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Swedish method for estimating emissions from Solvent Use

Further development of the calculation model

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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.

Content

Preface

This project has been performed by SMED (Swedish Environmental Emission Data) on commission by Swedish Environmental Protection Agency. This particular project was carried out by Swedish Environmental Institute (IVL) in collaboration with Swedish Chemical Agency (KemI).

We gratefully thank the members of the projects reference group, Anna Forsgren and Titus Kyrklund at the Swedish Environmental Protection Agency and Johanna Janson secretary at the Cross-Party Committee on Environmental Objectives, for contributing with valuable comments during the work process.

Summary

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.

On behalf of the Swedish Environmental Protection Agency (Swedish EPA), Swedish Environmental Emissions Data (SMED), has further developed the calculation model for estimating the national emissions of NMVOC and CO_2 from use of solvents in Sweden. The model has been revised in order to meet international reporting requirements according to CLRTAP and UNFCCC as well as to support national needs. The model makes it possible to test different sets of emission factors within the solvent use sector. This function can be used to assess different actions and emission reduction potentials. Furthermore, the model can generate emissions per user category and product group. This information can be used when following-up the Swedish environmental quality objectives.

The calculation model is consumption-based with a product-related approach. Amounts of NMVOC and C in solvents and solvent-based products, produced in, imported to, used in, and exported from Sweden, was derived from the Swedish Product Register hosted by the Swedish Chemicals Agency. Emission factors from the literature have been used as far as possible, but in the case when emission factors are unavailable, country specific emission factors have been developed.

The most significant sources of emissions of NMVOC and CO_2 during recent years are “Other solvent use” (NFR 2.D.3.i), “Domestic use” (NFR 2.D.3.a) and “Coating applications” (NFR 2.D.3.d).

The new model results in reduced national emissions of NMVOC and CO_2 from solvent use in comparison with previous estimates (-18% 1990, -10% 2005 and -28% for 2010 for NMVOC). This is mainly due to the following changes in the model:

- Reallocation of activities from 2.D.3.i “Other solvent use”. In previous estimates an emission factor of 0.95 was used for all activities reported in this NFR-code. In the revised model the emission factor depends on which NFR-code the activity has been allocated to.
- Introduction of a new emission factor for products that are used diluted in water. In previous estimates these products were not treated separately, and consequently an emission factor of 0.95 was used. In the new model an emission factor of 0.275 is used.

Simultaneously, however, the new model results in increased emissions for the following NFR-codes:

“Domestic use” (NFR 2.D.3.a): An increase from 2002 and onwards. This is mainly due to an increased use of the following product groups: washer fluid, degreasing agents and ignition fluids. Other solvent use (NFR 2.D.3.i): An increase since 1995. The increase is mainly due to a greater use of the product groups preservatives, refrigerants, metal mordants/etchants and coolant agents. To conclude, the new Swedish method for estimating emissions of NMVOC and CO_2 from Solvent 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.

Keywords: NMVOC, solvents, solvent use, coating, products, emissions, emission factors, calculation model, Swedish Product Register, Swedish Chemicals Agency.

1 Background

Sweden reports air emissions to the European Union, the UNFCCC and the CLRTAP on an annual basis. Under these frameworks reporting of emissions of NMVOCs and CO_2 from the use of solvents are required.

In 2005 SMED and the Swedish Chemicals Agency developed a calculation model for estimating national air emissions from solvent use (Skårman et al. 2006). In order to create a cost-effective, consistent and transparent method for calculating the annual emissions of NMVOC and CO_2 emissions from solvent use, all activity data were taken from the Product Register hosted by the Swedish Chemicals Agency.
After the model was developed the reporting structure for CLRTAP was changed, which required a more detailed reporting. (see Table 1). Moreover, both the Swedish EPA and the country administrative boards have lately shown interest in making use of the national emission data reported internationally for the monitoring of the national and regional environmental objectives.

In the autumn of 2014, SMED was contracted by the Swedish EPA to carry out a pre-study on further development of the emission inventory model for solvent use. The aim of the pre-study was to make an inventory of the data needs of all stakeholders with regard to solvent use, as well as to provide suggestions on how the model could be developed in order to meet the identified needs.

1.1 Definition of NMVOC

1.1.1 CLRTAP

At its thirty-second session in Geneva, 9–13 December 2013, the Executive Body for the LRTAP Convention adopted revised guidelines for reporting emission and projection data under the Convention (UNECE, 2014). The revised guidelines were adopted by decision 2013/3. In decision 2013/4 it was decided to revoke decision 2008/16 for the previous guidelines for reporting emission data under the convention on long-range transboundary air pollution (UNECE, 2009). The new guidelines entered into force on 1 January 2015.

In the revised guidelines (UNECE, 2014) “Non-methane volatile organic compounds” (NMVOCs) are defined as:

“all organic compounds of an anthropogenic nature, other than methane, that are capable of producing photochemical oxidants by reaction with nitrogen oxides in the presence of sunlight”.

In the previous guidelines (UNECE, 2009), NMVOC were defined as:

“any organic compound, excluding methane, having a vapour pressure of 0.01 kPa or more at 293.15 K, or having a corresponding volatility under the particular conditions of use. For the purpose of these Guidelines, the fraction of creosote which exceeds this value of vapour pressure at 293.15 K should be considered as an NMVOCs.”

1.1.2 UNFCCC

According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006), NMVOCs are defined as:

“any non-methane organic compound having at 293.15 K a vapour pressure of 0.01 kP or more, or having a corresponding volatility under the particular conditions of use.”

1.2 Reporting guidelines for Solvent use

1.2.1 CLRTAP

Parties shall use the reporting template given in Annex I to the Guidelines for Reporting Emission and Projection Data (UNECE, 2014). According to the template emissions of NMVOC shall be reported from year 1990. The different NFR codes for solvent use to be reported according to the guidelines are given in Table 1.

Table 1. NFR codes for solvent use to be reported according to the guidelines.

NFR Code	NFR Longname
2D3a	Domestic solvent use including fungicides
2D3d	Coating applications
2D3e	Degreasing (within the industry)
2D3f	Dry cleaning
2D3g	Chemical products
2D3h	Printing
2D3i	Other solvent use (please specify in the IIR)

1.2.2 UNFCCC

Compared to the 1996 Guidelines for National Greenhouse Gas Inventories, the sector "Solvent and Other Product Use" has been merged with the "Industrial Processes" sector in the 2006 IPCC Guidelines. The new sector is named "Industrial Processes and Product Use" (IPPU). The CRF code for solvent use to be reported according to CRF format given in the reporting guidelines is presented in Table 2.

Table 2. CRF code for solvent use to be reported according to the guidelines.

CRF Code	CRF Longname
2D3	Solvent Use

According to chapter 7 in 2006 IPCC Guidelines for National Greenhouse Gas Inventories (box 7.2), indirect emissions of CO_2 from atmospheric oxidation of emitted NMVOC could be accounted for according to the following equation:

$$Inputs_{CO2} = Emissions_{NMVOC} \times C \times \frac{44}{12}$$

Where **C** is the fraction of carbon in NMVOC by mass (default = 0.6)

The carbon content will vary depending on the source. Therefore, an inventory based on the speciation of the NMVOC compounds gives more accurate results. If any information on the speciation profile is not available, the default average carbon content of 60% by mass may be used.

