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Swedish Environmental Emissions Data

Revised Method for Estimating Emissions of NMVOC from Solvent and Other Product Use in Sweden

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SMED is short for Swedish Environmental Emissions Data, which is a collaboration between IVL Swedish Environmental Research Institute, SCB Statistics Sweden, SLU Swedish University of Agricultural Sciences, 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. Through a long-term contract for the Swedish Environmental Protection Agency extending until 2014, SMED is heavily involved in all work related to Sweden's international reporting obligations on emissions to air and water, waste and hazardous substances. A central objective of the SMED collaboration is to develop and operate national emission databases and offer related services to clients such as national, regional and local governmental authorities, air and water quality management districts, as well as industry. For more information visit SMED's website www.smed.se.

Summary

This report describes how a new method for estimating emissions of NMVOC and CO_2 from CRF sector 3, Solvent and Other Products Use, has been developed. This consumption-based method with a product related approach consists of two steps:

1. Data on amounts of solvents and solvent based products produced in, imported to or used in Sweden, and exported from Sweden, was derived from the Swedish Product Register at the Swedish Chemicals Inspectorate. The information was used for generating quantity time series for emissions of NMVOC and C from activities included in CRF sector 3.

2. Emission factors were established, considering emission reduction as well as application techniques, and emission time series for NMVOC were calculated. Knowledge of the carbon content of the individual NMVOCs was used for calculation of CO_2 emission time series.

This new Swedish method for estimating emissions of NMVOC and CO_2 from Solvent and Other Product Use is more transparent, complete and better adapted to its purposes compared to previous methods. The design of the model makes it easy to adjust emission factors and include new years in the time series, which facilitates consistent annual updates of time series in the future.

Swedish Summary

I denna rapport beskrivs hur en ny metod for att uppskatta NMVOC och CO_2 emissioner från CRF sektor 3 Lösningsmedel och annan produktanvändning har tagits fram. Metoden baseras på produktanvändning och kan indelas i två steg:

1. Uppgifter om mängder lösningsmedel och produkter innehållande lösningsmedel som produceras i, importeras till eller används i Sverige eller exporteras från Sverige har hämtats från Kemikalieinspektionens Produktregister. Med dessa uppgifter som grund skapades tidsserier över hanterad mängd NMVOC och C för aktiviteter inom CRF sektor 3.

2. Emissionsfaktorer fastställdes, med hänsyn tagen till emissionsreducerande åtgärder och produkternas användning och utnyttjades för att beräkna och skapa NMVOC-tidsserier. Kunskap om kolinnehållet i ingående NMVOC användes för att beräkna och skapa CO_2 tidsserierna.

Den nya svenska metoden för emissionsuppskattningar av NMVOC och CO_2 från sektorn Lösningsmedel och annan produktanvändning är mer transparent, fullständig och ändamålsenlig än tidigare använda metoder. Metoden gör det lätt att justera emissionsfaktorer och infoga nya år till tidsserien vilket underlättar att konsistent uppdatera tidsserierna framdeles.

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1 Introduction

1.1 Background

On a yearly basis Sweden is obliged to report national air emissions of several pollutants to UNFCCC (United Nations Framework Convention on Climate Change), the European Union's Mechanism for Monitoring Community Greenhouse Gas Emissions and for Implementing the Kyoto Protocol, CLRTAP (Convention of Long-range Transboundary Air Pollutants, and the EU NEC Directive (National Emissions Ceilings).

Reporting follows the revised 1996 IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse Gas Inventories[1] (IPCC Guidelines), IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories[2] (IPCC Good Practice Guidance), UNFCCC reporting guidelines on annual inventories[3] (FCCC/CP/2002/8) and CORINAIR / EMEP guidelines[4].

The base year for reporting NMVOC, according to the 1991 Geneva Protocol on the Control of Emissions of Volatile Organic Compounds[5], is 1988 for Sweden. Hence, the first year in the time series presented in this report is 1988.

During 2002, a SMED study was carried out[6], aiming at compiling time series of emissions of NMVOC in Sweden for all sectors included in the international reporting. In this study the estimated emissions of NMVOC from the sector Solvent and Other Product Use was based on information from various sources. For example data reported in companies environmental reports, data from the Products Register at the Swedish Chemicals Inspectorate, as well as information from experts or trade organisations is included. The major part of the estimated emissions is however based on earlier national reports, investigations and estimations of national NMVOC emissions. The time series for the sector Solvent and Other Product Use presented in the SMED report of 2002 are still to be considered as reliable. One of the main conclusions in the study of 2002 was that emissions from the sector Solvent and Other Product Use needed further attention, primarily concerning developing methods and finding sources of background data, in order to facilitate and make it possible to perform consistent annual updates of national emission data in the future.

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

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

[3] FCCC/CP/2002/8 (28 March 2003). Review of the implementation of commitments and of other provisions of the convention. National communications: greenhouse gas inventories from parties included in annex 1 to the convention UNFCCC guidelines on reporting and review.

[4] EEA (2004). EMEP/CORINAIR Emission Inventory Guidebook - 3rd edition September 2004 UPDATE. EEA Technical report No 30. http://reports.eea.eu.int/EMEPCORINAIR4/en

[5] UNECE (1991). Convention on Long-range Transboundary Air Pollution, Protocol on the Control of Emissions of Volatile Organic Compounds. http://www.unece.org/env/lrtap/vola_h1.htm

[6] Kindbom, K. et al., 2003. Estimated Emissions of NMVOC in Sweden 1988-2001.

1.2 Aim of project

The aim of the present project was to develop a method and a model for annual calculations of emissions of NMVOC from reporting sector 3, Solvent and Other Product Use, which fulfils the requirements according to IPCC and UNECE guidelines as well as to CORINAIR / EMEP guidelines. The model should be based on data from the Products Register at the Swedish Chemicals Inspectorate.

2 International emission reporting requirements and guidelines

2.1 General reporting requirements and guidelines

On a yearly basis Sweden is obliged to report national air emissions of several pollutants to several international bodies:

- UNFCCC (United Nations Framework Convention on Climate Change). Reporting according to IPCC (Intergovernmental Panel on Climate Change) guidelines[7]. Reporting follows revised 1996 IPCC (Intergovernmental Panel on Climate Change) Guidelines for National Greenhouse gas Inventories (IPCC Guidelines), IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse gas inventories (IPCC Good Practice Guidance)[8], and UNFCCC Reporting Guidelines on annual inventories (FCCC/CP/2002/8)[9].

- European Union's Mechanism for Monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol. Reporting follows IPCC guidelines (see above).

- CLRTAP (United Nation's Convention on Long-Range Transboundary Air Pollution) which follows CORINAIR / EMEP guidelines[10].

- Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants which follows CORINAIR / EMEP guidelines[10].

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

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

[9] FCCC/CP/2002/8 (28 March 2003). Review of the implementation of commitments and of other provisions of the convention. National communications: greenhouse gas inventories from parties included in annex 1 to the convention UNFCCC guidelines on reporting and review.

[10] EEA (2004). EMEP/CORINAIR Emission Inventory Guidebook - 3rd edition September 2004 UPDATE. EEA Technical report No 30. http://reports.eea.eu.int/EMEPCORINAIR4/en

Although some harmonisation exists between these bodies, there are some differences concerning pollutants, quality requirements, reporting intervals, source categories and geographical distribution. In general, common guidelines exist on choice of emission factors and calculation methodology (e.g. in EEA, 2004; IPCC, 1997) but each nation is free to adopt a calculation methodology which is best suited to local conditions.

2.2 Solvent and Other Product Use, reporting sector 3

In the inventory and reporting system, Solvent and Other Product Use is treated as a separate sector, apart from the sectors Energy, Industrial Processes, Agriculture, Land use, Land Use Change and Forestry (LULUCF) and Waste. Solvent and Other Product Use can be considered as an area source due to the fact that the solvent content in a variety of products for industrial, commercial and household applications is emitted when exposed to air. Solvent and Other Product Use is treated as a separate sector because the nature of this area source, with a number of very disperse activities and sources (described in Chapters 2.2.1, 2.2.2), requires a somewhat different approach for emission estimates than in other sectors.

2.2.1 Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

Solvents and related compounds include chemical cleaning substances used in dry cleaning, printing, metal degreasing, and a variety of industrial applications as well as household use. Also included in this category are paints, lacquers, thinners and related materials used in coatings in a variety of industrial, commercial and household applications. Table 2.1 lists some of the potentially important subcategories included under this source category.

Table 2.1 Potentially important sub-categories included under Solvent and Other Product Use[11].

Potentially important sub-categories included under "Solvent and Other Product Use"	
Surface coating (e.g. painting) operations	Application of paints, lacquer, enamel and primer to cans, wood products, metal parts, buildings etc. Use of thinning solvents.
Paper coating operations	Coating operations, mixing and use of thinning solvents.
Printing and publishing	Press operations, lithography, use of thinning solvents
General solvent use	Vapour degreasing, dry cleaning, textile manufacture, household solvent use.
Production of automobiles and trucks	Surface coating, cleaning/degreasing operations.
Ship building	Surface coating, cleaning/degreasing operations.
Chemical products manufacture and processing	Solvents are used in a variety of applications in the manufacturing of chemicals and chemical products.

[11] IPCC (1997). Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference manual, p.3.2

In the IPCC Guidelines[12] there are two basic approaches to emission estimations from Solvent and Other Product Use, depending on the availability of data on the activities producing emissions and the emission factors. The approaches are:

1) Production-based - In some cases, solvent or coating use is associated with centralised industrial production activities, such as automobile and ship production, textile manufacture, paper coating, chemical products manufacture, etc. In these cases it is generally possible to develop NMVOC emission factors based on unit of product output. These are based on the amount of paint, solvents, or other chemically volatile compounds consumed per unit of the final products. Once reasonable factors are developed it is straightforward to estimate annual emissions based on production data, which is generally available on an annual basis for most countries. Industrial production data is also compiled and published by international organisations (e.g., United Nations, 1992), and these data can be used as supplement to locally available data.

2) Consumption-based - In many applications of paints, solvents and similar products, the end uses are too small-scale, diverse, and dispersed to be tracked directly. Therefore emissions estimates are generally based on total consumption (i.e. sales) of the solvents, paints, etc., used in these applications. The assumption is that once these products are sold to end users, they are applied and emissions occur relatively rapidly. For most surface coating and general solvent use, this approach is used. Emission factors are developed based on the likely ultimate release of NMVOC to the atmosphere per unit of product consumed. These emission factors can then be applied to sales data for specific solvent or paint products.

2.2.1.1 Indirect emissions of CO_2 from atmospheric oxidation of NMVOC

According to UNFCCC Reporting Guidelines on annual inventories[13], indirect emissions of CO_2 from atmospheric oxidation of emitted NMVOC shall also be accounted for.

Indirect emissions of CO_2 from emissions of NMVOC in sector 3, Solvent and Other Product Use, should be accounted for by assuming that the carbon share in emitted NMVOC is 85%[14] according to the following equation:

$$\text{Emission}(CO_2) = C_{content} \times \text{Emission}(NMVOC) \times \frac{44}{12}$$

$C_{content}$ is the carbon content of the solvents and is set by default to 0.85. The user can modify the default value of $C_{content}$. The numbers 44 and 12 represents the molecular weights of CO_2 and C respectively.

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[12] IPCC (1997). Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference manual, p.3.2

[13] FCCC/CP/2002/8 (28 March 2003). Review of the implementation of commitments and of other provisions of the convention. National communications: greenhouse gas inventories from parties included in annex 1 to the convention UNFCCC guidelines on reporting and review. pp 46-47

[14] Pulles, T., Skákala, J., Svetlik, J. 1999. ReportER, User manual. Technical report No 32 European Environment Agency.

As pointed out in the second-order 2006 Draft IPCC Guidelines for National Greenhouse Gas Inventories[15], the carbon content in the NMVOC emissions from solvent use can be based on a speciation profile of these emissions, and the weighted average carbon content of the individual chemical species. If information on the speciation profile is not available, a default average carbon content of 60% by mass may be used. The default value has thereby been changed from 85% to 60% in the second-order 2006 Draft guidelines.

2.2.2 EMEP/CORINAIR Emission Inventory Guidebook

EMEP/CORINAIR Emission Inventory Guidebook (EEA, 2004) contains a general chapter with background information and guidelines for one simple and one more detailed methodology for estimating the overall solvent use in a country (Chapter B600 and B600a)[16].

The simple methodology for calculating NMVOC emissions from solvent use is based on per capita data for several source categories given in the guidelines. All relevant source categories that together contribute to more than 90% of the total NMVOC emission needs to be inventoried.

The detailed methodology is based on a mass balance per solvent. In the method all relevant solvents used or products consumed need to be inventoried, at least those together representing more than 90% of the total NMVOC emission. It is also, for the detailed methodology, pointed out that it is important not to double-count NMVOC compounds in making a solvent mass balance, and also that a decision has to be made whether to base the calculations on groups of NMVOC components, e.g. alkanes, chlorinated hydrocarbons etc, or on individual compounds.

A more specific methodology for each source category, with developed guidelines, is given in the chapters B610-641[16] in the guidelines. To get data for each source category it is necessary to collect all relevant consumption data. This approach is used in most of the chapters with specific guidance according to Table 2.2.

[15] IPPC (2006). Second order Draft of 2006 Guidelines (unpublished).

