	0.16	0.16	0.14	0.15	0.15
	NATIONAL TOTAL	22.9	19.3	17.2	17.3	15.5	12.2	10.7	8.7	7.5	6.3	6.9	7.0

	Cu (metric ton)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	ENERGY												
1 A 1 a	Public Electricity and Heat Production	1.38	1.52	1.09	1.21	0.87	0.84	1.25	1.04	1.12	0.82	0.74	0.91
1 A 1 b	Petroleum refining	0.09	0.09	0.12	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.03	0.03
1 A 2	Manufacturing Industries and Construction	1.38	1.57	1.70	1.72	1.93	1.53	1.48	1.21	1.20	1.11	2.68	1.23
1 A 3 b vi	R.T., Automobile tyre and brake wear	9.48	9.57	9.66	9.38	9.47	9.64	9.69	9.72	9.82	10.13	10.29	10.44
1 A 4 a	Commercial / Institutional	0.10	0.10	0.07	0.07	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04
1 A 4 b i	Residential plants	0.56	0.56	0.55	0.55	0.54	0.55	0.56	0.52	0.51	0.48	0.47	0.52
1 A 4 c i	Stationary, agriculture, forestry, fishing	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01
2	INDUSTRIAL PROCESSES												
2 A	MINERAL PRODUCTS	0.14	0.12	0.33	0.28	0.13	0.15	0.17	0.09	0.07	0.06	0.07	0.05
2 C	METAL PRODUCTION	20.52	18.51	25.73	15.64	6.30	5.79	6.30	7.24	5.16	3.03	2.19	1.81
2 D 1	Pulp and Paper	0.64	0.65	0.64	0.67	0.57	0.54	0.50	0.52	0.50	0.44	0.49	0.48
	NATIONAL TOTAL	34.3	32.7	40.1	29.7	20.0	19.2	20.1	20.5	18.6	16.2	17.0	15.5

	Hg (metric ton)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	ENERGY												
1 A 1 a	Public Electricity and Heat Production	0.34	0.27	0.19	0.16	0.13	0.15	0.14	0.12	0.11	0.08	0.07	0.07
1 A 1 b	Petroleum refining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
1 A 2	Manufacturing Industries and Construction	0.17	0.19	0.18	0.19	0.20	0.20	0.20	0.11	0.11	0.11	0.19	0.15
1 A 4 a	1 A 4 a Commercial / Institutional	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 b i	1 A 4 b i Residential plants	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03
1 A 4 c i	1 A 4 c i Stationary, agriculture, forestry, fishing	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1B1	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
2	INDUSTRIAL PROCESSES												
2 A	2 A MINERAL PRODUCTS (b)	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 B	2 B CHEMICAL INDUSTRY	0.26	0.26	0.25	0.16	0.18	0.13	0.14	0.11	0.14	0.11	0.09	0.07
2 C	2 C METAL PRODUCTION	0.46	0.33	0.31	0.29	0.28	0.29	0.29	0.26	0.24	0.36	0.27	0.17
2 D 1	2 D 1 Pulp and Paper	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
6	WASTE												
6 C	6 C WASTE INCINERATION (e)	0.26	0.27	0.28	0.29	0.29	0.29	0.28	0.27	0.22	0.18	0.12	0.12
	NATIONAL TOTAL	1.56	1.40	1.27	1.14	1.13	1.12	1.11	0.92	0.88	0.89	0.81	0.65