1.3 The Swedish environmental objectives

The Swedish environmental objectives system consists of three different types of objectives: one generational goal, 16 environmental quality objectives and 24 milestone targets. The generational goal and the environmental quality objectives should be achieved by 2020, with the exception of objective “Reduced Climate Impact”, which should be achieved by 2050. The milestones have different target dates for realisation.

The environmental quality objectives are followed up annually. The follow-up includes an assessment whether or not current policy instruments and actions made before 2020 are sufficient to achieve the objectives. The assessment is summarized in the three different grades; yes, close or no.

Once every fourth year, an in-depth assessment of the prospects of achieving the generation goal and environmental quality objectives is made. The Environmental Protection Agency is responsible for coordinating the follow-up of seven of the environmental quality objectives.

The result from the present project could be used as input when assessing the following environmental quality objectives:

- Reduced Climate Impact
- Clean Air

1.4 The Swedish Product Register

In the Swedish Products Register, chemical products imported to or manufactured in Sweden are registered. The register is handled by the Swedish Chemicals Agency.

In the Environmental Code (SFS 1998:808) it is stated that all chemical products that are brought to or manufactured professionally in Sweden shall be registered in a register. In the Ordinance of chemical products and biotechnical organisms (SFS 2008:245), the Swedish Chemicals Agency is appointed the authority to keep the register. All products, imported or manufactured, in quantities exceeding 100 kg per year and included in the annex to the ordinance (SFS 2008:245), 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 several hundred types of products, most of them also intuitively included in the more public term “Chemical products”. Where there is a disagreement whether a product belongs to a type that has to be registered or not, guidance can be received from the national authority Swedish Customs.

Information that shall be reported to the Products Register is stated in the Swedish Chemicals Agency Regulations (KIFS 2008:2). The products shall be reported at the latest before the end of February the year after import or manufacture was started. Also products bought 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 product type
- 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 (accounting report), including the information above, is sent to the company to be completed with information on 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 achieved.

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.

Liable to register are both substances and mixtures. This means that the classification and codification of product types depend on possible functions of both raw material substance and preparations. The company has to use these codes when registering the product. Between 1992 and 2001 about 220 different codes were used in the register to describe product type. In 2002 a more extensive set of codes was introduced with about 700 different

product types, most of them among paint and adhesive products. The same set of codes is used by the Norwegian and Danish product registers.

A substance has always to be stated with the unambiguous chemical name, mostly specified by the substance's 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 substances that do not have a CAS-number, a special treatment is required.

The substance concentration has to be given with exact percentage except for paints, for which percentages can be reported as intervals. All substances classified as hazardous have to be stated, as well as all other substances making up at least five percent (by weight) of the composition. Substances that are carcinogenic, sensitising, mutagenic or toxic to reproduction, as well as all preservatives, always have to be stated.

About 15 000 substances are registered as ingredients of the over 90 000 imported or manufactured chemical products in 2015. About 4 000 of the substances are polymers.

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 chemical products each year, since 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.

1.5 Aim of the project

The aim of the project is to develop the current emission calculation method for solvent use so that the model generates data:

- in accordance with the reporting requirements as stated by CLRTAP and UNFCCC,
- for purposes other than international reporting, for example, for:
  - follow-up of the national environmental quality objectives,
  - assessment of action/measure potentials, and
  - to be able to answer questions from the public on emission trends.

The project has been carried out in close collaboration with the Swedish Chemicals Agency.

2 Description of the model

Emissions of NMVOC and CO_2 from 1995 and onwards have been calculated according to the general method for calculating emissions from a specific source, namely 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

Emissions of CO_2 have been calculated with the following equation:

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

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

The developed method for calculating emissions from solvent Use is consumption-based with a product related approach. The definition for NMVOC stated in the guidelines for reporting emissions and projections data under the LRTAP Convention (se section 1.1.1) is used. The method can be summarised as follows:

1. The sold amount (i.e. production + import – export) of solvents and solvent-based products are derived from the Products Register.

2. The use of the solvents and solvent-based products in each specific industrial and commercial sector as well as in households is estimated.
3. Emission factors from the literature have been used as far as possible. When no factors are available, country specific emission factors have been developed.

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 to CLRTAP and UNFCCC. The use of running average results in a smoother time series for quantities of both NMVOC and C.

The Products Register does not provide reliable data for the period 1990-1994 for most industry categories. For these years, data from reported time series compiled in a dedicated study on NMVOC emissions carried out by SMED in 2002 (Kindbom et. al, 2004) has been used. In this study the emissions of NMVOC from the sector Solvent Use were estimated based on information from various sources, e.g. data reported in companies' environmental reports, data from the Products Register, as well as information from experts and trade organisations. However, the major part of the estimated emissions was based on earlier reports, investigations and estimations of national NMVOC emissions. When evaluating data for the early 1990's some errors were found, which have been corrected.

2.1 Substances

When the Swedish calculation model was developed in 2005 the definition of NMVOCs from the reporting guidelines from 1997 (UNECE, 2009)) was used. As was mentioned in section 1.1.1 the definition of NMVOCs was revised in the reporting guidelines from 2014 (UNECE, 2014). However, it was decided within the project to continue to use the NMVOC definition from 1997 (UNECE, 2009). There were several reasons for this decision:

- The 1997 definition is consistent with the 2006 IPCC Guidelines.
- It includes a reference both to vapour pressure and temperature and consequently it is easy to apply to the available information in the Product Register.

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 and those found in quantities over 100 tonnes were listed. This quantity limit was chosen on the basis that substances that can be found in the Products Register in quantities less than 100 tonnes represent only 0.03% of the total solvent sales at 400 000 tonnes. This control is performed every year and all new substances exceeding 100 tonnes are included in the substance list. Consequently, the substance list for 2003 has been complemented with substances found in quantities exceeding 100 tonnes in the extractions for the years 2004-2013.

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. The final substance list for 2013 contains 427 substances defined as NMVOC. The list includes CAS-number, name, molecular formula and carbon share for each substance (see Appendix I). 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 Swedish Chemicals Agency as 85% of NMVOC, based on information in the Products Register. In cases where the carbon content cannot be derived from the Products Register, the default value of 60%, given in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, has been used (se section1.1.2).

2.2 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 2013. The extractions show for each year:

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

When analysing the extractions from the Products Register, data for 1992-1994 showed not to be reliable to use for quantitative estimates of NMVOC and C emissions. The reason is that during this period the emissions of

many substances still were reported as intervals, even if work has been done by the Swedish Chemicals Agency in order to further specify the amounts. There were also changes in the code system during this period. Therefore data from the Products Register are only used for 1995-2013. Furthermore, it has been decide not to use the information in the Product Register concerning consumers, since this information is not considered reliable for the purposes of this project.

2.2.1 Allocation

The extractions from the Products Register for 1995-2013 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 has been given a specific:
NFR-code (according to the reporting guidelines, see Table 1):

- SNAP-code (according to EMEP/EEA guidebook)
- Industry group (grouping industry categories)
- Product group (grouping of product codes)
- Use category (industry, consumer and other)

Furthermore, it has to be determined if the product is used as raw material or not. Quantities of NMVOC used as raw material have been identified and handled separately from other quantities for each NFR code, since most of the solvents used as raw material will not be emitted but bound in products.

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 judgements made for industry categories are presented in Table 3 and Table 4. All industrial activities reported in other NFR-codes are excluded from the extractions from the Products Register.