[16] EEA (2004). EMEP/CORINAIR Emission Inventory Guidebook - 3rd edition September 2004 UPDATE. EEA Technical report No 30. http://reports.eea.eu.int/EMEPCORINAIR4/en/group_06.pdf

Table 2.2 Sources covered by the EMEP/CORINAIR Guidebook (EEA, 2004)

Code	Guidelines developed	Sources covered
3A	Paint application	Manufacture of automobiles, Car repairing, Construction and building, Domestic use, Coil coating, Boat building, Wood, Other industrial and non-industrial paint application
3B	Degreasing, dry-cleaning and electronics	Metal degreasing, Dry cleaning
3C	Chemical products manufacturing or processing	Asphalt blowing, Polyurethane foam processing, Polystyrene foam processing
3D	Other use of solvents and related activities	Printing industry; Fat, edible and non edible oil extraction; Preservation of wood; Underseal treatment and conservation of vehicles; Vehicles dewaxing; Domestic solvent use

3 Definition of VOC

NMVOC (Non Methane Volatile Organic Compounds) is a diverse mixture of substances that for international reporting of emissions are added together. NMVOC arise from combustion processes and industrial processes, but are also to a large extent emitted as fugitive emissions from industrial process areas, from storage and handling of e.g. oil products, and from the use of solvent or solvent containing products. There are many different definitions for NMVOC that are used in the literature, but when developing this method the definition stated in the Council directive 1999/13/EC of March 1999 has been used[17]. This definition is also used in the UNECE Guidelines for Estimating and Reporting Emission data under the Convention on Long-range Transboundary Air Pollution.

3.1 EU-regulation

COUNCIL DIRECTIVE 1999/13/EC of 11 March 1999

The so-called VOC Solvents Directive[17] is the main instrument for reduction of VOC emissions in the European Community from a wide range of activities and installations. The definition of the term VOC according to the Directive is:

"Volatile organic compound (VOC) shall mean any organic compound having at 293.15º K a vapour pressure of 0.01 kPa or more, or having a corresponding volatility under the particular conditions of use. For the purpose of this Directive, the fraction of creosote which exceeds this value of vapour pressure at 293.15º K shall be considered a VOC."

[17] European Commission (1999). Council Directive 1999/13/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations. 29.3.1999, L85/1. http://europa.eu.int/eur-lex/pri/en/oj/dat/1999/l_085/l_08519990329en00010022.pdf

"**Organic compound** shall mean any compound containing at least the element carbon and one or more of hydrogen, halogens, oxygen, sulphur, phosphorus, silicon or nitrogen, with the exception of carbon oxides and inorganic carbonates and bicarbonates."

4 Methods in other countries

Norway, Denmark and Germany have all developed consumption-based methods and models for handling emissions from Solvent and Other Product Use. The Norwegian and Danish methods have both a solvent balance approach, while the German method is product related.

4.1 Norwegian method:

The Norwegian method[18] was developed in 1994 and uses a solvent balance approach when estimating emissions of NMVOC from Solvent and Other Product Use. The solvent balance is defined as:

*Emission = (production + import - export - destruction - feedstock) * solvent content * fraction emitted + emissions from certain industrial processes*

Certain industrial processes = emissions from production processes where solvents are used as feedstock or in industries where the emissions originating from solvent are well known.

The solvent balance is based on the commodities in the foreign trade and production statistics that are either pure solvents or products containing solvents. The needed data is summarised in Table 4.1.

[18] Rypdal, K. (1995). Løsemiddelbalanse for Norge. Utslipp, förbruk og metode, Statens Forurensningstillsyn, SFT Rapport 95:02. ISBN 82-7655-271-4.

Table 4.1 Needed statistics for the Norwegian solvent balance.

Activity	Needed statistics/ information	Data source
Import, export	Trade statistics, annually	Statistics Norway, Norwegian customs authorities
Production in the country	Manufacturing statistics, annually.	Statistics Norway, Norwegian Products Register
Destruction of solvent waste	Amount waste delivered and incinerated, information about the plants	NORSAS (Norwegian Resource Centre for Waste Management and Recycling), Norwegian Pollution Control Authority
Feedstock used in industrial processes	Manufacturing statistics (not collected annually)	Statistics Norway
Solvent content in products	Average solvent content is determined from the average chemical composition of the product categories	Norwegian Products Register
Fraction NMVOC emitted to air i.e. emission factor	Assumed for each commodity based on average chemical composition (NMVOC-profile)	Norwegian Products Register, published research etc.
Emissions from certain industry proc. where solvents are used as raw material	Reported emissions	Norwegian Pollution Control Authority

The calculation of indirect CO_2 emissions from NMVOC is based upon the content of carbon in NMVOC. The Norwegian GHG inventory assumes that the average content is about 82%. The indirect emission factor for CO_2 is then 3 kg CO_2/kg NMVOC (0.82*44/12).

4.2 Danish method

Denmark has chosen a solvent balance approach based on substances when estimating the emissions of NMVOC from Solvent and Other Product Use. The method is inspired by the Norwegian method.

The Danish method can be summarised as followed:

1. Identification of substances defined as NMVOC - a list that includes 427 substances, substance groups and products

2. Collection of production-, import- and export data concerning pure substances and products from Denmark's Statistics Bank

3. Categorizing of substances /products according to industry and NACE-code from the SPIN database[19] (Substances in Preparations in Nordic Countries)

4. Determination of emission factors. One for production of specific substances and one for consumption of products including the defined substances

[19] SPIN on the Internet Substances in Preparations in Nordic Countries. http://www.spin2000.net/spin.html

4.3 German method

In Germany they use a consumption-based method with a product related approach[20] when calculating emissions of NMVOC from Solvent and Other Product Use. In the method they use the NMVOC definition stated in the Council directive 1999/13/EC of March 1999[21] (se section 3.1). The German method includes the following steps:

1. The use of solvents and solvent based products are derived from production statistics and foreign trade statistics *(production + import - export).*

2. The use of the solvents and solvent based products in each specific industrial and commercial sector and in households are estimated.

3. The emission factors are developed in consideration of application techniques, emission control measure and other pathways of NMVOC release (e.g. waste, water, recycling).

5 The Swedish Products Register

In the Swedish Products Register, chemical products imported to or manufactured in Sweden are registered. It was launched in 1978 and in the beginning it contained only names of companies and products. It has been extended over the years and the latest more extensive change in the registration rules was done in 1992. In the beginning the Products Register was associated with the then existing Produktkontrollbyrån, and since 1986 the register is handled by the Swedish Chemicals Inspectorate.

In chapter 14 §10 in the Environmental Code[22] the existence of a register for the chemical products that professionally are brought to or manufactured in Sweden is fixed. In the Ordinance of chemical products and biotechnical organisms (1998:941)[23], § 10-12, the Swedish Chemicals Inspectorate is appointed the authority to keep the register. All products, imported or manufactured, in volumes exceeding 100 kg during a year and included in the annex to the ordinance[23], are obliged to be registered. The products in the annex are specified by their statistical customs number according to the CN (Combined Nomenclature). It encompasses many hundred types of products, most of them also intuitively included in the term "Chemical products" by the public. Where there is disagreement whether a product belongs to a type of products that has to be registered or not, guidance can be received from the Customs Authority.

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[20] Theloke, J., Friedrich, R. (2003). Development of an improved product based approach for the calculation of NMVOC emissions from solvent use in Germany and uncertainty analysis. Paper presented at the 12th International Emission Inventory Conference "Emission Inventories - Applying New Technologies," San Diego, April 29 - May 1, 2003. www.epa.gov/ttn/chief/conference/ei12/area/theloke.pdf

[21] European Commission (1999). Council Directive 1999/13/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations. 29.3.1999, L85/1. http://europa.eu.int/eur-lex/pri/en/oj/dat/1999/l_085/l_08519990329en00010022.pdf

[22] In Swedish: Miljöbalk, (SFS 1998:808),. 14 kap 10 §. http://www.notisum.se/rnp/sls/lag/19980808.HTM

[23] In Swedish: Förordning (SFS 1998:941) om kemiska produkter och biotekniska organismer, 10-12§ http://www.notisum.se/rnp/sls/lag/19980941.htm

5.1 Content of the Products Register

Information that shall be included in the Products Register is stated in the Swedish Chemicals Inspectorate Regulation (KIFS 1998:8)[24], chapter 7. The products shall at the latest be reported before the end of February the year after import or manufacture was started. Also products brought on the Swedish market to be sold under a new brand name have to be registered. The intention is that all product names of chemical products on the Swedish market are included in the Products Register.

The following information shall be reported:

- Registering company
- Name of the product
- The statistical customs number of the product
- Whether the product is imported, manufactured or/and has changed market name
- The registration number of an approved pesticide
- If the product is intended to be sold to consumers
- The quantity imported or manufactured last year
- Industrial sectors to which the product is sold
- The intended use of the product, the type of product
- The labelling regarding health and environmental danger, if applicable
- Risk phrases if the product can be carcinogenic, allergenic or toxic to reproduction
- The chemical composition with exact names and concentrations

Each year a form, including the information above, is sent to the company to be completed with last year's quantities and any other changes in name or market information. As the reporting is mandatory an annual update of the quantities is thus achieved.

[24] In Swedish: Kemikalieinspektionens föreskrifter (KIFS 1998:8) om kemiska produkter och biotekniska organismer; 7 kap. Anmälan till produktregistret, ISSN 0283-1937.
http://www.kemi.se/upload/Lagar%20m.m/KIFS/K98_8.pdf

5.2 Information of purchasing industrial sector

The reporting company shall state to which industrial sectors the product is sold. If a company imports a product to be used within its own production, the industrial category shall be reported. The industrial categories are stated by use of SNI code, the Swedish Standard Industrial Classification based on the international NACE nomenclature for economic activities. In the Products Register not all industrial sectors in SNI are used. Some industrial sectors are to be stated on a very high level e.g. the Construction sector. The grouping of industrial categories has changed during the years: Some categories have been split and others have disappeared, and for some years both the overall industrial category and one or several of its included under-categories have been possible to report.

Maximum three industrial categories can be reported as purchasing the product. If the product has a statistical customs number beginning with 28 or 29 the percentage sold to each of the three shall be stated. Also exported percentage shall be reported. The percentage can be stated for other products than the mandatory as well, but if this is not done the quantities are distributed arithmetically when summations are done.

5.3 Information on type of product

Liable to register are both substances and formulations. This means that the classification and codification of types of products is depending on both possible functions of raw material substance and of preparations. The company has to use those codes when registering the product. Between 1992 and 2001 about 220 different codes where used in the register to describe type of product. In 2002 a more extensive set of codes was introduced with about 700 different types of product codes, most of them among paint and adhesive products. It is the same set of codes that is used by the Norwegian and Danish product registers.

It is neither asked for nor possible to report a distribution of use between the product types. When extracting quantities per product type from the register the quantities are arithmetically distributed.

5.4 Information on chemical composition

A substance has always to be stated with the unambiguous chemical name, mostly the name is specified by its CAS-number. For registering, all substances have to be identified by their CAS-number which is used in the register to store and process data. For the very few that don’t have a CAS-number, special treatment is required.

The substance concentration has to be given with exact percentage except for paints, where the percentage can be reported within ten percents intervals. All substances that make a product hazardous have to be stated, as well as all other if they amount to more than five percentages. Substances that are carcinogenic, sensitising, mutagenic or toxic to reproduction have always to be stated, as also any preservative.

Ca 13 000 substances are registered as ingredients of the almost 70 000 imported or manufactured chemical products in 2003. Of those about 3 000 are polymers.

6 Extracts from the Products Register

6.1 Over the years

The categorisation of industrial sectors and types of products has been changed during the years. As some industrial categories have been added or have disappeared during the years, the extract of quantity data for a certain industrial sector over time necessitates knowledge of the category/code history of that sector. Above all the sectors of "Manufacture of transport equipment" (DM, D34, D35), "Trade" (G) and "Community, social and personal service" (O), have been made more disaggregated.

The same problem applies for types of product. Here, the thorough change of codes in 2002 is forming the main obstacle, but also the changes in small steps during earlier years.

According to the Regulation[25] maximum three industrial categories have to be stated. Most products are sold to only one sector. Products that are sold to many industrial categories are mostly pure substances. They are sold as raw material to more than three industrial categories, and the entire quantity cannot be reported in percent as the regulation and reporting form is designed now. The consequence is that for a part of the quantity in the product register there is no industrial category at all stated. Therefore, in queries that include summarising industrial category quantities, a part of the total sum may be missing.

[25] In Swedish: Kemikalieinspektionens föreskrifter (KIFS 1998:8) om kemiska produkter och biotekniska organismer; 7 kap. Anmälan till produktregistret, ISSN 0283-1937.
http://www.kemi.se/upload/Lagar%20m.m/KIFS/K98_8.pdf

6.2 Type of product data

Caution shall be taken in interpreting quantity and number of products of a certain type as a very exact observation. The specification from the registering companies of the product type(s) can be different even if products are similar or the same. This depends on that product type is not an absolutely defined concept, as the product can be used for several things and different suppliers emphasise different properties for different markets. So, when evaluating data, one has to bear in mind that products might include product types with close definitions, and sometimes it can be necessary to summarise all related product types to a more superior level.

6.3 Composition data

Solvents and other volatile substances used in chemical products are mostly well-defined substances. Some are refined natural mixtures, like the petroleum solvents. All have known CAS-numbers and very few volatile organic compounds are added as new ingredients in chemicals each year, as recent innovation is not focussing on volatile functional chemicals at all. The concept of volatility is not searchable in the Products Register as it contains no physical/chemical property data, and when particular substances are searched for, the CAS-numbers have to be used.

7 Method

7.1 Overview

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

$$E = AD \times EF$$

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

The developed method for calculating emissions of NMVOC from Solvent and Other Product Use is consumption-based with a product related approach. The definition for NMVOC stated in the Council directive of March 1999[26] (se section 3.1) is used. The method can be summarised as follows:

1. The sold amount of solvents and solvent based products are derived from the Products Register at the Swedish Chemicals Inspectorate. *(production + import - export)*

2. The use of the solvents and solvent based products in each specific industrial and commercial sector and in households are estimated.

3. The emission factors are developed taken into consideration the application techniques, emission reduction and other pathways of release (e.g. waste or water).

The emissions for 1995-2003 have been calculated with activity data, quantity of NMVOC and C in sold and imported amount of solvents, obtained from the Products Register at the Swedish Chemicals Inspectorate and country specific emissions factors.