	Ni (metric ton)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	ENERGY												
1 A 1 a	1 A 1 a Public Electricity and Heat Production	4.35	4.84	4.80	5.18	4.89	5.19	7.30	4.50	6.13	3.84	2.28	3.56
1 A 1 b	1 A 1 b Petroleum refining	4.37	4.10	5.90	5.74	5.27	5.26	5.26	5.26	5.49	5.31	0.71	0.71
1 A 2	1 A 2 Manufacturing Industries and Construction	11.08	9.85	8.94	10.33	12.68	13.36	12.54	14.95	14.04	12.74	10.43	10.24
1 A 4 a	1 A 4 a Commercial / Institutional	2.27	2.04	1.19	1.18	0.70	0.45	0.45	0.39	0.08	0.22	0.22	0.33
1 A 4 b i	1 A 4 b i Residential plants	1.31	1.47	1.01	1.00	1.38	0.92	0.73	0.71	0.70	0.48	0.29	0.39
1 A 4 c i	1 A 4 c i Stationary, agriculture, forestry, fishing	0.35	0.35	0.31	0.30	0.28	0.38	0.38	0.37	0.38	0.19	0.27	0.27
2	INDUSTRIAL PROCESSES												
2 A	2 A MINERAL PRODUCTS (b)	1.02	0.75	0.63	0.56	0.65	0.42	0.39	0.36	0.43	0.33	0.47	0.38
2 C	2 C METAL PRODUCTION	7.27	6.17	6.90	7.36	8.16	7.85	2.99	2.27	1.70	1.06	0.75	0.72
2 D 1	2 D 1 Pulp and Paper	0.47	0.48	0.47	0.49	0.42	0.40	0.37	0.38	0.37	0.33	0.36	0.35
	NATIONAL TOTAL	32	30	30	32	34	34	30	29	29	24	16	17

	Pb (metric ton)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	ENERGY												
1 A 1 a	1 A 1 a Public Electricity and Heat Production	2.70	2.13	1.99	1.88	1.46	1.66	2.16	1.78	2.05	1.52	1.34	1.61
1 A 1 b	1 A 1 b Petroleum refining	0.27	0.26	0.37	0.36	0.33	0.33	0.33	0.33	0.34	0.33	0.09	0.09
1 A 2	1 A 2 Manufacturing Industries and Construction	2.04	2.55	2.56	2.67	2.99	3.03	2.94	2.37	2.32	2.14	2.47	2.55
1 A 3 b i	1 A 3 b i R.T., Passenger cars	352	298	271	213	14	NO	NO	NO	NO	NO	NO	NO
1 A 3 b ii	1 A 3 b ii R.T., Light duty vehicles	38.0	32.0	29.0	22.0	1.45	NO	NO	NO	NO	NO	NO	NO
1 A 3 b iv	1 A 3 b iv R.T., Mopeds & Motorcycles	0.08	0.08	0.09	0.03	0.13	NO	NO	NO	NO	NO	NO	NO
1 A 3 b vi	1 A 3 b vi R.T., Automobile tyre and brake wear	2.26	2.29	2.31	2.24	2.26	2.30	2.31	2.32	2.34	2.42	2.46	2.49
1 A 4 a	1 A 4 a Commercial / Institutional	0.21	0.19	0.13	0.13	0.10	0.08	0.08	0.07	0.06	0.06	0.06	0.07
1 A 4 b i	1 A 4 b i Residential plants	1.03	1.04	1.01	1.01	0.99	0.81	0.82	0.76	0.75	0.69	0.68	0.76
1 A 4 c i	1 A 4 c i Stationary, agriculture, forestry, fishing	0.07	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.02	0.03	0.03
2	INDUSTRIAL PROCESSES												
2 A	2 A MINERAL PRODUCTS (b)	1.69	1.72	1.69	1.41	1.19	1.73	1.54	1.70	1.67	2.75	2.91	0.80
2 C	2 C METAL PRODUCTION	73.49	57.07	44.88	30.50	20.05	13.50	10.78	10.54	8.85	7.57	5.10	6.00
2 D 1	2 D 1 Pulp and Paper	0.40	0.42	0.40	0.42	0.36	0.34	0.32	0.33	0.32	0.28	0.31	0.30
	NATIONAL TOTAL	474	398	355	276	45	24	21	20	19	18	15	15

	Se (metric ton)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	ENERGY												
1 A 1 a	1 A 1 a Public Electricity and Heat Production	0.16	0.17	0.17	0.17	0.15	0.19	0.24	0.20	0.22	0.20	0.18	0.22
1 A 1 b	1 A 1 b Petroleum refining	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.01
1 A 2	1 A 2 Manufacturing Industries and Construction	0.24	0.30	0.31	0.32	0.37	0.37	0.36	0.27	0.28	0.26	0.28	0.28
1 A 4 a	1 A 4 a Commercial / Institutional	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01
1 A 4 b i	1 A 4 b i Residential plants	0.11	0.11	0.10	0.10	0.10	0.10	0.11	0.10	0.10	0.09	0.09	0.10
1 A 4 c i	1 A 4 c i Stationary, agriculture, forestry, fishing	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NATIONAL TOTAL	0.56	0.63	0.65	0.65	0.67	0.71	0.75	0.61	0.64	0.60	0.57	0.61