Table 3. List of industry categories excluded from the extractions from the Product Register except for NFR 2.D.3.d (Coating applications). NFR codes given for reporting of emissions from other activities.

Industry category	Industry code	NFR 2.D.3.d	Reported in NFR code
Manufacture of coke, refined petroleum products and nuclear fuels	D23	x	1.B.1.b
Petroleum refineries, lubricants-, asphalt- and coal products industries	C19	x	1.B.2.a.iv
Other industrial production	C32	x	2
Manufacture of articles of concrete, plaster and cement	C23.6, D26.6	x	2.A.1
Manufacture of cement, lime and plaster	C23.5, D26.5	x	2.A.1, 2.A.2
Manufacture of glass and glass products	C23.1, D26.1	x	2.A.3
Manufacture of ceramic tiles and flags	C23.31, D26.3	x	2.A.4.a
Manufacture of bricks, tiles and construction products, in baked clay	C23.32	x	2.A.4.a
Manufacture of non-refractory ceramic goods other than construction purposes; manufacture of refractory ceramic products	D26.2	x	2.A.4.a
Mining and quarrying	B, C	x	2.A.5.a
Manufacture of other organic basic chemicals	C20.14, D24.14	x	2.B.10.a
Manufacture of plastics in primary forms	C20.16, D24.16	x	2.B.10.a
Manufacture of pesticides and other agrochemical products	C20.2, D24.20	x	2.B.10.a
Manufacture of soap, detergents, cleaning and polishing preparations	C20.41, D24.51	x	2.B.10.a
Manufacture of perfumes and toilet preparations	C20.42, D24.52	x	2.B.10.a
Manufacture of other chemical products n.e.c	C20.59, D24.66	x	2.B.10.a
Manufacture of basic pharmaceutical products	C21.1	x	2.B.10.a
Pharmaceutical industry	C21.2, D24.42	x	2.B.10.a
Manufacture of plastic products	C22.2, D25.2	x	2.B.10.a
Other chemical industry	D24.6	x	2.B.10.a
Manufacture of industrial gas	D24.11	x	2.B.10.a
Manufacture of other inorganic basic chemicals	D24.13	x	2.B.10.a
Manufacture of fertilizers and nitrogen compounds	D24.15	x	2.B.10.a
Manufacture of glues and gelatines*	D24.62	x	2.B.10.a

Industry category	Industry code	NFR 2.D.3.d	Reported in NFR code
Manufacture of essential oils	D24.63	x	2.B.10.a
Manufacture of photochemical material	D24.64	x	2.B.10.a
Manufacture of man-made fibres	D24.70	x	2.B.10.a
Manufacture of explosives		x	2.B.10.a
Manufacture of basic metals	C24, D27	x	2.C
Manufacture of fabricated metal products, except machinery equipment	C25, D28	x	2.C
Treatment and coating of metals; general mechanical components	C25.6, D28.5	x	2.C
Manufacture of pulp, paper and paper products	C17, D21	x	2.H.1
Manufacture of food products and beverages	C10, D15	x	2.H.2
Manufacture of various other non-metallic mineral products (for example mineral wool)	C23.9, D26.8	x	2.H.3
Recycling	E38.3	x	5

Table 4. List if industry categories excluded from the extractions from the Product Register.

Industry category	Industry code
Trade with goods	G
Wholesale trade and commission trade, except of motor vehicles and motorcycles	G46, G51
Agents involved in the sale of fuels, ores, metals and industrial chemicals	G46.12, G51.12
Wholesale of china and glassware, wallpaper and cleaning materials	G46.44, G51.44
Wholesale of pharmaceutical products	G46.46, G51.46
Wholesale of chemical products	G46.75, G51.55
Other wholesale	G46.9, G51.7, G51.9

The judgements made for excluded product codes are shown in Table 5. All products burned when used are excluded in the extractions from the Products Register, though CO_2 may be emitted. But since the reported emissions of CO_2 are to be based on emitted NMVOC, the product is excluded for both gases.

Table 5. Product codes excluded from the extraction from the Product 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
Flux agents for casting	F20100	Burned and not emitted
Flux agents for galvanic coating	G05300	Burned and not emitted
Road paving materials	K35500	Reported in NFR 2.D.3_Other_Road paving with asphalt
Construction materials, other	K35900	Reported in NFR 2.A.5.b
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
Explosives, other	S50900	Burned and not emitted
Flux agents for welding	S75100	Burned and not emitted
Welding product, other	S75400	Burned and not emitted
Welding product, other	S75400	Burned and not emitted

2.3 Emission Factors

Emission factors given in the literature, for example the EMEP/EEA guidebook (EEA, 2013), EU legislations, and other countries IIR´s, have been compiled and included in the model. The used emission factors are presented in Appendix II. The model has been developed in order to make it possible to test different datasets of emission factors. 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.

A new emission factor for products used diluted in water has been introduced in the new model. The new emission factor is set to 0.275 and it has been calculated based on available information given in the EMEP/EEA guidebook (2:D.3.a Domestic solvent use). In the previous estimates these products were not treated separately and consequently the emission factor of 0.95 was used also for water diluted products.

The country specific emission factors have been developed in order to adjust to the old time series 1990-2001, developed by SMED in 2002 (Kindbom et. al., 2004). However, for some activities errors have been identified in previously reported data for 1990, and consequently those emissions have been corrected (see section 3.2). Furthermore, application techniques, available information in the environmental reports for specific industries, as well as other pathways of release (e.g. water), have been considered when developing the country specific emission factors. How the different emission factors for different activities have been developed is discussed further in section 3.2.

3 Results and discussion

3.1 National totals for solvent use

In Figure 1 and Figure 2 it can be seen that the estimates according to the new model results in a significant reduction in the emissions of NMVOC and CO_2 from solvent use in comparison with the old estimates (-18% for 1990, -10% for 2005 and -28% for 2010 for NMVOC). The decrease is mainly due to following changes within the model:

- Reallocation of activities from 2.D.3.i “Other solvent use”. In previous estimates an emission factor of 0.95 was used for all activities reported in this NFR code. In the new estimates the emission factor depends on which NFR- code the activity is allocated to.
- Introduction of the new emission factor for products that are used diluted in water. In previous estimates these products were not treated separately and consequently the emission factor of 0.95 was used. In the new model an emission factor of 0.275 is used.

In 2012, the Gothenburg Protocol under the LRTAP Convention was amended in order to include national emission reduction commitments to be achieved in 2020 and beyond. In decision 2012/2 (UNECE, 2012a) it is stated that Sweden shall reduce the national emission levels of VOC by 25% from 2005 to 2020. In decision 2012/3 (UNECE, 2012b) it is stated that the application of improved emission inventory methodologies should not put a Party at a disadvantage in terms of meeting its emission reduction commitments. The national total emission of NMVOC given in decision 2012/2 for 2005 was 197 k tonnes and in submission 2016 the corresponding total was 222 k tonnes. The new model estimates results in a revised national total for 2005 of 214 k tonnes NMVOC (emissions for all other activities are based on submission 2016).

EU’s National Emission Ceilings Directive (2001/81/EC) is currently under revision, and consequently the national emission ceilings are not yet set within this framework. In 2001/81/EC the Swedish national emission ceiling was set to 241 k tonnes NMVOC to be achieved by 2010 (Swedish EPA, 2016).