The Products Register can not deliver reliable data, in this matter, for 1988-1994 for most industry categories. For these years data from former reported time series, compiled in a special study concerning NMVOC emissions, carried out by SMED in 2002[27], have been used since these time series are considered reliable. For most sub-codes, data from 1988 are known and emissions have been interpolated between 1988 and 1995. For some industries the whole time series for 1988-1994 has been used instead of interpolating between 1988 and 1995.

[26] European Commission (1999). Council Directive 1999/13/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations. 29.3.1999, L85/1. http://europa.eu.int/eur-lex/pri/en/oj/dat/1999/l_085/l_08519990329en00010022.pdf

[27] Kindbom, K. et al., 2003. Estimated Emissions of NMVOC in Sweden 1988-2001.

7.2 Substances

A list of substances that are defined as NMVOC, and can be found in the Products Register in a quantity over 100 tonnes, has been compiled. The following definition of NMVOC has been used:

"**Volatile organic compound** (VOC) shall mean any organic compound having at 293.15 K a vapour pressure of 0.01 kPa or more, or having a corresponding volatility under the particular conditions of use. For the purpose of this Directive, the fraction of creosote which exceeds this value of vapour pressure at 293.15° K shall be considered a VOC[26]."

All substances that could be found, in any of the approximately 65 000 active products, in the Products Register for 2003 were extracted with CAS-number, name and quantity. The substances were sorted by quantity range and the substances that could be found in quantities over 100 tonnes were listed. The limit of 100 tonnes were chosen on the basis that substances that can be found in the Products Register in quantities less than 100 tonnes are equivalent to 0.03% of the total solvent sales of 400 000 tonnes. The substance list for 2003 has been complemented with substances found in quantities exceeding 100 tonnes in the extractions for 1992-2002. This check will be done every year and if a new substance exceeds 100 tonnes the substance will be put on the substance list.

A manual selection has been made in order to select each substance with vapour pressure of 0.01 kPa or more at 293.15° K according to the chosen definition of VOC (see definition above).

The final substance list contains 344 substances defined as NMVOC. The list includes CAS-number, name, molecular formula and carbon share for each substance. The substance list is presented in Appendix 1. The carbon share for each substance has been calculated based on the molecular formula. In some cases a mixture of substances are included in the substance list, and for the mixtures the carbon content has been estimated by the Chemicals Inspectorate as 85% of NMVOC, based on information in the Products Register. In those cases when the carbon content can not be derived from the Products Register, the default value, given in UNFCCC second-order draft guidelines 2006[28], of 60% has been used (se section 2.2.1.1).

7.3 Activity data

The substance list has been used to extract quantities of NMVOC and C in substances found in the Products Register. Data extractions have been made for each year from 1992 to 2003. The extractions show for each year:

[28] IPPC (2006). Second order Draft of 2006 Guidelines (unpublished).

- The intended use of the product, the type of product (product code)
- Industry to which the product is sold (industry category)
- Quantity NMVOC
- Quantity C
- Number of products

When analysing the extractions from the Products Register, data for 1992-1994 showed not to be reliable to use for quantity estimations of NMVOC and C. The reason is that during this period many concentrations still were reported as intervals, even if work has been done by the Chemicals Inspectorate in order to further specify the concentrations. There were also changes in the code system during this period. Therefore data from the Products Register has only been used for 1995-2003. One exception to this rule is made for the industry categories that are includes in CRF "3D Other, other" where data also for 1995 are considered as not reliable.

7.4 Emission factors

Country specific emission factors for 1995-2003 have been developed for each reported activity within each CRF code. The emission factors have been developed in order to adjust to the old time series 1988-2001, which were developed by SMED in 2002[29], since they are considered reliable. The emission factors have been developed also considering the application techniques, the reported emissions presented in environmental reports for specific industries, as well as other pathways of release (e.g. waste or water). For example, in industries where most of the solvents are used in water solutions, an emission factor of 10% has been used. For emissions to air two emission factors have been developed for each activity; one for solvents used as raw material and one for the remaining quantities. The emission factors for raw material have been set very low, since most of the solvents will end up in the product and will not be emitted during production. The developed emission factors are presented in Appendix 2.

7.5 Conversion of C to CO_2

Emission of CO_2 has been calculated with the following equation:

$$\text{Emission}(CO_2) = C_{quantity} \times \text{Emission Factor} \times \frac{44.0098}{12.0011}$$

$C_{quantity}$ is the carbon quantity in NMVOC quantity. 44.0098 and 12.0011 are the molecular weights of CO_2 and C, respectively.

7.5.1 CO_2 emissions for 1988-1994

Since the method for calculating CO_2 emissions have been changed compared to the method used in previous submissions, the reported emissions of NMVOC for 1988-94 have been related to the calculated emissions NMVOC for 1995. This ratio has been

[29] Kindbom, K. et al., 2003. Estimated Emissions of NMVOC in Sweden 1988-2001.

used to calculate the emissions of CO_2 for each CFR code (3A-D) according to the following equation:

$$\text{Emission } (CO_2, \text{n}) = (Emission(NMVOC, n) \div Emission(NMVOC, 1995)) \times Emission(CO_2, 1995)$$

where n is emission year.

8 The Excel model

The model consists of two steps:

1. Generating time series for quantities of NMVOC and C for activities within CRF sector 3.

2. Calculating time series for emissions of NMVOC and CO_2 for activities within CRF sector 3.

8.1 Time series for quantities of NMVOC and C, step 1 of the model

8.1.1 Overview

The extractions from the Products Register for 1992-2003 have been used in order to compile a connection diagram with all combinations of "product codes" and "industry categories". For all combinations, decisions whether to include or exclude from reporting are based on expert judgements in order to avoid double-counting. If the combination should be included, it's specific CRF code has been decided. Furthermore, it has to be determined if the product is used as raw material or not. The quantities of NMVOC used as raw material in processes have been identified and treated separately from the other quantities for each CRF code, because most of the solvents used as raw material will not be emitted. An Excel macro has been written in order to compile time series with quantities of NMVOC and C for each sub-code within CRF sector 3.

8.1.2 Reporting of NMVOC in other sectors/cross-cutting issues

In order to avoid double-counting of reported emissions within other sectors an expert judgement has been made on both industry category and product function. The industries that are excluded in the extractions from the Products Register are considered to be reported in CRF 1, 2 or 6. The judgements made for industry categories are presented in Table 8.1 and Table 8.2. All industrial activities reported in CRF-codes other than CRF 3, are excluded in the extractions from the Products Register. This judgement is made regardless of presence of NMVOC emissions for the activity.

Table 8.1 Industry categories excluded in the extractions from the Products Register except for CRF 3A (Paint application) and CRF-code used for reporting the activity.

Industry category	Industry code	CRF 3A**	Reported in CRF-code
Petroleum refineries, lubricants-, asphalt- and coal products industries	7	X	1B2a iv, 2A5, 2A6
Mining and quarrying	C	X	2A7
Manufacture of food products and beverages	D15	X	2D2
Manufacture of pulp, paper and paper products	D21	X	2D1
Manufacture of coke, refined petroleum products and nuclear fuels	D23	X	1B1B
Manufacture of industrial gas	D24.11	X	2B5
Manufacture of other inorganic basic chemicals	D24.13	X	2B5
Manufacture of other organic basic chemicals	D24.14	X	2B5
Manufacture of fertilizers and nitrogen compounds	D24.15	X	2B5
Manufacture of plastics in primary forms	D24.16	X	2B5
Manufacture of synthetic rubber in primary forms	D24.17	X	2B5
Manufacture of pesticides and other agrochemical products	D24.20	X	2B5
Manufacture of basic pharmaceutical products	D24.41	X	2B5
Manufacture of pharmaceutical preparations	D24.42	X	2B5
Industry for soap and detergents, perfumes and toiletries	D24.5	X	2B5
Manufacture of soap, detergents, cleaning and polishing preparations	D24.51	X	2B5
Manufacture of perfumes and toilet preparations	D24.52	X	2B5
Other chemical industry	D24.6	X	2B5
Manufacture of explosives	D24.61	X	2B5
Manufacture of glues and gelatines*	D24.62	X	2B5
Manufacture of essential oils	D24.63	X	2B5
Manufacture of photochemical material	D24.64	X	2B5
Manufacture of other chemical products n.e.c	D24.66	X	2B5
Manufacture of man-made fibres	D24.70	X	2B5
Manufacture of plastic products	D25.2	X	2B5
Manufacture of glass and glass products	D26.1	X	2A7
Manufacture of non-refractory ceramic goods other than construction purposes; manufacture of refractory ceramic products	D26.2	X	2A7
Manufacture of ceramic tiles and flags	D26.3	X	2A7
Manufacture of bricks, tiles and construction products, in baked clay	D26.4	X	2A7
Manufacture of cement, lime and plaster	D26.5	X	2A1
Manufacture of articles of concrete, plaster and cement	D26.6	X	2A7

Industry category	Industry code	CRF 3A**	Reported in CRF-code
Cutting , shaping and finishing of ornamental and building stone	D26.7	X	2A7
Manufacture of various other non-metallic mineral products (for example glass- and mineral wool)	D26.8	X	2A7
Manufacture of basic metals	D27	X	2C
Manufacture of fabricated metal products, except machinery equipment	D28	X	2C
Treatment and coating of metals; general mechanical components	D28.5	X	2C
Recycling	D37	X	6

*All glue that are coded in the Products Register as it was sold to the glue industry are reported as CRF 3D-other, other, due to the sold amount of glue not are used by the industry but are sold further for domestic use.
** The product codes for paint begin with M05.

Table 8.2 Industry categories excluded in the extractions from the Products Register.

Industry category	Industry code	Always excluded
Other industrial production	11	X
Wholesale trade and commission trade, except of motor vehicles and motorcycles	G51	X
Trade with goods	G	X
Agents involved in the sale of fuels, ores, metals and industrial chemicals	G51.12	X
Wholesale of china and glassware, wallpaper and cleaning materials	G51.44	X
Wholesale of pharmaceutical products	G51.46	X
Wholesale of chemical products	G51.55	X

The judgements made for product codes are shown in Table 8.3. All products burned when used are excluded in the extractions from Products Register, though CO_2 may emit. But since the reported emissions of CO_2 are to be based on emitted NMVOC, the product is excluded for both gases.

Table 8.3 Product codes that are excluded in the extractions from the Products Register.

Product functions	Product code	Explanation
Motor fuels	B55100	Reported in CRF 1
Ignition gas	B55150	Reported in CRF 1
Heating fuels	B55200	Reported in CRF 1
Fuels, other	B55300	Reported in CRF 1
Anti-knocking agents	B60100	Reported in CRF 1
Fuel additives	B60200	Reported in CRF 1
EP-additives	E20100	Burned and not emitted
Road paving materials	K35500	Reported in CRF 2A
Construction materials, other	K35900	Reported in CRF 2A
Flux agents for soldering	L15100	Burned and not emitted
Soldering metals	L15200	Burned and not emitted
Soldering agents, other	L15990	Burned and not emitted
Gunpowder	S50100	Burned and not emitted
Pyrotechnical products	S50200	Burned and not emitted
Explosives, other	S50900	Burned and not emitted
Flux agents for welding	S75100	Burned and not emitted
Electrodes (welding)	S75200	Burned and not emitted
Welding product, other	S75400	Burned and not emitted

8.1.3 Description

Input data is in the form of the quantity of chemical produced in and imported to Sweden each year. Each chemical is assigned a unique identifier, called ‘Funk:Anv’ and expert judgement is used to decide:

1) which chemicals should be included in the calculations,
2) which CRF code the chemical should be reported under,
3) whether the chemicals are used as raw material.

The model then calculates the total mass of chemicals produced in and imported to Sweden under each CRF code and CRF sub-code, disaggregated into raw material and non-raw material.

The model is contained in an Excel Workbook with worksheets. The worksheets are presented in Table 8.4.

Table 8.4 The different worksheets in the Excel model.

Worksheet name	Worksheet description
"Ingående C"	Result sheet for emissions of C, summarised for each CRF code (ton)
"Ingående NMVOC"	Result sheet for emissions of NMVOC, summarised for each CRF code (ton)
"Kopplingar"	One row for each 'Funk:Anv' code. In column H, 'Inkluderas', it is defined whether the chemical should be included in the model calculations ('Ja') or not ('Nej'). If the chemical is to be included then it is assigned to a CRF code (column I). Whether it is deemed to be a raw material or not is defined in column J. The most recent year that the chemical appears in the database is shown in column K.
"2003", "2002", etc.	Input data from Products Register. One worksheet for each year. The quantity of volatile organic compound produced/imported per year, including the Swedish Chemicals Inspectorate categorisation of the use of the VOC. Input data is found in columns C-K. Each row of input is assigned a unique identifier, called 'Funk:Anv' which is shown in column A. The input data are processed and the results are shown in columns M-R.
"Kopp_filtered"	This is a summarisation of worksheet 'Kopplingar ' for all chemicals that are to be included in the calculations (i.e. all rows which are marked for inclusion in the 'Kopplingar ' worksheet. CRF code is shown in column D and whether the chemical is a raw material is shown in column E.
"CRF_NFR"	A list of the possible CRF codes that the chemicals can be assigned to.
"Gamla koder"	Not currently used in the model but included for reference purposes. A coupling table for old identifier codes from the Swedish Chemicals Inspectorate.

8.1.4 How does the model work?

8.1.4.1 Preparation:

1) Data from Products Register is imported into the worksheets '2003', '2002' etc. This is done by simple 'copy and paste' methods.
2) Each row is assigned a 'Funk:Anv' code based on the function ('Funktion') and use ('Användning') fields. For recent years 'Funk:Anv' is simply a concatenation of the two codes. For earlier years it is a combination of the function ('Funktion') and the old area code ('Omr.kod'). A control is made to ensure that each 'Funk:Anv' code exists in the 'Kopplingar' worksheet.

8.1.4.2 Running the model:

3) Data for each chemical that is to be included in the calculations is copied from worksheet 'Kopplingar ' to worksheet 'Kopp_filtered'.