	Zn (metric ton)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	ENERGY												
1 A 1 a	1 A 1 a Public Electricity and Heat Production	11.02	11.26	8.77	13.31	12.86	19.77	30.86	24.43	24.96	27.72	26.60	33.17
1 A 1 b	1 A 1 b Petroleum refining	0.22	0.20	0.29	0.29	0.26	0.26	0.26	0.26	0.27	0.27	0.05	0.05
1 A 2	1 A 2 Manufacturing Industries and Construction	30.70	29.70	36.00	34.81	39.82	37.84	36.72	35.06	35.38	33.12	25.68	33.43
1 A 3 b vi	1 A 3 b vi R.T., Automobile tyre and brake wear	13.22	13.35	13.47	13.08	13.20	13.45	13.51	13.55	13.69	14.12	14.35	14.56
1 A 4 a	1 A 4 a Commercial / Institutional	0.29	0.20	0.14	0.14	0.11	0.10	0.10	0.12	0.10	0.10	0.10	0.11
1 A 4 b i	1 A 4 b i Residential plants	8.02	4.11	4.10	4.14	3.90	4.17	4.25	4.01	3.94	3.70	3.69	4.21
1 A 4 c i	1 A 4 c i Stationary, agriculture, forestry, fishing	0.42	0.29	0.17	0.15	0.09	0.07	0.05	0.05	0.05	0.03	0.01	0.02
2	INDUSTRIAL PROCESSES												
2 A	2 A MINERAL PRODUCTS (b)	0.72	1.13	1.71	0.79	0.92	0.77	1.05	0.39	0.31	0.36	0.30	0.33
2 C	2 C METAL PRODUCTION	112.7	97.00	70.94	70.07	65.07	49.79	34.25	32.98	30.42	19.48	18.95	19.65
2 D 1	2 D 1 Pulp and Paper	0.80	0.83	0.81	0.85	0.72	0.68	0.63	0.65	0.63	0.56	0.61	0.60
	NATIONAL TOTAL	178	158	136	138	137	127	122	112	110	99	90	106

		PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4
	PAH-4 (metric ton)	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
1	**ENERGY**										
1 A 1 a	Public Electricity and Heat Production	1.40	0.14	0.41	0.41	0.55	0.69	0.77	0.56	0.57	0.45
1 A 1 b	Petroleum refining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 2	Manufacturing Industries and Construction	5.93	0.01	6.15	4.93	3.12	2.99	2.73	1.62	1.67	1.19
1 A 4 a	Commercial / Institutional	NE	NE	NE	0.20	0.22	0.21	0.37	0.37	0.37	0.37
1 A 4 b i	Residential plants	NE	NE	NE	39.01	44.28	51.44	46.48	40.42	36.30	33.00
1 A 4 c	Agriculture / Forestry / Fishing	NE	NE	NE	0.15	0.16	0.18	0.21	0.22	0.23	0.20
1 B 1 b	Solid fuel transformation	NE	NE	NE	NE	NE	NE	NE	1.12	0.90	0.99
2	**INDUSTRIAL PROCESSES**										
2 C	METAL PRODUCTION	NE	NE	NE	NE	6.87	6.08	4.86	1.62	3.57	4.86
2 D 1	Pulp and Paper	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02
6	**WASTE**										
6 C	WASTE INCINERATION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NATIONAL TOTAL				44.71	55.22	61.61	55.45	45.96	43.63	41.08

		PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4	PAH-4
	PAH-4 (metric ton)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
1	**ENERGY**												
1 A 1 a	Public Electricity and Heat Production	0.51	0.50	0.49	0.50	0.48	0.45	0.54	0.48	0.44	0.38	0.36	0.43
1 A 1 b	Petroleum refining	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
1 A 2	Manufacturing Industries and Construction	1.25	0.93	1.11	0.73	0.84	0.41	0.40	0.36	0.21	0.21	0.14	0.19
1 A 4 a	Commercial / Institutional	0.37	0.35	0.24	0.24	0.37	0.24	0.28	0.29	0.32	0.29	0.32	0.37
1 A 4 b i	Residential plants	31.39	29.49	27.64	25.91	22.41	22.11	20.54	17.50	15.26	12.59	18.03	20.60
1 A 4 c	Agriculture / Forestry / Fishing	0.19	0.18	0.18	0.17	0.19	0.09	0.09	0.09	0.09	0.09	0.00	0.00
1 B 1 b	Solid fuel transformation	1.06	1.13	1.16	1.15	1.15	1.16	1.17	1.16	1.16	0.16	1.20	1.20
2	**INDUSTRIAL PROCESSES**												
2 C	METAL PRODUCTION	3.89	5.19	2.59	2.27	2.92	3.66	4.40	2.53	4.70	6.45	3.21	4.05
2 D 1	Pulp and Paper	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
6	**WASTE**												
6 C	WASTE INCINERATION	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NATIONAL TOTAL	38.67	37.78	33.44	31.00	28.37	28.14	27.44	22.43	22.21	20.18	23.29	26.86

		Diox	Diox	Diox	Diox	Diox	Diox	Diox	Diox	Diox	Diox
	Dioxin (g)	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
1	**ENERGY**										
1 A 1 a	Public Electricity and Heat Prod.	120.01	47.01	72.44	72.44	92.94	102.06	87.36	64.11	34.27	18.83
1 A 2	Manufacturing Industries and	9.02	1.31	10.72	10.72	7.79	8.73	8.04	8.07	8.56	9.02
1 A 3 b	Road Transportation	6.35	6.37	6.39	6.42	5.84	5.87	5.36	4.29	4.48	4.69
1 A 4 a	Commercial / Institutional	NE	NE	NE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 b	Residential	NE	NE	NE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 c	Agriculture / Forestry / Fishing	NE	NE	NE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	**INDUSTRIAL PROCESSES**										
2 A	MINERAL PRODUCTS	6.11	5.51	5.56	6.27	6.60	7.45	7.42	7.33	7.48	7.71
2 B	CHEMICAL INDUSTRY	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2 C	METAL PRODUCTION	37.60	31.90	29.50	28.00	27.90	27.50	24.80	22.70	23.00	20.80
2 D 1	Pulp and Paper	1.90	1.90	1.70	1.90	2.10	1.60	1.60	1.30	1.30	0.80
6	**WASTE**										
6 C	WASTE INCINERATION	0.42	0.43	0.44	0.44	0.45	0.48	0.48	0.49	0.51	0.51
6 D	OTHER WASTE	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	NATIONAL TOTAL	194.41	107.43	139.75	139.19	156.62	166.69	148.06	121.29	92.60	75.36

		Diox	Diox	Diox	Diox	Diox	Diox	Diox	Diox	Diox	Diox	Diox	Diox
	Dioxin (g)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
1	**ENERGY**												
1 A 1 a	Public Electricity and Heat Prod.	14.34	13.28	5.46	9.61	6.05	8.72	11.14	10.09	10.05	10.21	9.89	11.37
1 A 2	Manufacturing Industries and Construction	11.56	11.55	12.52	12.62	13.79	13.57	13.29	10.03	10.18	9.46	10.65	11.07
1 A 3 b	Road Transportation	4.28	3.96	3.64	2.18	0.51	0.52	0.53	0.53	0.55	0.55	0.56	0.57
1 A 4 a	Commercial / Institutional	NE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NE	0.00	0.00
1 A 4 b	Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 A 4 c	Agriculture / Forestry / Fishing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NE	NE
2	**INDUSTRIAL PROCESSES**												
2 A	MINERAL PRODUCTS	7.39	6.81	6.29	6.82	6.29	3.01	1.05	1.14	1.65	1.15	1.69	1.35
2 B	CHEMICAL INDUSTRY	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	0.20
2 C	METAL PRODUCTION	17.93	13.23	12.73	11.81	11.10	9.49	7.08	7.94	6.54	6.18	7.17	5.52
2 D 1	Pulp and Paper	0.80	0.60	0.60	0.50	0.50	0.40	0.40	0.50	0.50	0.50	0.50	0.50
6	**WASTE**												
6 C	WASTE INCINERATION	0.53	0.54	0.54	0.55	0.54	0.55	0.60	0.61	0.61	0.62	0.63	0.59
6 D	OTHER WASTE	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	NATIONAL TOTAL	69.83	62.97	54.78	57.10	51.78	49.26	47.09	43.84	43.08	41.67	44.09	44.17

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