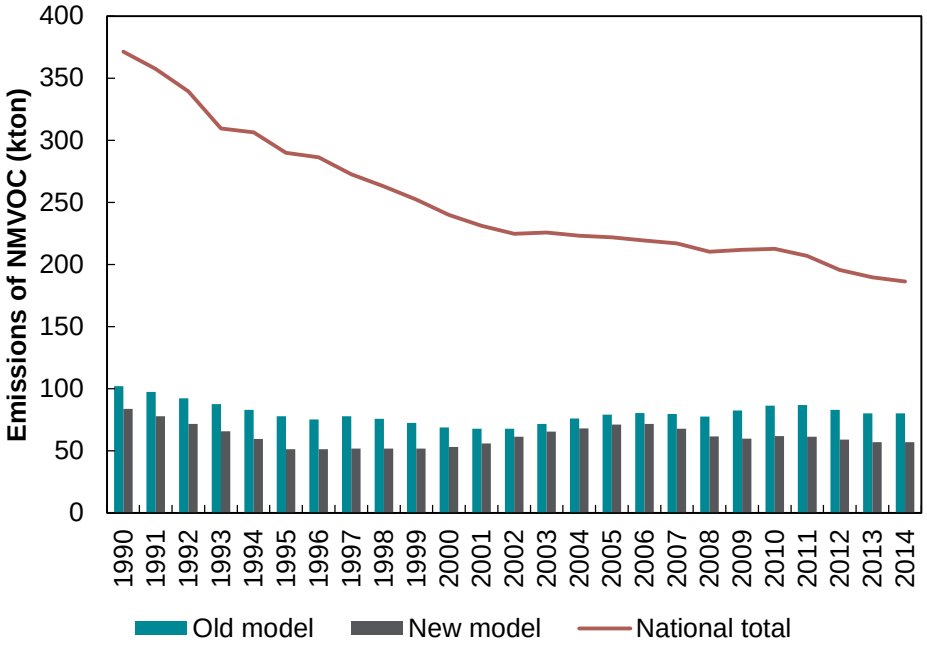

Figure 1. Estimated emissions of NMVOC (ktons) according to the old and new model together with the national total according to submission 2016.

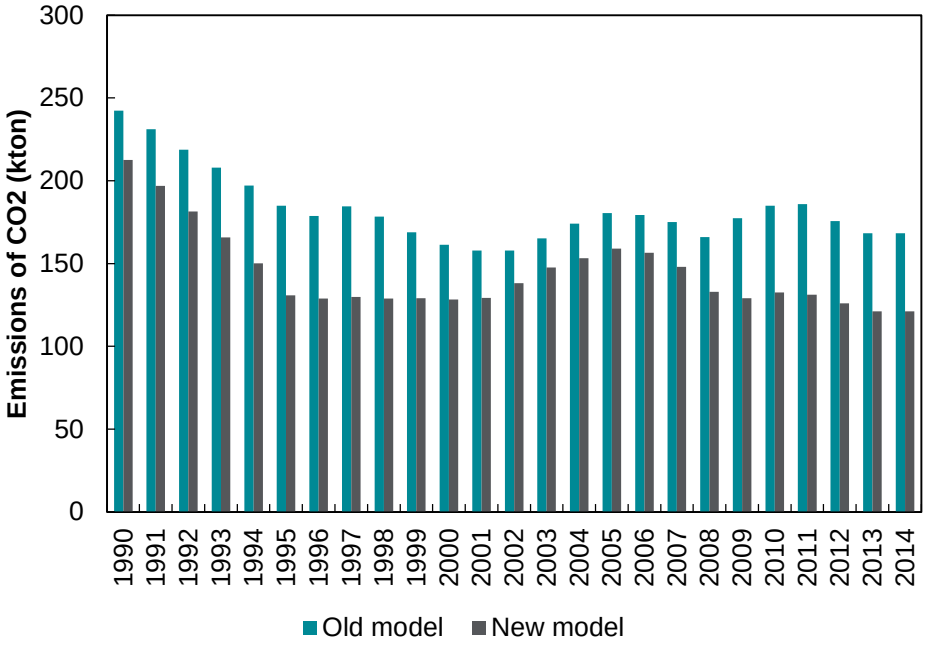

Figure 2. Estimated emissions of CO_2 (ktons) according to the old and new model together with the national total according to submission 2016.

3.1.1 Comparison with GAINS

The national total emissions of NMVOC, resulting from the old and new calculation model for solvent use, have been compared with corresponding emissions according to the current legislation scenario in the GAINS model (GAINS, 2016). The emissions from pharmaceutical industry and polystyrene processing given in the GAINS model have been excluded in the comparison. The reason for this exclusion in GAINS data is that these activities are not included in the national solvent calculation model. These activities are included in NFR 2.B.10.a. The results of the comparison are given in Table 6. It can be seen that the estimates from the new model correspond better to the information in the GAINS model.

Table 6. Comparison between emissions from solvent use according to the new model and the GAINS model.

Year	Old model kton	New model kton	GAINS kton
2005	79.2	71.1	62.3
2010	86.4	61.8	58.1

3.1.2 Comparison with the other Nordic countries

Implied emission factors for solvent use, based on population and emissions reported in submission 2016, have been calculated for all Nordic countries (see Figure 3). In the figure it can be seen that the Swedish IEF is in line with the other countries.

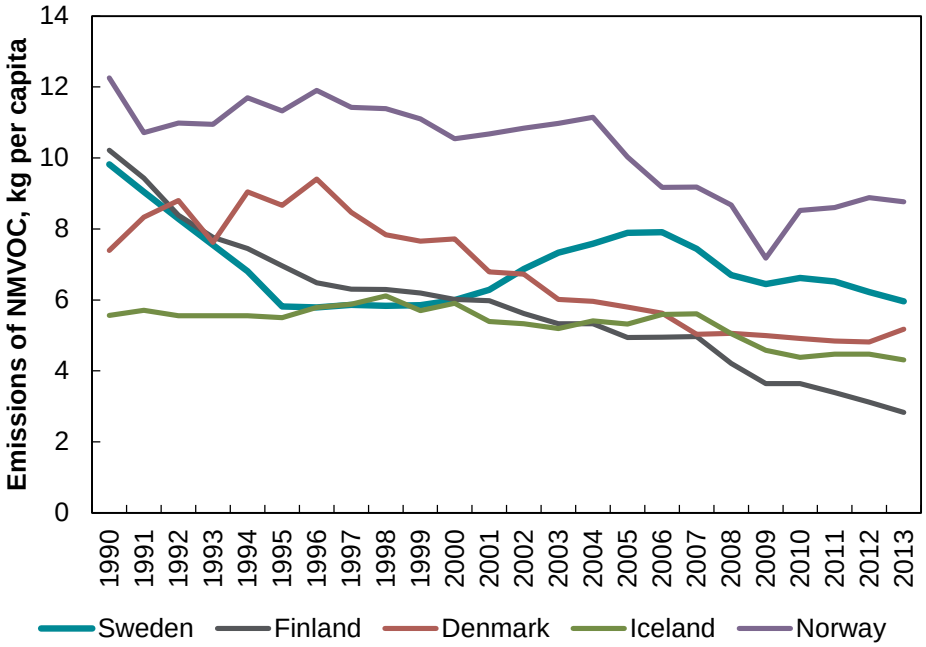

Figure 3. Implied emission factors, based on population, for solvent use for the Nordic countries.