(Sub: Copy_JaRader)

4) For each row in each sheet of input data (2003, 2002 etc.) a lookup is made to check whether the chemical is to be included in the calculations. This is done by controlling whether the 'Funk:Anv' code is present in worksheet 'Kopp_filtered'.

If the chemical is to be included, then the quantity C and quantity NMVOC is copied into the relevant column M-P, depending on whether the chemical is a raw material or not. The CRF code and sub-code are copied to columns Q and R respectively.

If the chemical is not to be included, then the zeros is written in the relevant column M-P, depending on whether the chemical is a raw material or not. The CRF code and sub-code are filled with a hyphen (‘-‘).

(Sub: Collect_from_Kemisheets)

5) For each CRF code and sub-code found in rows 1 and 2 in the worksheet “Ingående C”, and for each year for which there is a ‘year worksheet’ (i.e. “2003”,”2002” etc), a lookup is done in columns M, N, O and P and a total emissions (C icke råvara, C råvara, NMVOC icke råvara, NMVOC råvara), for each year and CRF code is calculated. The results are written in ‘Ingående C’ and ‘Ingående NMVOC’.

(Sub: Sum_Emissions)

8.1.5 Updating to include new years

To include new years in the time series the KemiSheetArray in Main and Collect_from_Kemisheets need to be updated in Visual Basics. All other required updates have been flagged up as comments in the scripts.

8.2 Time series for emissions of NMVOC and CO_2, step 2 of the model

8.2.1 Overview

The time series for quantities that step 1 of the model generates are copied to the calculation step of the model. The following calculations are made within step 2 of the model:

1) Running average over three years

2) Emissions for 1995-2003 are estimated based on the calculated quantities with the running average and emission factors. Conversion of quantities of C to CO_2.

8.2.2 Description

8.2.2.1 Running average

The sold amount of volatile organic compound is not always identical to the amount of substance used in a single year and therefore the time series for quantities of NMVOC and C has been recalculated using a running average over three years. This means that reported emissions for two years need to be updated in every new submission. The use of running average results in a smoother time series for quantities of both NMVOC and C.

8.2.2.2 Emissions for 1995-2003

The developed country specific emission factors, see section 7.4, are used when calculating emissions of NMVOC and CO_2 for 1995-2003. When adding data for a new year the emission factors for each sub-code needs to be updated, both for raw material and remaining quantities. When calculating emissions of CO_2 the equation presented in section 7.5 is used.

9 Uncertainty analysis

During 2005, a SMED study was carried out, aiming to improve the transparency and quality in the present uncertainty estimates in the Swedish National Greenhouse Gas Inventory by making the underlying documentation and structures for uncertainty estimates more consistent and traceable. The uncertainty estimates have been performed for direct greenhouse gases. Each source was evaluated regarding uncertainties (%) on activity data (AD), emission factors (EF) or direct emissions (EM).

The uncertainties have been set on sector level for CRF 3, Solvent and Other Product Use. For activity data the uncertainties have been discussed and assigned in co-operation with the Swedish Chemicals Inspectorate. Uncertainty estimates for the country specific emission factors used were estimated by expert judgement.

The uncertainty analysis is performed according the IPCC Guidelines Tier 1 method as described in Good Practice Guidance section 6.3.2, see especially table 6.1[30]. For each source, the uncertainty for activity data (U_{AD}) and emission factors (U_{EF}) is estimated and given in percents. The combined uncertainty (CU) for activity data and emission factors – the uncertainty for the reported emissions from each source – is calculated as:

$$CU = \sqrt{U_{AD}^{\ 2} + U_{EF}^{\ 2}}$$

[30] IPCC. 2000. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

10 Results

10.1 Revised estimates

The percentage proportion of the reported emissions of NMVOC in sub-codes within CRF 3, Solvent and Other Product Use, is presented in Figure 10.1. The sub-codes are 3A- Paint Application, 3B- Degreasing and Dry Cleaning, 3C- Chemical Products, Manufacturing and Processing and 3D- Other. As it can be seen in the figure, CRF 3D-Other is the most dominating code within the sector.

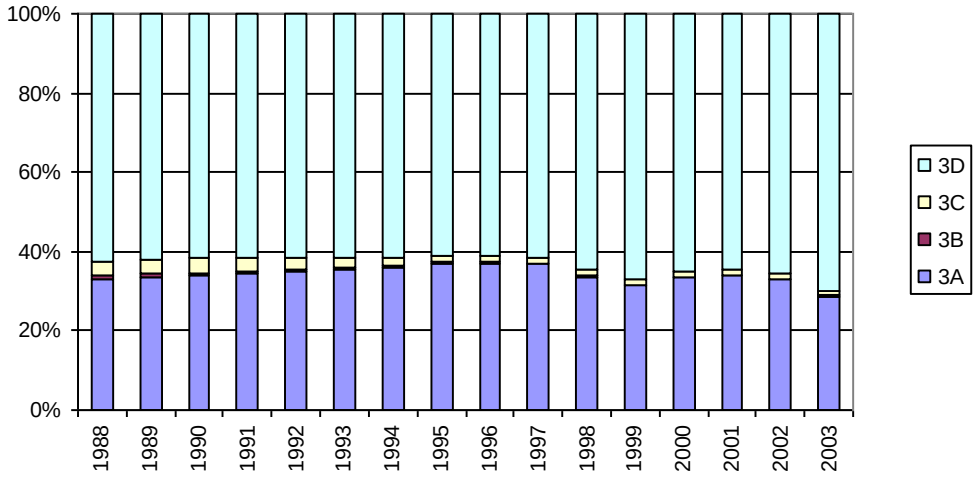

Figure 10.1 The sub-code proportion (%) of reported emissions of NMVOC in CRF 3.

In the following figures the emitted amounts of NMVOC and CO_2 for each sub-code are presented. In order to describe the eventual change of carbon content in NMVOC the quota CO_2/NMVOC is also shown.

10.1.1 CRF 3A, Paint Application

Emissions from Paint Application for 1988 are taken from the time series that were compiled in a special study concerning NMVOC emissions, which was carried out by SMED in 2002[31]. The emissions for 1989-1994 have been interpolated based on the information from 1988 and known data for 1995. The time series for CRF 3A, Paint Application, between 1988 and 2003 can be seen in Figure 10.2 below.

[31] Kindbom, K. et al., 2003. Estimated Emissions of NMVOC in Sweden 1988-2001.

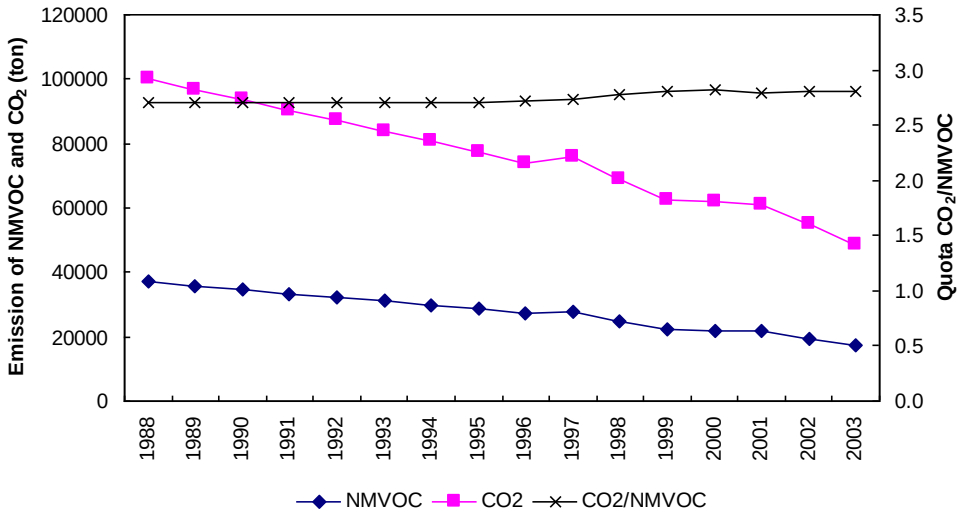

Figure 10.2 Emissions of NMVOC and CO_2 from paint application and the quota CO_2/NMVOC describing the change in carbon content in NMVOC during 1988-2003.

10.1.2 CRF 3B, Degreasing and Dry Cleaning

For CRF 3B, Degreasing and Dry Cleaning, emission data for 1988 are taken from reported quantities of tetrachloretylene from the Swedish Chemical Inspectorate. After 1995 also other substances for degreasing and dry cleaning are included. Of the total amount of NMVOC used within CRF 3B these "non tetrachloretylene" substances stand for approximately 30%. Therefore, the quantity of NMVOC for 1988 has been adjusted upwards by 30%. Emissions between 1989 and 1994 have been interpolated based on the information from the late 1980´s and known data for 1995. A new lower emission factor compared to previous submissions, where an emission factor of 1 was used, has been developed in the new method. The time series between 1988 and 2003 can be seen in Figure 10.3. Compared to the other sub-codes within the sector it can be seen in the figure that the solvents used within the laundry industry includes a lower carbon share that the solvent than are used in the other industries.

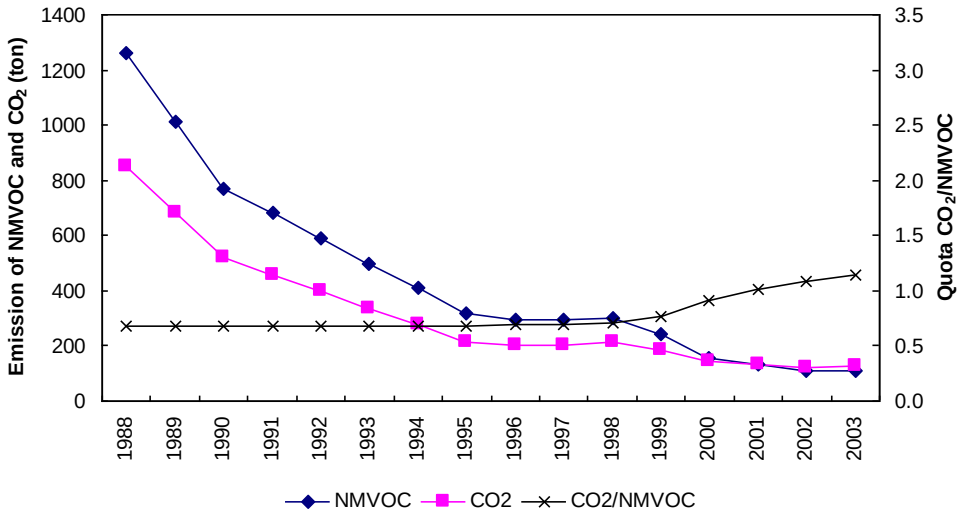

Figure 10.3 Emissions of NMVOC and CO_2 from dry cleaning and the quota CO_2/NMVOC describing the change in carbon content in NMVOC during 1988-2003.

10.1.3 CRF 3C, Chemical Products, Manufacturing and Processing

The percentage proportion of the reported emissions within CRF 3C is presented in Figure 10.4. The figure shows that car manufacturing is the dominating source of NMVOC emissions within CRF 3C.

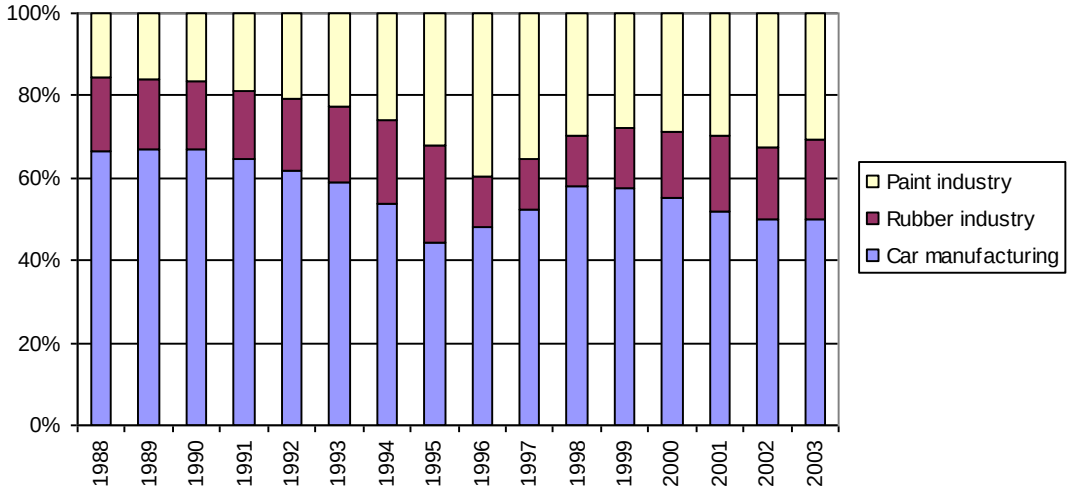

Figure 10.4 The proportion (%) of reported emissions of NMVOC in CRF 3C.

10.1.3.1 Car manufacturing

The time series between 1988 and 2003 can be seen in Figure 10.5. The emission of NMVOC for 1988 is estimated based on known emissions for 1990. Emissions for 1989 and for 1991 - 1994 have been interpolated based on the information from 1990 and known data for 1995.