3.2 NFR-codes

In Figure 4 it can be seen that other solvent use (NFR 2.D.3.i) is the major source of NMVOC on a national level. Other important sources are coating application (NFR 2.D.3.d) and domestic use (NFR 2.D.3.a). The emissions from NFR 2.D.3.a and 2.D.3.i have increased over time. On the other hand, the emissions from NFR 2.D.3.d have decreased over time, due to reduced solvent content in used products as indicated in activity data.

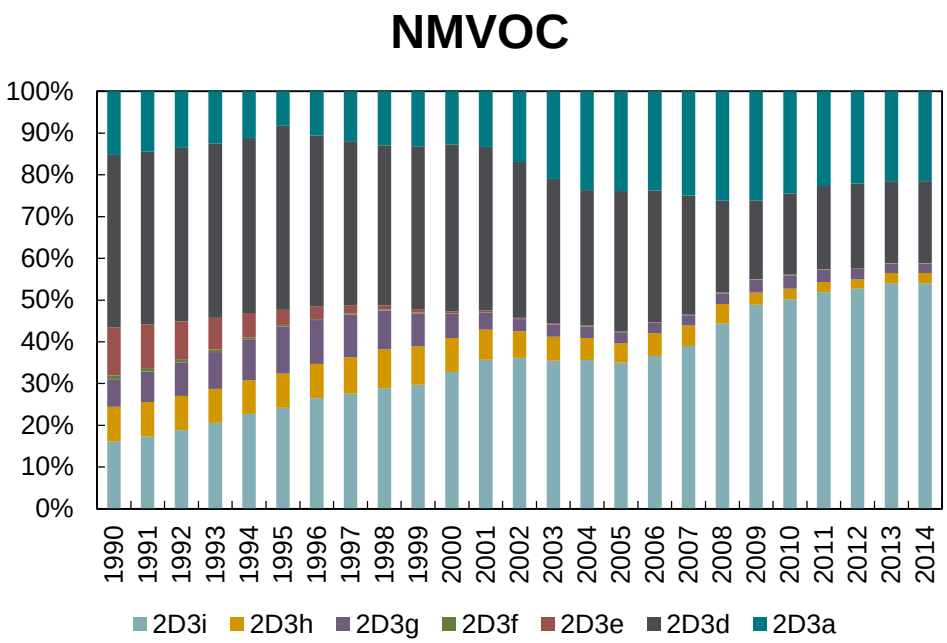

Figure 4. Distribution of the estimated emissions of NMVOC as percentages per NFR codes.

3.2.1 Domestic solvent use including fungicides (2.D.3.a)

In Figure 4 it can be seen that NFR 2.D.3.a, i.e. domestic solvent use, is a moderate source of NMVOC on a national level and that it increases over time. This increase, starting in 2002, is due to an increased use of the product groups washer fluid, degreasing agents, and ignition fluids (see Figure 5). However, a decrease in emissions from the use of ignition fluids can be seen (Figure 5) for later years.

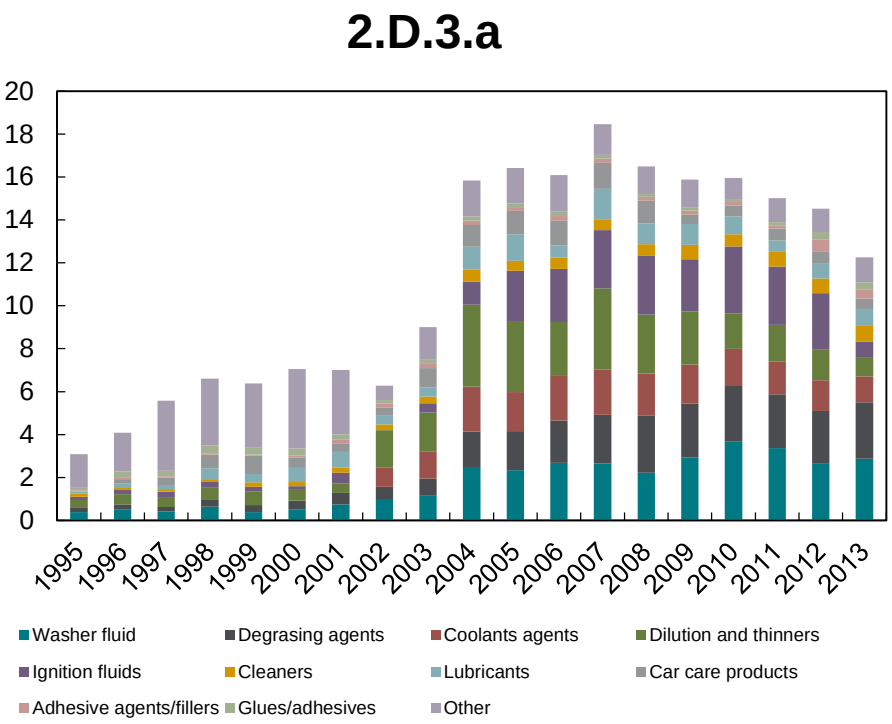

Figure 5. Emissions of NMVOC from domestic solvent use presented per product group during 1990-2014.

In the previous estimates this activity was included in NFR 2.D.3.i, i.e. other solvent use, and consequently it is reallocated and reported separately in the revised estimates. Two different emission factors are used for domestic solvent use which are used for the whole time series:

- Diluted 0.275 (product groups that are used diluted in water)
- Not diluted 0.95 (product groups that are not used diluted in water)

The separation between diluted and not diluted products is a new approach compared to the old calculation model. In Figure 6 it can be seen that the emissions of NMVOC and CO_2 from domestic solvent use increased from 1990 to 2007, and after 2007 the use of solvent containing products has subsided.

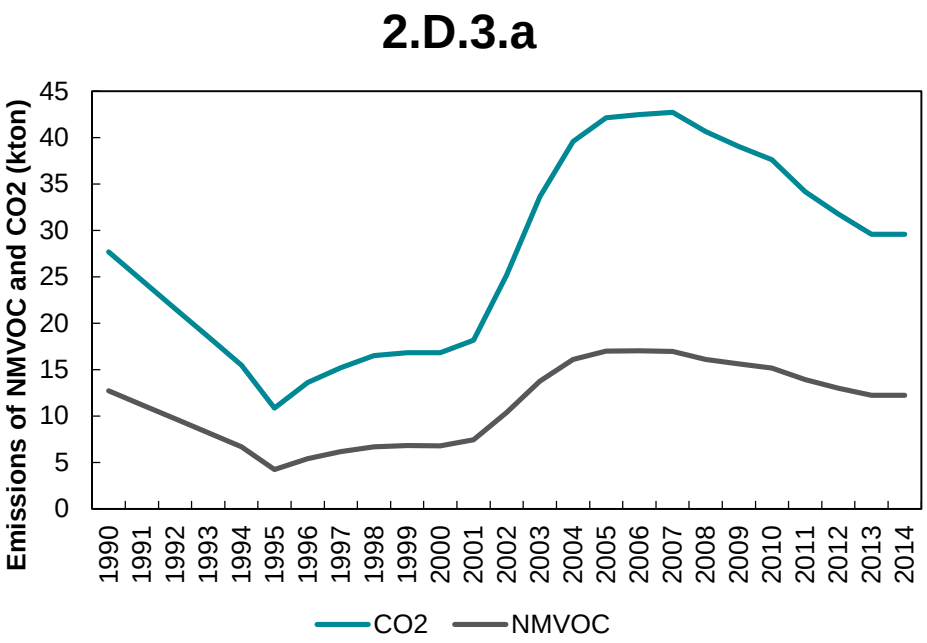

Figure 6. Emissions of NMVOC and CO_2 from domestic solvent use for the period 1990-2014.

3.2.2 Coating applications (2.D.3.d)

In Figure 4 it can be seen that NFR 2.D.3.d, i.e. coating applications, is a moderate source of NMVOC at national level and that it has decreased over time. In Figure 7 it can be seen that coating in industry is the dominating source, followed by domestic coating, and that non-industry coating is of less importance.

The emission factors for coating in the industry have been revised. The revised emission factors are based on available information in environmental reports for each industry and available information in the EMEP/EEA guidebook. For some industries the emission factor has increased and for some it has been reduced compared to previous estimates. For domestic- and non-industrial coating no revisions have been performed, and consequently the emission factor 0.95 is kept for the whole time series.

In Figure 8 it can be seen that emissions of NMVOC and CO_2 from coating application have decreased for the whole time series from 1990 to 2014. The decrease is both due to reduced use of paints containing solvents and more efficient abatement technologies as indicated in available environmental reports.

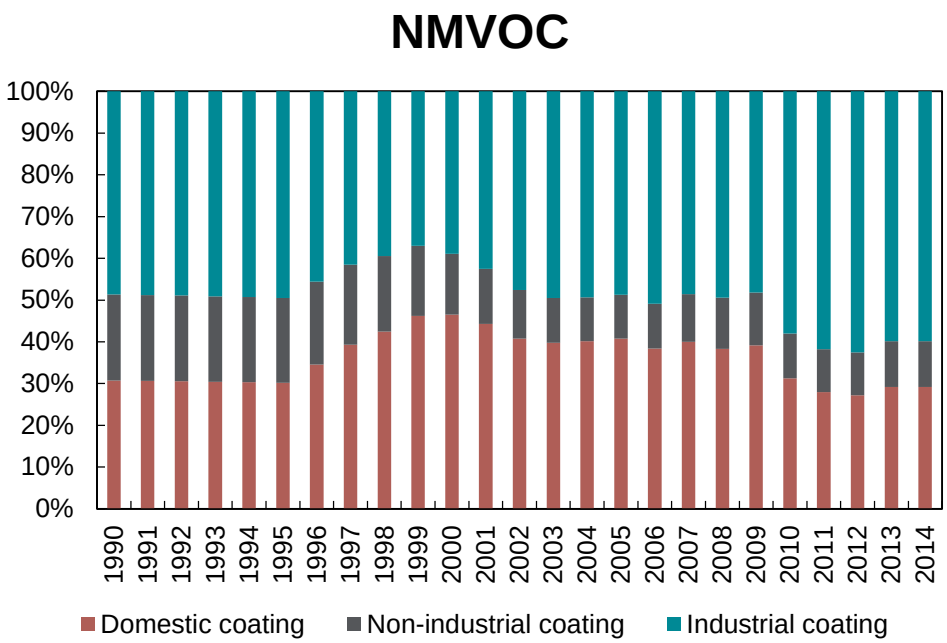

Figure 7. Distribution of the estimated emissions of NMVOC as percentages per different use categories within NFR 2D3e.

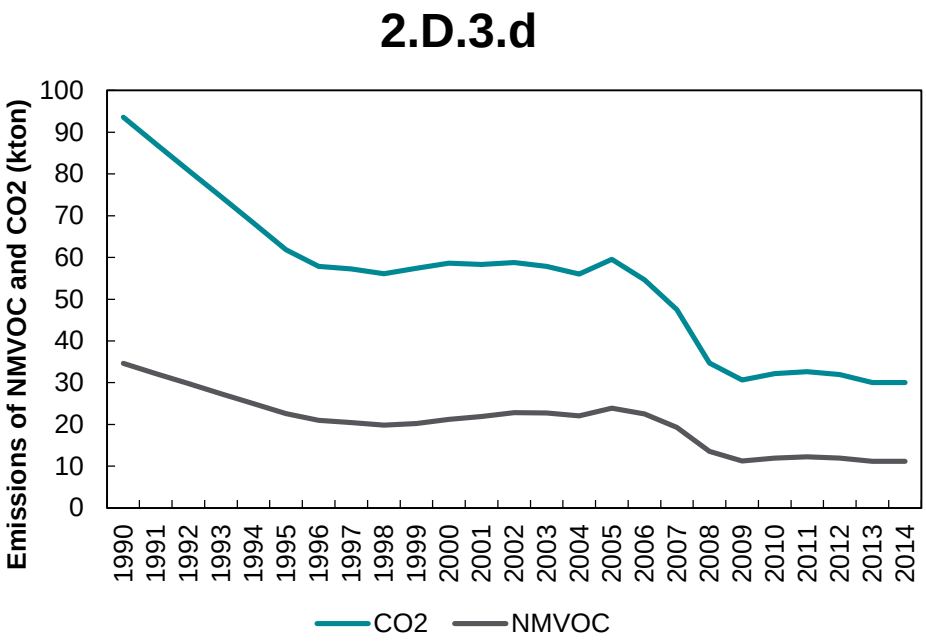

Figure 8. Emissions of NMVOC and CO_2 from coating application for the period 1990-2014.

3.2.3 Degreasing (2.D.3.e)

In Figure 4 it can be seen that NFR 2.D.3.e, i.e. degreasing within the industry, is a minor source of NMVOC on a national level and that it has decreased over time.

In order to be consistent with the reporting guidelines the activity has been reallocated from NFR 2.D.3.i, i.e. other solvent use, to NFR 2.D.3.e. In the previous estimates the emission factor for other solvent use was set to 0.95 for the whole time series. In the revised estimates abatement efficiency factors given in EMEP/EEA guidebook have been used for developing emission factors (see Table 7). The distribution between different abatement technologies has been based on information available in the GAINS-model (scenario: EGEO_Baseline_CLE) for 1995, 2000, 2005 and 2010.

Table 7. Abatement efficiency factors given in EMEP/EEA guidebook and the distribution between abatement technologies.

Year	Abatement efficiency		Distribution abatement technology	
	Semi open-top degreaser and good housekeeping	Sealed chamber system using chlorinated solvents	Semi open-top degreaser and good housekeeping	Sealed chamber system using chlorinated solvents
1990	25%	95%	100%	0%
1995	25%	95%	80%	20%
2000	25%	95%	60%	40%
2005	25%	95%	40%	60%
2010	25%	95%	20%	80%

The emissions for 1990 have been calculated with activity data from the GAINS-model and the emission factors given in Table 7. The resulting emissions correspond to previous estimates. The emissions for 1991-1994 have been interpolated based on the available information from 1990 and the known data for 1995. In Figure 9 the time series for degreasing can be seen. Emissions of both NMVOC and CO_2 have decreased from 1990 to 2014, mainly due to a decreased use of degreasing products, but also a shift in technology, i.e. lower emission factors for the later years.