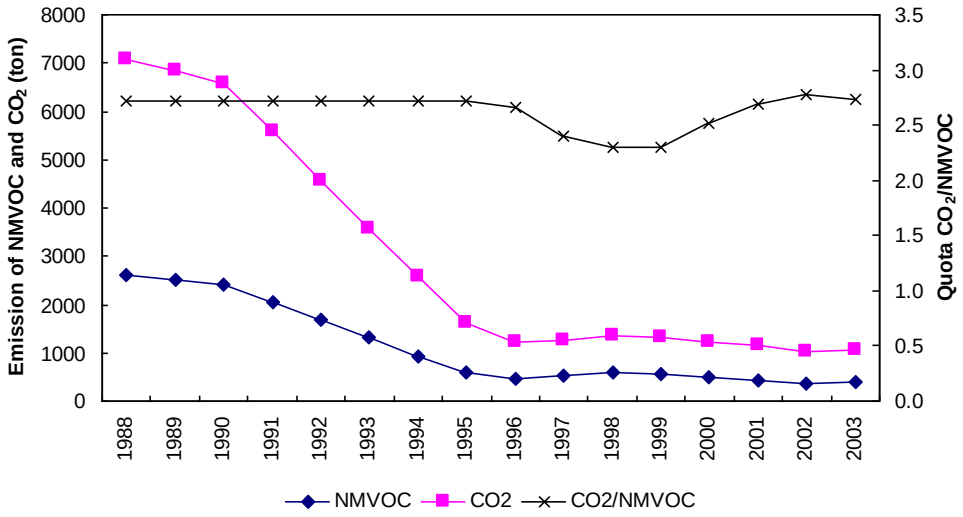

Figure 10.5 Emissions of NMVOC and CO_2 from car manufacturing and the quota CO_2/NMVOC describing the change in carbon content in NMVOC during 1988-2003.

10.1.3.2 Rubber industry

The time series between 1988 and 2003 can be seen in Figure 10.6. Emissions between 1989 and 1994 have been interpolated based on information for 1988 from the old time series[32] and known data for 1995.

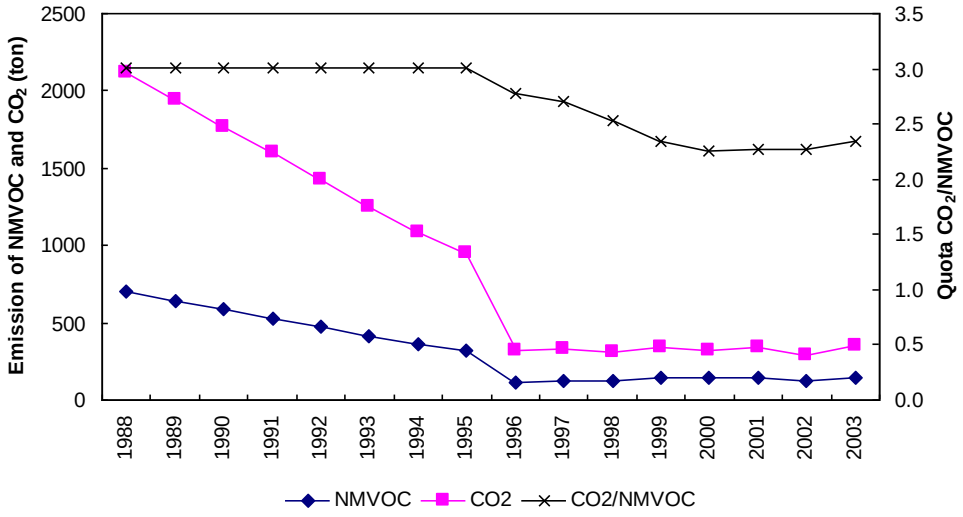

Figure 10.6 Emissions of NMVOC and CO_2 from rubber industry and the quota CO_2/NMVOC describing the change in carbon content in NMVOC during 1988-2003.

[32] Kindbom, K. et al., 2003. Estimated Emissions of NMVOC in Sweden 1988-2001.

10.1.3.3 Paint industry

The time series between 1988 and 2003 can be seen in Figure 10.7. Emissions for 1988 - 1992 have been taken from the special study from 2003[33] and emissions for 1993-1994 have been interpolated based on known emissions for 1992 and 1995.

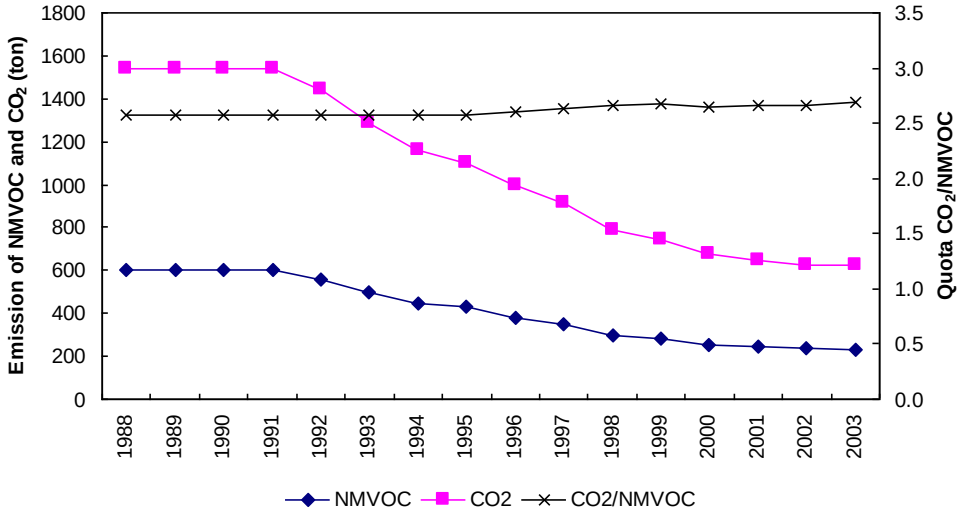

Figure 10.7 Emissions of NMVOC and CO_2 from paint industry and the quota CO_2/NMVOC describing the change in carbon content in NMVOC during 1988-2003.

10.1.4 CRF 3D, Other

The percentage proportion of the reported emissions within CRF 3D is presented in Figure 10.8. The figure shows that the sub-code "3D, Other, other" is the dominating source of NMVOC emissions within CRF 3D.

[33] Kindbom, K. et al., 2003. Estimated Emissions of NMVOC in Sweden 1988-2001.

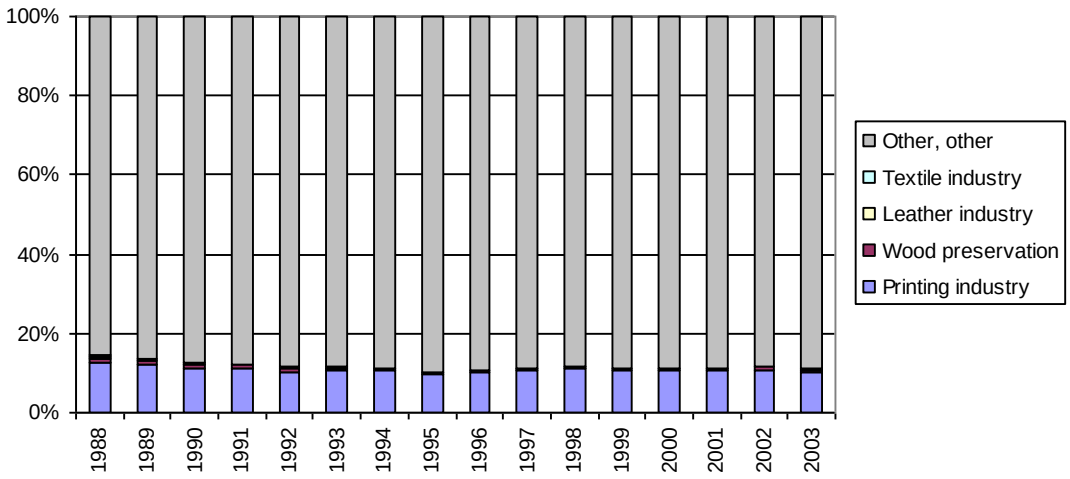

Figure 10.8 The proportion (%) of reported emissions of NMVOC in CRF 3D.

10.1.4.1 Printing industry

The time series between 1988 and 2003 can be seen in Figure 10.9. Emissions for 1988-1994 are taken from the old time series that were compiled in the special study concerning NMVOC performed in 2003[34].

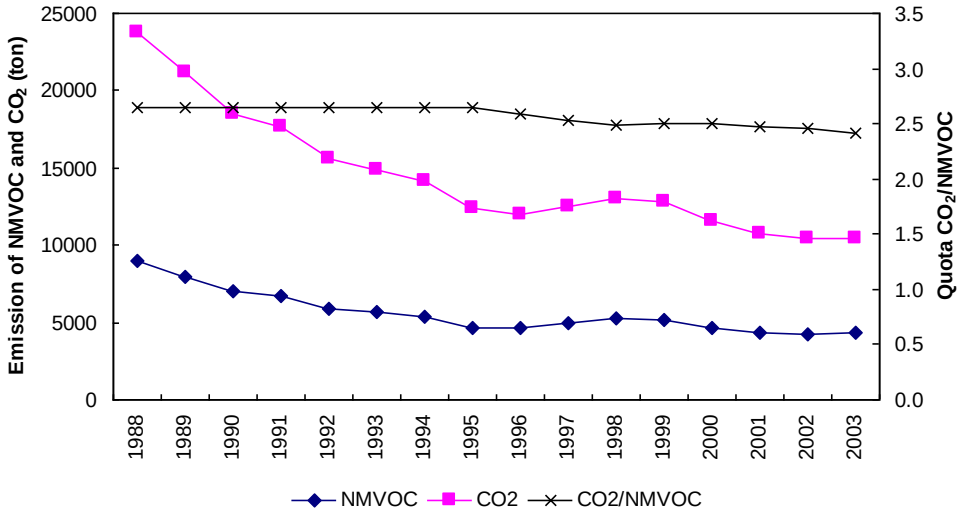

Figure 10.9 Emissions of NMVOC and CO_2 from printing industry and the quota CO_2/NMVOC describing the change in carbon content in NMVOC during 1988-2003.

[34] Kindbom, K. et al., 2003. Estimated Emissions of NMVOC in Sweden 1988-2001

10.1.4.2 Preservation of woods

The time series between 1988 and 2003 can be seen in Figure 10.10. The quantity of NMVOC has been estimated for 1988 based on information from the Chemicals Inspectorate and the Swedish Wood Preserving Association. The quantities of NMVOC between 1989 and 1994 have been interpolated based on the estimated quantity for 1988 and the known quantity for 1995 from the Products Register. The emissions have then been calculated with the country specific emission factors given in Annex 2. The emission factor changed from 0.65 in 1994 to 0.15 in 1995, due to significant change towards use of water based products[35].

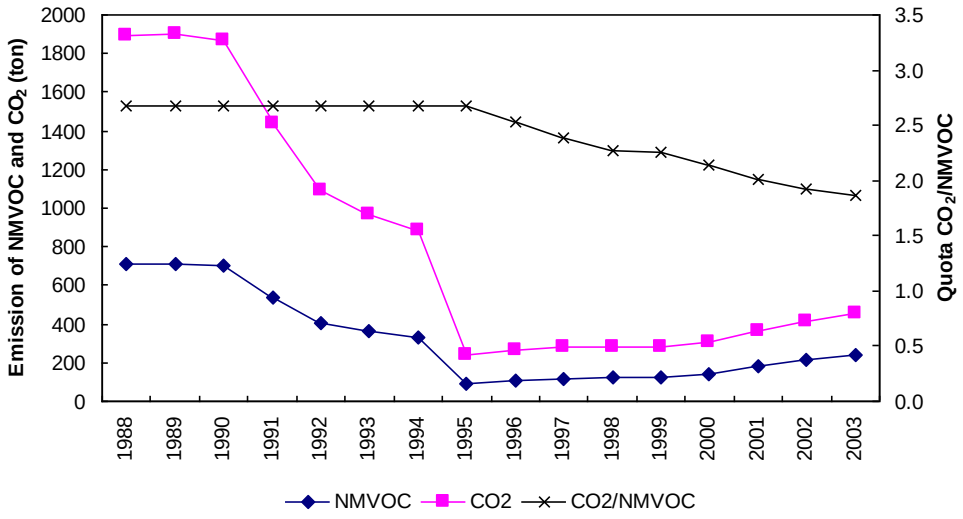

Figure 10.10 Emissions of NMVOC and CO_2 from preservation of woods and the quota CO_2/NMVOC describing the change in carbon content in NMVOC during 1988-2003.

10.1.4.3 Leather industry

The time series between 1988 and 2003 can be seen in Figure 10.11. The emissions for 1988 - 1994 have been taken from the old time series[36].

[35] Swedish Chemicals Inspectorate, personal communication

[36] Kindbom, K. et al., 2003. Estimated Emissions of NMVOC in Sweden 1988-2001

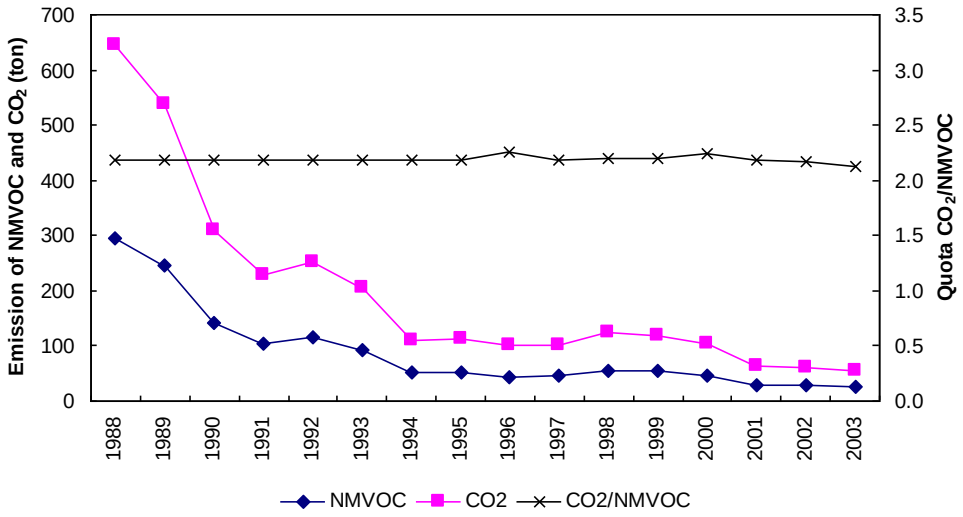

Figure 10.11 Emissions of NMVOC and CO_2 from leather industry and the quota CO_2/NMVOC describing the change in carbon content in NMVOC during 1988-2003.

10.1.4.4 Textile industry

The time series between 1988 and 2003 can be seen in Figure 10.12. The emissions for 1988 - 1991 are found in the study from 2003[37]. The emissions for 1992-1994 have been assumed. One major facility stopped using paraffin oil in the process which leads to a substantial change in total emissions between 1991 and 1992.

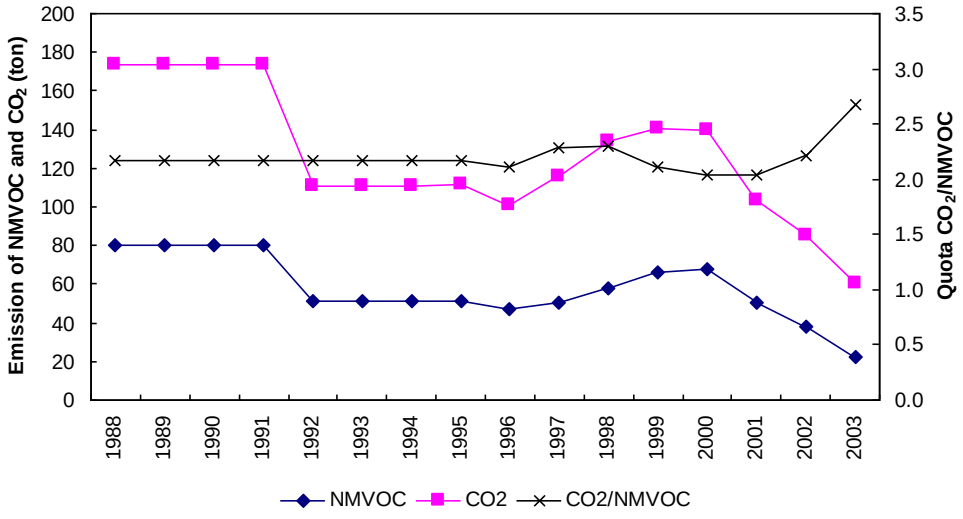

Figure 10.12 Emissions of NMVOC and CO_2 from textile industry and the quota CO_2/NMVOC describing the change in carbon content in NMVOC during 1988-2003.

[37] Kindbom, K. et al., 2003. Estimated Emissions of NMVOC in Sweden 1988-2001

10.1.4.5 Other

The time series between 1988 and 2003 can be seen in Figure 10.13. The emission for 1988 is from Kindbom et al. (2003)[37]. The emissions of NMVOC between 1989 and 1995 have been interpolated based on the known emission for 1988 and the calculated emission for 1996.

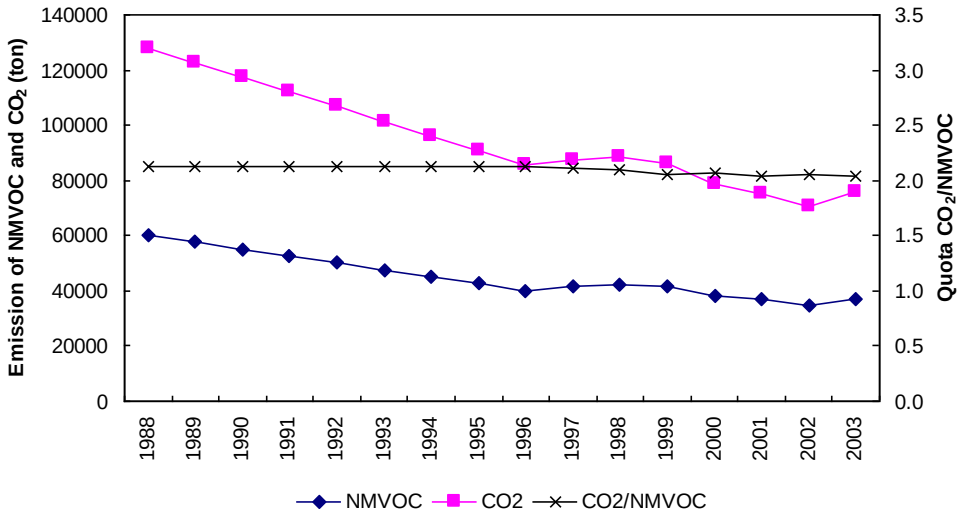

Figure 10.13 Emissions of NMVOC and CO_2 from CRF-code other-other and the quota CO_2/NMVOC describing the change in carbon content in NMVOC during 1988-2003.

10.2 Comparison between previous and revised estimates

10.2.1 NMVOC

The differences in previous and revised estimates for NMVOC for CRF 3, 1988-2003, are presented in Figure 10.14. In the figure it can be seen that the emissions of NMVOC in the revised estimates have increased for later years compared to the previous estimates. The emission of NMVOC from the sector is reduced from the base year 1990 compared to 2003 with 47%.

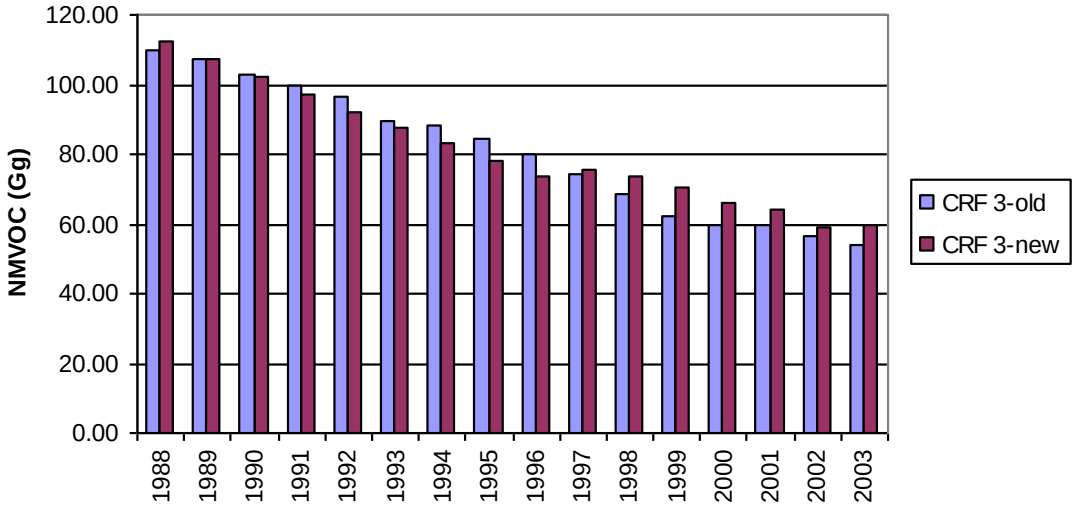

Figure 10.14 Reported emissions of NMVOC according to previous and revised estimates for CRF 3.

10.2.2 CO_2

The differences in previous and revised estimates for CO_2 for CRF 3, 1990-2003, are presented in Figure 10.15. In the figure it can be seen that the reported emissions of CO_2 have decreased when comparing the revised and the previous estimates, mainly due to the new method for calculating CO_2 (see section 7.2 and 7.5). The emission of CO_2 from the sector is reduced from the base year 1990 compared to 2003 with 43%.

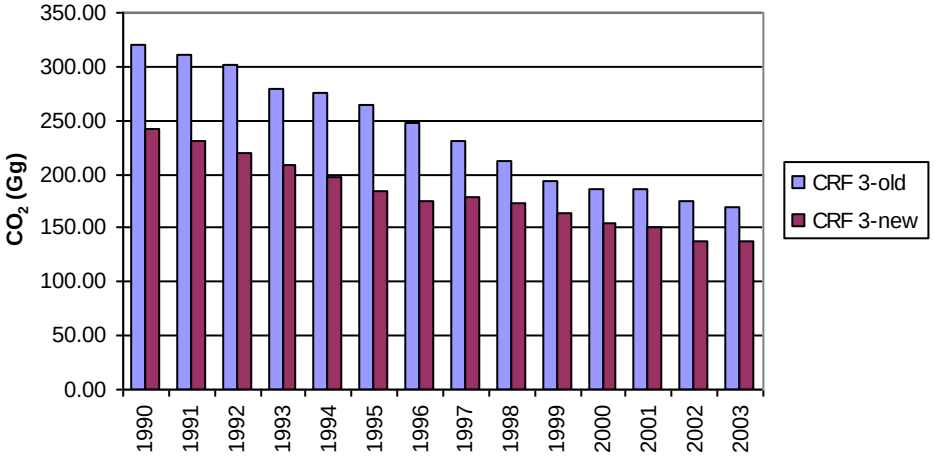

Figure 10.15 Reported emissions of CO_2 according to previous and revised estimates for CRF 3.

10.3 Uncertainty analysis

The result of the uncertainty analysis for the base year 1990 is presented in Table 10.1.

Table 10.1 The result of the uncertainty analysis for CRF 3 for the base year 1990.

CRF	IPPC source category	GHG	Activity data uncertainty (%)	Emission factor uncertainty (%)	Combined uncertainty (%)	Combined uncertainty as % of total emissions in 1990
3	Solvent and Other Product Use	CO_2	15	20	25	0.08
3	Solvent and Other Product Use	NMVOC	15	20	25	-

11 Discussion and conclusions

During the project, the Norwegian, Danish and German methods have been used as material of comparison. Of these, the German model is the one most in accordance with the new Swedish model. Both models are based on knowledge of amounts of solvents produced in, imported to and used within the country, exported from the country, as well as on knowledge of where the volatile compounds and products containing them are used (e.g. industrial or commercial sector or for domestic use). The NMVOC definition used is the same[38], and the development of emission factors is also done in a similar way, and aimed to reflect differing degree of emission reduction depending on substance, function and area of use.

The previous time series were based on reported data from companies' environmental reports, data from the Products Register at the Swedish Chemicals Inspectorate, information from experts or trade organisations and, for the larger part of the estimated emissions, based on various national reports, investigations and earlier efforts in estimating national emissions of NMVOC. The previously estimated time series for 1988-2003 are still considered reliable and has to some degree been used when setting the country specific emission factors in order to adjust the new time series to the previous ones. Furthermore, emission data from the previous times series have been used for the earlier years when estimating the emissions for 1988-1994 where the Products Register lack reliable data.

One disadvantage with the new model is that data from the Swedish Chemicals Inspectorate for the latest year is not official and accessible before December 31 every year, while the yearly reporting is delivered to the Swedish Environmental Protection Agency by November 1. This means that the emissions will be reported with one year delay in every submission. Furthermore, the use of the sliding average means that data for two years needs too be updated in every submission. Another weak point of the model is that judgements have to be done when deciding whether a use category and product function should be included in the estimates or not. But on the over hand the risk of double-counting of reported emissions is reduced, since it is very clear which industries are included in the calculations.

One of the most important results from the project is that the annually available information from the Products Register at the Swedish Chemicals Inspectorate is now used at its full potential in the calculations of emissions of NMVOC and CO_2 from Solvent and Other Product Use. This was not the case in the previous calculations, where information from different sources was used when performing the emission inventory for the sector.

[38] European Commission (1999). Council Directive 1999/13/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations. 29.3.1999, L85/1. http://europa.eu.int/eur-lex/pri/en/oj/dat/1999/l_085/l_08519990329en00010022.pdf

The estimates of CO_2 are considered to be more accurate compared to the previous estimates due to the direct carbon content in sold amount of NMVOC are used as input information in the calculations. In the previous estimates a default value of 85% carbon content in the NMVOC were used.

To conclude, the new Swedish method for estimating emissions of NMVOC and CO_2 from Solvent and Other Product Use is more transparent, complete and better adapted to its purposes compared to previous methods. The design of the model makes it easy to adjust emission factors and include new years in the time series, which facilitates consistent annual updates of time series in the future.

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13 Appendix 1

Table 13.1 Substance list.

CAS-Nr	Name	Molecular formula	Share of C
100-37-8	Ethanol, 2-(diethylamino)-	C6H15NO	61%
100-41-4	Benzene, ethyl-	C8H10	91%
100-42-5	Benzene, ethenyl-	C8H8	92%
100-51-6	Benzenemethanol	C7H8O	78%
100-52-7	Benzaldehyde	C7H6O	79%
100-66-3	Benzene, methoxy-	C7H8O	78%
100-97-0	1,3,5,7-Tetraazatricyclo[3.3.1.13,7]decane	C6H12N4	51%
101-68-8	Benzene, 1,1'-methylenebis[4-isocyanato-	C15H10N2O2	72%
101-84-8	Benzene, 1,1'-oxybis-	C12H10O	85%
102-76-1	1,2,3-Propanetriol, triacetate	C9H14O6	50%
102110-13-4	Hydrocarbons, C4-7	Mix	85%
103-11-7	2-Propenoic acid, 2-ethylhexyl ester	C11H20O2	72%
103-76-4	1-Piperazineethanol	C6H14N2O	55%
103-83-3	Benzenemethanamine, N,N-dimethyl-	C9H13N	80%
104-68-7	Ethanol, 2-(2-phenoxyethoxy)-	C10H14O3	66%
104-76-7	1-Hexanol, 2-ethyl-	C8H18O	74%
105-59-9	Ethanol, 2,2'-(methylimino)bis-	C5H13NO2	50%
105-60-2	2H-Azepin-2-one, hexahydro-	C6H11NO	64%
106-42-3	Benzene, 1,4-dimethyl-	C8H10	91%
106-65-0	Butanedioic acid, dimethyl ester	C6H10O4	49%
1068-27-5	Peroxide, (1,1,4,4-tetramethyl-2-butyne-1,4-diyl)bis[(1,1-dimethylethyl)	C16H30O4	67%
106-89-8	Oxirane, (chloromethyl)-	C3H5ClO	39%
106-92-3	Oxirane, [(2-propenyloxy)methyl]-	C6H10O2	63%
106-97-8	Butane	C4H10	83%
106-98-9	1-Butene	C4H8	86%
106-99-0	1,3-Butadiene	C4H6	89%
107-01-7	2-Butene	C4H8	86%
107-05-1	1-Propene, 3-chloro-	C3H5Cl	47%
107-06-2	Ethane, 1,2-dichloro-	C2H4Cl2	24%
107-11-9	2-Propen-1-amine	C3H7N	62%
107-13-1	2-Propenenitrile	C3H3N	68%
107-15-3	1,2-Ethanediamine	C2H8N2	40%
107-21-1	1,2-Ethanediol	C2H6O2	39%
107-22-2	Ethanedial	C2H2O2	41%
107-41-5	2,4-Pentanediol, 2-methyl-	C6H14O2	61%
107-83-5	Pentane, 2-methyl-	C6H14	84%
107-92-6	Butanoic acid	C4H8O2	55%
107-98-2	2-Propanol, 1-methoxy-	C4H10O2	53%