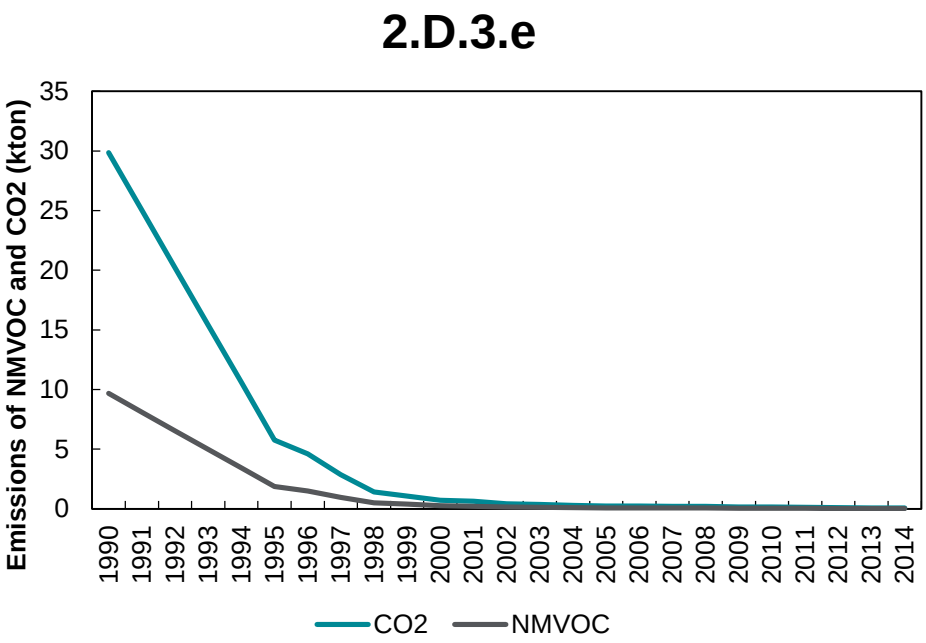

Figure 9. Emissions of NMVOC and CO_2 from degreasing for the period 1990-2014.

3.2.4 Dry cleaning (2.D.3.f)

In Figure 4 it can be seen that NFR 2.D.3.f, i.e. dry cleaning, is a minor source of NMVOC on a national level. In the revised estimate the previous country specific emission factor has been changed for the whole time series from 0.57 to 0.3 in accordance with EMEP/EEA guidebook (chapter 2.D.3.f, table 3.3). The time series for emissions of NMVOC and CO_2 from dry cleaning between 1990 and 2014 can be seen in Figure 10. The decrease in emissions for the activity can be explained by less use of dilution and thinner products.

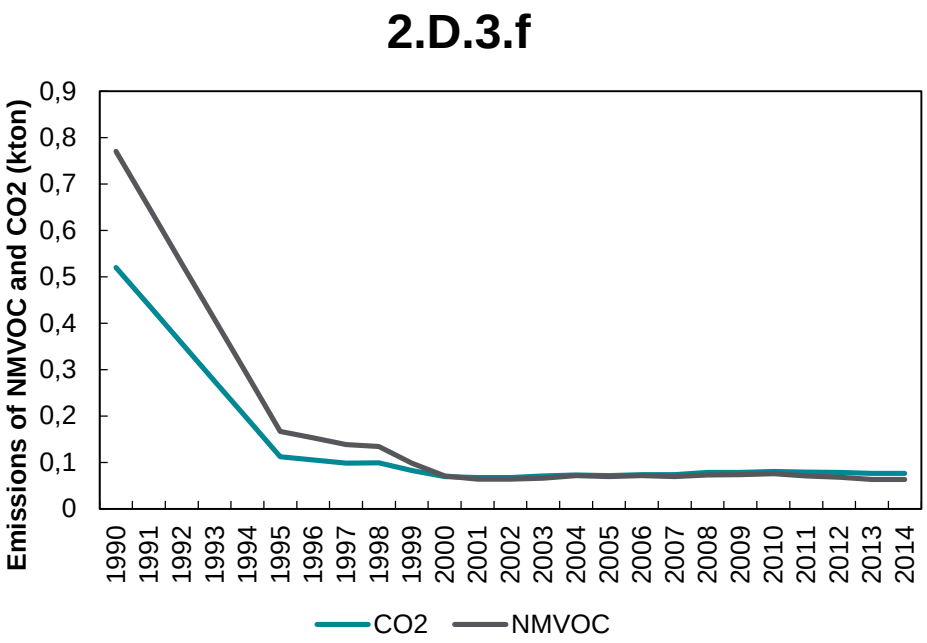

Figure 10. Emissions of NMVOC and CO_2 from dry cleaning for the period 1990-2014.

3.2.5 Chemical products (2.D.3.g)

In Figure 4 it can be seen that chemical products (NFR 2.D.3.g) is a minor source of NMVOC at national level. It is shown in Figure 11 that the vehicle industry is the predominant source of emissions for chemical products. In Figure 12 the emissions of NMVOC and CO_2 from 1990 to 2014 are shown. It can clearly be seen that the emissions are decreasing over time.

The decrease during the 90's is both due to reduced solvent content in used products as indicated in activity data, as well as more efficient abatement technologies according to information available in environmental reports for the rubber and vehicle industry.

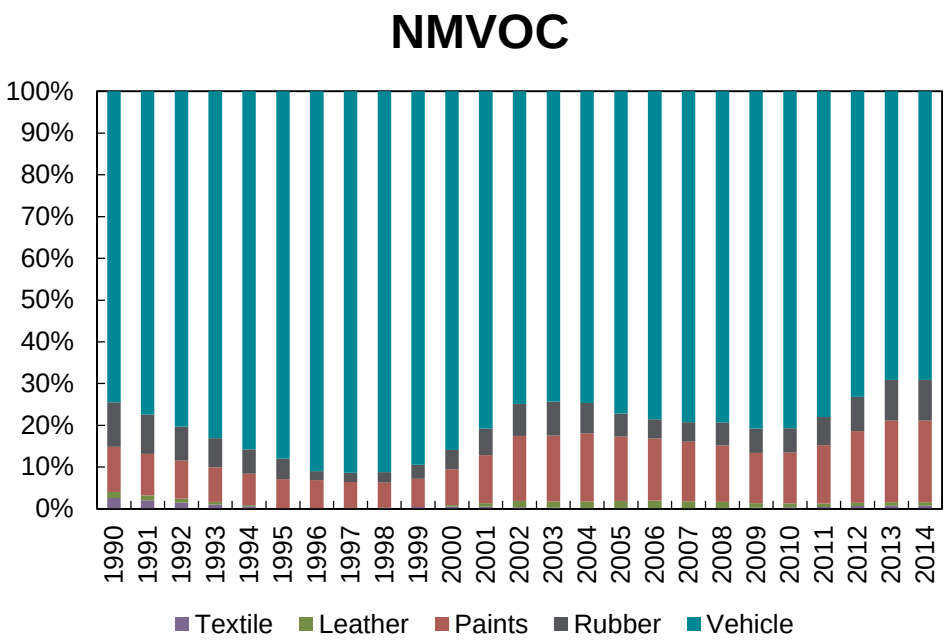

Figure 11. Distribution of the estimated emissions of NMVOC as percentages per different sub-categories within NFR 2D3g.