CAS-Nr	Name	Molecular formula	Share of C
108-01-0	Ethanol, 2-(dimethylamino)-	C4H11NO	54%
108-05-4	Acetic acid ethenyl ester	C4H6O2	56%
108-10-1	2-Pentanone, 4-methyl-	C6H12O	72%
108-21-4	Acetic acid, 1-methylethyl ester	C5H10O2	59%
108-24-7	Acetic acid, anhydride	C4H6O3	47%
108-31-6	2,5-Furandione	C4H2O3	49%
108-32-7	1,3-Dioxolan-2-one, 4-methyl-	C4H6O3	47%
108-38-3	Benzene, 1,3-dimethyl-	C8H10	91%
108-39-4	Phenol, 3-methyl-	C7H8O	78%
108-46-3	1,3-Benzenediol	C6H6O2	65%
108-65-6	2-Propanol, 1-methoxy-, acetate	C6H12O3	55%
108-67-8	Benzene, 1,3,5-trimethyl-	C9H12	90%
108-78-1	1,3,5-Triazine-2,4,6-triamine	C3H6N6	29%
108-83-8	4-Heptanone, 2,6-dimethyl-	C9H18O	76%
108-87-2	Cyclohexane, methyl-	C7H14	86%
108-88-3	Benzene, methyl-	C7H8	91%
108-94-1	Cyclohexanone	C6H10O	73%
108-95-2	Phenol	C6H6O	77%
109-01-3	Piperazine, 1-methyl-	C5H12N2	60%
109-52-4	Pentanoic acid	C5H10O2	59%
109-60-4	Acetic acid, propyl ester	C5H10O2	59%
109-66-0	Pentane	C5H12	83%
109-83-1	Ethanol, 2-(methylamino)-	C3H9NO	48%
109-86-4	Ethanol, 2-methoxy-	C3H8O2	47%
109-87-5	Methane, dimethoxy-	C3H8O2	47%
109-99-9	Furan, tetrahydro-	C4H8O	67%
110-12-3	2-Hexanone, 5-methyl-	C7H14O	74%
110-15-6	Butanedioic acid	C4H6O4	41%
110-17-8	2-Butenedioic acid (E)-	C4H4O4	41%
110-19-0	Acetic acid, 2-methylpropyl ester	C6H12O2	62%
110-43-0	2-Heptanone	C7H14O	74%
110-54-3	Hexane	C6H14	84%
110-62-3	Pentanal	C5H10O	70%
110-63-4	1,4-Butanediol	C4H10O2	53%
110-80-5	Ethanol, 2-ethoxy-	C4H10O2	53%
110-82-7	Cyclohexane	C6H12	86%
110-85-0	Piperazine	C4H10N2	56%
110-86-1	Pyridine	C5H5N	76%
110-91-8	Morpholine	C4H9NO	55%
110-94-1	Pentanedioic acid	C5H8O4	45%
110-98-5	2-Propanol, 1,1'-oxybis-	C6H14O3	54%
111-15-9	Ethanol, 2-ethoxy-, acetate	C6H12O3	55%
111-30-8	Pentanedial	C5H8O2	60%
111-40-0	1,2-Ethanediamine, N-(2-aminoethyl)-	C4H13N3	47%

CAS-Nr	Name	Molecular formula	Share of C
111-41-1	Ethanol, 2-[(2-aminoethyl)amino]-	C4H12N2O	46%
111-42-2	Ethanol, 2,2'-iminobis-	C4H11NO2	46%
111-46-6	Ethanol, 2,2'-oxybis-	C4H10O3	45%
111-65-9	Octane	C8H18	84%
111-76-2	Ethanol, 2-butoxy-	C6H14O2	61%
111-77-3	Ethanol, 2-(2-methoxyethoxy)-	C5H12O3	50%
111-87-5	1-Octanol	C8H18O	74%
111-90-0	Ethanol, 2-(2-ethoxyethoxy)-	C6H14O3	54%
111-96-6	Ethane, 1,1'-oxybis[2-methoxy-	C6H14O3	54%
1119-40-0	Pentanedioic acid, dimethyl ester	C7H12O4	52%
111109-77-4	Propane, oxybis[methoxy-	C8H18O3	59%
112-05-0	Nonanoic acid	C9H18O2	68%
112-07-2	Ethanol, 2-butoxy-, acetate	C8H16O3	60%
112-15-2	Ethanol, 2-(2-ethoxyethoxy)-, acetate	C8H16O4	55%
112-24-3	1,2-Ethanediamine, N,N'-bis(2-aminoethyl)-	C6H18N4	49%
112-27-6	Ethanol, 2,2'-[1,2-ethanediylbis(oxy)]bis-	C6H14O4	48%
112-34-5	Ethanol, 2-(2-butoxyethoxy)-	C8H18O3	59%
112-35-6	Ethanol, 2-[2-(2-methoxyethoxy)ethoxy]-	C7H16O4	51%
112-42-5	1-Undecanol	C11H24O	77%
115-07-1	1-Propene	C3H6	86%
115-10-6	Methane, oxybis-	C2H6O	52%
115-11-7	1-Propene, 2-methyl-	C4H8	86%
115-77-5	1,3-Propanediol, 2,2-bis(hydroxymethyl)-	C5H12O4	44%
121-44-8	Ethanamine, N,N-diethyl-	C6H15N	71%
123-05-7	Hexanal, 2-ethyl-	C8H16O	75%
123-31-9	1,4-Benzenediol	C6H6O2	65%
123-38-6	Propanal	C3H6O	62%
123-42-2	2-Pentanone, 4-hydroxy-4-methyl-	C6H12O2	62%
123-54-6	2,4-Pentanedione	C5H8O2	60%
123-72-8	Butanal	C4H8O	67%
123-86-4	Acetic acid, butyl ester	C6H12O2	62%
123-91-1	1,4-Dioxane	C4H8O2	55%
124-17-4	Ethanol, 2-(2-butoxyethoxy)-, acetate	C10H20O4	59%
124-40-3	Methanamine, N-methyl-	C2H7N	53%
124-68-5	1-Propanol, 2-amino-2-methyl-	C4H11NO	54%
125451-23-2	Ethane, mixt. with methane	C2H6.CH4	78%
126-30-7	1,3-Propanediol, 2,2-dimethyl-	C5H12O2	58%
126-98-7	2-Propenenitrile, 2-methyl-	C4H5N	72%
127-18-4	Ethene, tetrachloro-	C2Cl4	14%
127-19-5	Acetamide, N,N-dimethyl-	C4H9NO	55%
127-91-3	Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-	C10H16	88%
1319-77-3	Phenol, methyl-	C7H8O	78%
1320-67-8	Propanol, methoxy-	C4H10O2	53%

CAS-Nr	Name	Molecular formula	Share of C
1330-20-7	Benzene, dimethyl-	C8H10	91%
1338-23-4	2-Butanone, peroxide	C8H16O4	55%
13466-78-9	Bicyclo[4.1.0]hept-3-ene, 3,7,7-trimethyl-	C10H16	88%
13475-82-6	Heptane, 2,2,4,6,6-pentamethyl-	C12H26	85%
137-32-6	1-Butanol, 2-methyl-	C5H12O	68%
138-86-3	Cyclohexene, 1-methyl-4-(1-methylethenyl)-	C10H16	88%
140-31-8	1-Piperazineethanamine	C6H15N3	56%
140-88-5	2-Propenoic acid, ethyl ester	C5H8O2	60%
141-32-2	2-Propenoic acid, butyl ester	C7H12O2	66%
141-43-5	Ethanol, 2-amino-	C2H7NO	39%
141-78-6	Acetic acid ethyl ester	C4H8O2	55%
142-82-5	Heptane	C7H16	84%
149-57-5	Hexanoic acid, 2-ethyl-	C8H16O2	67%
1569-01-3	2-Propanol, 1-propoxy-	C6H14O2	61%
1569-02-4	2-Propanol, 1-ethoxy-	C5H12O2	58%
15821-83-7	1-Propanol, 2-butoxy-	C7H16O2	64%
1589-47-5	1-Propanol, 2-methoxy-	C4H10O2	53%
1634-04-4	Propane, 2-methoxy-2-methyl-	C5H12O	68%
1694-31-1	Butanoic acid, 3-oxo-, 1,1-dimethylethyl ester	C8H14O3	61%
19089-47-5	1-Propanol, 2-ethoxy-	C5H12O2	58%
1965-29-3	Ethanol, 2-[[2-[(2-aminoethyl)amino]ethyl]amino]-	C6H17N3O	49%
2163-42-0	1,3-Propanediol, 2-methyl-	C4H10O2	53%
23235-61-2	1,3-Propanediol, 2,2'-[oxybis(methylene)]bis[2-ethyl-	C12H26O5	58%
25155-25-3	Peroxide, [phenylenebis(1-methylethylidene)]bis[(1,1-dimethylethyl)	C20H34O4	71%
25167-67-3	Butene	C4H8	86%
25265-71-8	Propanol, oxybis-	C6H14O3	54%
25339-17-7	Isodecanol	C10H22O	76%
25498-49-1	Propanol, [2-(2-methoxymethylethoxy)methylethoxy]-	C10H22O4	58%
2612-29-5	1,3-Propanediol, 2-ethyl-	C5H12O2	58%
26447-40-5	Benzene, 1,1'-methylenebis[isocyanato-	C15H10N2O2	72%
27215-95-8	Nonene	C9H18	86%
27458-94-2	Isononanol	C9H20O	75%
2768-02-7	Silane, ethenyltrimethoxy-	C5H12O3Si	41%
280-57-9	1,4-Diazabicyclo[2.2.2]octane	C6H12N2	64%
2807-30-9	Ethanol, 2-propoxy-	C5H12O2	58%
2855-13-2	Cyclohexanemethanamine, 5-amino-1,3,3-trimethyl-	C10H22N2	71%
298-12-4	Acetic acid, oxo-	C2H2O3	32%
29387-86-8	Propanol, butoxy-	C7H16O2	64%
29911-27-1	2-Propanol, 1-(1-methyl-2-propoxyethoxy)-	C9H20O3	61%
29911-28-2	2-Propanol, 1-(2-butoxy-1-methylethoxy)-	C10H22O3	63%

CAS-Nr	Name	Molecular formula	Share of C
30525-89-4	Paraformaldehyde	(CH2O)x	40%
30899-19-5	Pentanol	C5H12O	68%
31295-54-2	1,4-Piperazinediethanamine, N-(2-aminoethyl)-	C10H25N5	56%
34590-94-8	Propanol, (2-methoxymethylethoxy)-	C7H16O3	57%
37187-22-7	2,4-Pentanedione, peroxide	Unspecified	60%
4497-92-1	Bicyclo[4.1.0]hept-2-ene, 3,7,7-trimethyl-, (1S-cis)-	C10H16	88%
4767-03-7	Propanoic acid, 3-hydroxy-2-(hydroxymethyl)-2-methyl-	C5H10O4	45%
50-00-0	Formaldehyde	CH2O	40%
50-21-5	Propanoic acid, 2-hydroxy-	C3H6O3	40%
51200-87-4	Oxazolidine, 4,4-dimethyl-	C5H11NO	59%
5131-66-8	2-Propanol, 1-butoxy-	C7H16O2	64%
51774-11-9	Isoheptanol	C7H16O	72%
5187-23-5	1,3-Dioxane-5-methanol, 5-ethyl-	C7H14O3	58%
540-59-0	Ethene, 1,2-dichloro-	C2H2Cl2	25%
540-84-1	Pentane, 2,2,4-trimethyl-	C8H18	84%
54839-24-6	2-Propanol, 1-ethoxy-, acetate	C7H14O3	58%
55934-93-5	Propanol, [(butoxymethylethoxy)methylethoxy]-	C13H28O4	63%
56-23-5	Methane, tetrachloro-	CCl4	8%
5625-90-1	Morpholine, 4,4'-methylenebis-	C9H18N2O2	58%
565-75-3	Pentane, 2,3,4-trimethyl-	C8H18	84%
57-55-6	1,2-Propanediol	C3H8O2	47%
57018-52-7	2-Propanol, 1-(1,1-dimethylethoxy)-	C7H16O2	64%
57350-24-0	1-Propanol, 2-ethoxy-, acetate	C7H14O3	58%
584-84-9	Benzene, 2,4-diisocyanato-1-methyl-	C9H6N2O2	62%
592-41-6	1-Hexene	C6H12	86%
5989-27-5	Cyclohexene, 1-methyl-4-(1-methylethenyl)-, (R)-	C10H16	88%
60-29-7	Ethane, 1,1'-oxybis-	C4H10O	65%
6032-29-7	2-Pentanol	C5H12O	68%
610-39-9	Benzene, 4-methyl-1,2-dinitro-	C7H6N2O4	46%
616-38-6	Carbonic acid, dimethyl ester	C3H6O3	40%
616-45-5	2-Pyrrolidinone	C4H7NO	56%
623-84-7	1,2-Propanediol, diacetate	C7H12O4	52%
627-82-7	1,2-Propanediol, 3,3'-oxybis-	C6H14O5	43%
627-93-0	Hexanedioic acid, dimethyl ester	C8H14O4	55%
629-40-3	Octanedinitrile	C8H12N2	71%
629-82-3	Octane, 1,1'-oxybis-	C16H34O	79%
63231-51-6	Aromatic hydrocarbons	Mix	85%
64-17-5	Ethanol	C2H6O	52%
64-18-6	Formic acid	CH2O2	26%
64-19-7	Acetic acid	C2H4O2	40%
64741-42-0	Naphtha (petroleum), full-range straight-run	Mix	85%
64741-44-2	Distillates (petroleum), straight-run middle	Mix	85%

CAS-Nr	Name	Molecular formula	Share of C
64741-52-2	Distillates (petroleum), light naphthenic	Mix	85%
64741-64-6	Naphtha (petroleum), full-range alkylate	Mix	85%
64741-65-7	Naphtha (petroleum), heavy alkylate	Mix	85%
64741-70-4	Naphtha (petroleum), isomerization	Mix	85%
64741-73-7	Distillates (petroleum), alkylate	Mix	85%
64741-92-0	Naphtha (petroleum), solvent-refined heavy	Mix	85%
64742-46-7	Distillates (petroleum), hydrotreated middle	Mix	85%
64742-47-8	Distillates (petroleum), hydrotreated light	Mix	85%
64742-48-9	Naphtha (petroleum), hydrotreated heavy	Mix	85%
64742-49-0	Naphtha (petroleum), hydrotreated light	Mix	85%
64742-81-0	Kerosine (petroleum), hydrodesulfurized	Mix	85%
64742-82-1	Naphtha (petroleum), hydrodesulfurized heavy	Mix	85%
64742-88-7	Solvent naphtha (petroleum), medium aliph.	Mix	85%
64742-89-8	Solvent naphtha (petroleum), light aliph.	Mix	85%
64742-94-5	Solvent naphtha (petroleum), heavy arom.	Mix	85%
64742-95-6	Solvent naphtha (petroleum), light arom.	Mix	85%
64742-96-7	Solvent naphtha (petroleum), heavy aliph.	Mix	85%
64771-72-8	Paraffins (petroleum), normal C5-20	Mix	85%
66455-17-2	Alcohols, C9-11	C9H20O-C11H24O	75%
67-56-1	Methanol	CH4O	37%
67-63-0	2-Propanol	C3H8O	60%
67-64-1	2-Propanone	C3H6O	62%
67-66-3	Methane, trichloro-	CHCl3	10%
67-68-5	Methane, sulfinylbis-	C2H6OS	31%
67762-38-3	Fatty acids, C16-18 and C18-unsatd., Me esters	ca C19H36O2	77%
68-12-2	Formamide, N,N-dimethyl-	C3H7NO	49%
682-09-7	1-Butanol, 2,2-bis[(2-propenyloxy)methyl]-	C12H22O3	67%
682-11-1	1,3-Propanediol, 2-ethyl-2-[(2-propenyloxy)methyl]-	C9H18O3	62%
68333-88-0	Aromatic hydrocarbons, C9-17	Mix	85%
68334-30-5	Petroleum products, diesel oil	Mix	85%
68409-99-4	Distillates (petroleum), catalytic cracked overheads	Mix	85%
68476-40-4	Hydrocarbons, C3-4	Mix	85%
68476-85-7	Petroleum products, liquefied gas	Mix	85%
68511-50-2	1-Propene, 2-methyl-, sulfurized	Mix	60%
68514-15-8	Gasoline, vapor-recovery	Mix	85%
68526-55-6	Alkenes, C9-rich	Mix	85%
68551-07-5	Alcohols, C8-18	C8H18O-C18H38O	77%
68527-16-2	Hydrocarbons, C1-3	Mix	85%
68606-11-1	Gasoline, straight-run, topping-plant	Mix	85%
68783-66-4	Hydrocarbons, C3-6, sweetened	Mix	85%

CAS-Nr	Name	Molecular formula	Share of C
68938-03-4	Alcohols, C9-iso-, distn. overheads	C9H20O	75%
691-37-2	1-Pentene, 4-methyl-	C6H12	86%
70657-70-4	1-Propanol, 2-methoxy-, acetate	C6H12O3	55%
71-23-8	1-Propanol	C3H8O	60%
71-36-3	1-Butanol	C4H10O	65%
71-41-0	1-Pentanol	C5H12O	68%
71-43-2	Benzene	C6H6	92%
71-55-6	Ethane, 1,1,1-trichloro-	C2H3Cl3	18%
7397-62-8	Acetic acid, hydroxy-, butyl ester	C6H12O3	55%
7473-98-5	1-Propanone, 2-hydroxy-2-methyl-1-phenyl-	C10H12O2	73%
74-84-0	Ethane	C2H6	80%
74-85-1	Ethene	C2H4	86%
74-86-2	Ethyne	C2H2	92%
74-87-3	Methane, chloro-	CH3Cl	24%
74-98-6	Propane	C3H8	82%
75-00-3	Ethane, chloro-	C2H5Cl	37%
75-01-4	Ethene, chloro-	C2H3Cl	38%
75-05-8	Acetonitrile	C2H3N	59%
75-07-0	Acetaldehyde	C2H4O	55%
75-08-1	Ethanethiol	C2H6S	39%
75-09-2	Methane, dichloro-	CH2Cl2	14%
75-15-0	Carbon disulfide	CS2	16%
75-21-8	Oxirane	C2H4O	55%
75-28-5	Propane, 2-methyl-	C4H10	83%
75-31-0	2-Propanamine	C3H9N	61%
75-35-4	Ethene, 1,1-dichloro-	C2H2Cl2	25%
75-56-9	Oxirane, methyl-	C3H6O	62%
75-65-0	2-Propanol, 2-methyl-	C4H10O	65%
76-05-1	Acetic acid, trifluoro-	C2HF3O2	21%
763-69-9	Propanoic acid, 3-ethoxy-, ethyl ester	C7H14O3	58%
770-35-4	2-Propanol, 1-phenoxy-	C9H12O2	71%
77-73-6	4,7-Methano-1H-indene, 3a,4,7,7a-tetrahydro-	C10H12	91%
77-99-6	1,3-Propanediol, 2-ethyl-2-(hydroxymethyl)-	C6H14O3	54%
78-00-2	Plumbane, tetraethyl-	C8H20Pb	30%
78-59-1	2-Cyclohexen-1-one, 3,5,5-trimethyl-	C9H14O	78%
78-78-4	Butane, 2-methyl-	C5H12	83%
78-83-1	1-Propanol, 2-methyl-	C4H10O	65%
78-84-2	Propanal, 2-methyl-	C4H8O	67%
78-92-2	2-Butanol	C4H10O	65%
78-93-3	2-Butanone	C4H8O	67%
79-01-6	Ethene, trichloro-	C2HCl3	18%
79-09-4	Propanoic acid	C3H6O2	49%
79-10-7	2-Propenoic acid	C3H4O2	50%
79-11-8	Acetic acid, chloro-	C2H3ClO2	25%

CAS-Nr	Name	Molecular formula	Share of C
79-20-9	Acetic acid, methyl ester	C3H6O2	49%
79-33-4	Propanoic acid, 2-hydroxy-, (S)-	C3H6O3	40%
79-34-5	Ethane, 1,1,2,2-tetrachloro-	C2H2Cl4	14%
79-41-4	2-Propenoic acid, 2-methyl-	C4H6O2	56%
79-43-6	Acetic acid, dichloro-	C2H2Cl2O2	19%
8006-61-9	Gasoline, natural	Mix	85%
8006-64-2	Turpentine, oil	Mix	60%
8008-20-6	Kerosine	Mix	85%
80-43-3	Peroxide, bis(1-methyl-1-phenylethyl)	C18H22O2	80%
8032-32-4	Ligroine	Mix	85%
8052-41-3	Stoddard solvent	Mix	85%
80-56-8	Bicyclo[3.1.1]hept-2-ene, 2,6,6-trimethyl-	C10H16	88%
80-62-6	2-Propenoic acid, 2-methyl-, methyl ester	C5H8O2	60%
84-66-2	1,2-Benzenedicarboxylic acid, diethyl ester	C12H14O4	65%
84540-57-8	Propanol, methoxy-, acetat	C6H12O3	55%
85116-56-9	Naptha (petroleum), catalytic reformed, C8-arom. fraction	Mix	85%
85566-12-7	Alcohols, C8-10	C8H18O-C10H22O	75%
85586-25-0	Fatty acids, rape-oil, Me esters	ca C19H36O2	77%
86290-81-5	Gasoline	Mix	85%
86508-42-1	Perfluoro compounds, C5-18	ca C5F12-C18F38	22%
872-50-4	2-Pyrrolidinone, 1-methyl-	C5H9NO	61%
87-69-4	Butanedioic acid, 2,3-dihydroxy- [R-(R*,R*)]-	C4H6O6	32%
9004-70-0	Cellulose, nitrate	Mix	60%
9005-90-7	Turpentine	Mix	60%
90-12-0	Naphthalene, 1-methyl-	C11H10	93%
90622-56-3	Alkanes, C7-10-iso-	Mix	85%
90622-57-4	Alkanes, C9-12-iso-	Mix	85%
90622-58-5	Alkanes, C11-15-iso-	Mix	85%
90669-79-7	Paraffins (petroleum), normal C5-20, acid- and clay-treated	Mix	85%
91-17-8	Naphthalene, decahydro-	C10H18	87%
91-57-6	Naphthalene, 2-methyl-	C11H10	93%
91770-15-9	Kerosine (petroleum), sweetened	Mix	85%
91722-33-7	Tar, wood	Mix	60%
92045-37-9	Kerosine (petroleum), straight-run wide-cut	Mix	85%
92045-49-3	Naphtha (petroleum), C4-12 butane-alkylate, isooctane-rich	Mix	85%
92045-50-6	Naphtha (petroleum), heavy catalytic cracked, sweetened	Mix	85%
92045-53-9	Naphtha (petroleum), hydrodesulfurized light, dearomatized	Mix	85%
92045-59-5	Naphtha (petroleum), light catalytic cracked sweetened	Mix	85%

CAS-Nr	Name	Molecular formula	Share of C
92062-15-2	Solvent naphtha (petroleum), hydrotreated light naphthenic	Mix	85%
93924-37-9	Hydrocarbons, C7	Mix	85%
93924-42-6	Hydrocarbons, C10-14	Mix	85%
94-36-0	Peroxide, dibenzoyl	C14H10O4	69%
95-47-6	Benzene, 1,2-dimethyl-	C8H10	91%
95-63-6	Benzene, 1,2,4-trimethyl-	C9H12	90%
96-29-7	2-Butanone, oxime	C4H9NO	55%
96-48-0	2(3H)-Furanone, dihydro-	C4H6O2	56%
96-49-1	1,3-Dioxolan-2-one	C3H4O3	41%
96733-38-9	Tripropylene glycol, buthyl ether	C13H28O4	63%
97593-01-6	Alkenes, C8-10-branched, C9-rich	Mix	60%
97-64-3	Propanoic acid, 2-hydroxy-, ethyl ester	C5H10O3	51%
97-88-1	2-Propenoic acid, 2-methyl-, butyl ester	C8H14O2	68%
98-00-0	2-Furanmethanol	C5H6O2	61%
99-99-0	Benzene, 1-methyl-4-nitro-	C7H7NO2	61%

14 Appendix 2

Table 14.1 Country specific emission factors for CRF 3A-C.

Year	3A Paint Application-industry		3A Paint Application-consumers		3B Degreasing and Dry Cleaning		3C-Car manufacturing		3C - Rubber industry		3C - Paint industry	
	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material
1988					0.57	0.001						
1989					0.57	0.001						
1990					0.57	0.001						
1991					0.57	0.001						
1992					0.57	0.001						
1993					0.57	0.001						
1994					0.57	0.001						
1995	0.95	0.001	0.95	0.001	0.57	0.001	0.5	0.001	0.3	0.001	0.0035	0.001
1996	0.95	0.001	0.95	0.001	0.57	0.001	0.46	0.001	0.29	0.001	0.0034	0.001
1997	0.95	0.001	0.95	0.001	0.57	0.001	0.42	0.001	0.29	0.001	0.0033	0.001
1998	0.8	0.001	0.95	0.001	0.57	0.001	0.38	0.001	0.28	0.001	0.0031	0.001
1999	0.6	0.001	0.95	0.001	0.57	0.001	0.33	0.001	0.28	0.001	0.0030	0.001
2000	0.6	0.001	0.95	0.001	0.57	0.001	0.29	0.001	0.27	0.001	0.0029	0.001
2001	0.55	0.001	0.95	0.001	0.57	0.001	0.25	0.001	0.26	0.001	0.0028	0.001
2002	0.4	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.26	0.001	0.0026	0.001
2003	0.3	0.001	0.95	0.001	0.57	0.001	0.2	0.001	0.25	0.001	0.0025	0.001

Table 14.2 Country specific emission factors for CRF 3D.

Year	3D Other - Other - Printing industry		3D Other - Other - Preservation of woods		3D Other - Other - Leather industry		3D Other - Other - Textile finishing		3D Other - Other - Other solvent use		3D Other - Other - De-iser	
	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material	Remaining	Raw material
1988			0.65	0.001								
1989			0.65	0.001								
1990			0.65	0.001								
1991			0.65	0.001								
1992			0.65	0.001								
1993			0.65	0.001								
1994			0.65	0.001								
1995	0.65	0.001	0.15	0.001	0.35	0.1	0.1	0.1			0.1	0.001
1996	0.6375	0.001	0.15	0.001	0.31	0.1	0.1	0.1	0.95	0.95	0.1	0.001
1997	0.625	0.001	0.15	0.001	0.27	0.1	0.1	0.1	0.95	0.95	0.1	0.001
1998	0.6125	0.001	0.15	0.001	0.23	0.1	0.1	0.1	0.95	0.95	0.1	0.001
1999	0.6	0.001	0.15	0.001	0.18	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2000	0.5875	0.001	0.15	0.001	0.14	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2001	0.575	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2002	0.5625	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001
2003	0.55	0.001	0.15	0.001	0.1	0.1	0.1	0.1	0.95	0.95	0.1	0.001


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