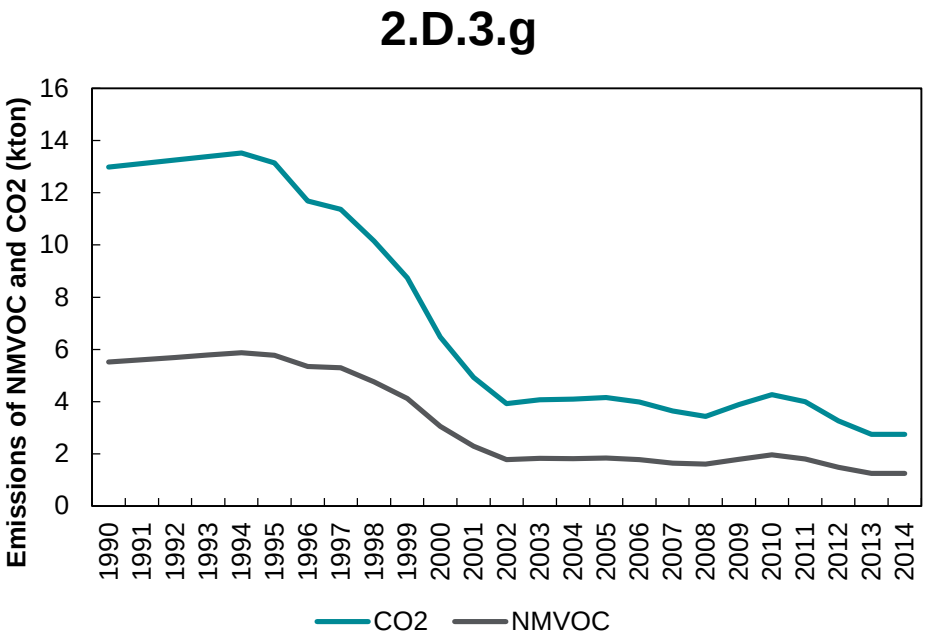

Figure 12. Emissions of NMVOC and CO_2 from chemical products for the period 1990-2014.

Vehicle industry

In Figure 11 it can be seen that the vehicle industry is the greatest contributor to the emissions within NFR 2.D.3.g, i.e. chemical products.

When evaluating the time series for car manufacturing an error was identified in the previous reported emission for 1990. The reported emission should have been allocated as coating in the industry instead of car manufacturing. Some products (for example anticorrosion products, polishing agents and pigments) used in car manufacturing have been reallocated to coating application within the industry. The emission factors used for 1995 and onwards have not been changed compared to previous estimates.

Since the NMVOC and CO_2 emissions from car manufacturing are unknown for 1990, information on the number of produced vehicles in Sweden have been used for the 1990 estimates. The number of produced vehicles was around 22 % lower in 1990 than in 1995, and this information has been used to calculate the NMVOC and CO_2 emissions for 1990. The emissions for 1991-1994 have been interpolated based on the available information from 1990 and the known data for 1995.

Rubber industry

In Figure 11 it can be seen that the rubber industry is a minor contributor to the emissions within NFR 2.D.3.g, i.e. chemical products. It is also shown that the emissions are quite stable over time.

The previous developed emission factor for the activity is considered as accurate, since it is consistent with what is suggested by EMEP/EEA guidebook (abatement efficiency 2.D.3.g table 3-21). The revised emission for the activity is slightly lower than the previous estimates, due to reallocation of a few product codes.

Paint industry

In Figure 11 it can be seen that the paint industry is the second largest contributor to the emissions within NFR 2D3g, i.e. chemical products. It can also be seen that the emissions are quite stable over time, with the exception of the period 1995-2000.

The emission factor has been changed in the revised estimates for all years from 2000 and onwards. The revision is based on available information in the environmental reports for one of the largest facilities. The new emission factor is slightly higher than the old one.

Textile and leather industry

In Figure 11 it can be seen that both the textile and the leather industry are minor sources of the emissions within NFR 2D3g, i.e. chemical products.

However, some changes have been made in the revised estimates. The changes include reallocation for both industries from NRF 2D3i, i.e. other solvent use. Furthermore, minor revisions of the emission factors for the leather industry have been made for the years 2008 to 2014. The revised emission factors are based on available information in the environmental reports for two facilities.

3.2.6 Printing industry (2.D.3.h)

In Figure 4 it can be seen that NFR 2.D.3.h, i.e. printing industry, is a minor source of NMVOC on a national level.

The emission factors for printing industry have been revised. When the model was developed in 2005 an implied emission factor was developed for 2001 based on information from Kindbom et al 2004. A new country specific emission factor has been estimated for 2014 based on available information in the facilities environmental reports for the industry. The emission factors for 2002-2013 have been interpolated based on the available information from 2001 and 2014.

A steady decrease in the emissions of NMVOC and CO_2 from printing industry can be seen in Figure 13. The decrease depends on a reduced use of solvent products within the industry as well as a technology shift.

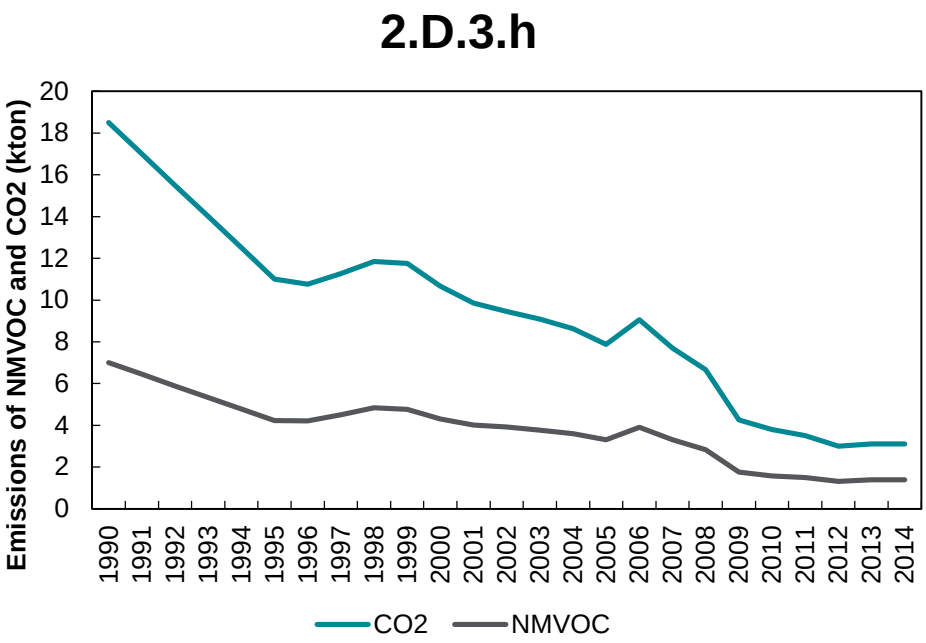

Figure 13. Emissions of NMVOC and CO_2 from printing industry for the period 1990-2014.

3.2.7 Other solvent use (2.D.3.i)

In Figure 4 it can be seen that NFR 2.D.3.i, i.e. other solvent use, is a major source of NMVOC on a national level and that it has increased over time. The emissions of NMVOC and CO_2 for other solvent use between 1990 and 2014 can be seen in Figure 15. The increased emissions for the activity are mainly due to a greater use of the product groups preservatives, refrigerants, metal mordants/etchants and coolant agents. These products account for about 70% of the increase. As for manufacturing of vehicles, emission data 1990 for other solvent use are unknown. For estimates of 1990 emissions of NMVOC and CO_2, the correlation between GDP (gross domestic product) (Ekonomifakta, 2016) and NMVOC emissions 1995 - 2013 have been used (Figure 14). From known GDP for 1990 and the mathematical function for the correlation between emissions and GDP, emissions of NMVOC and CO_2 have been calculated.

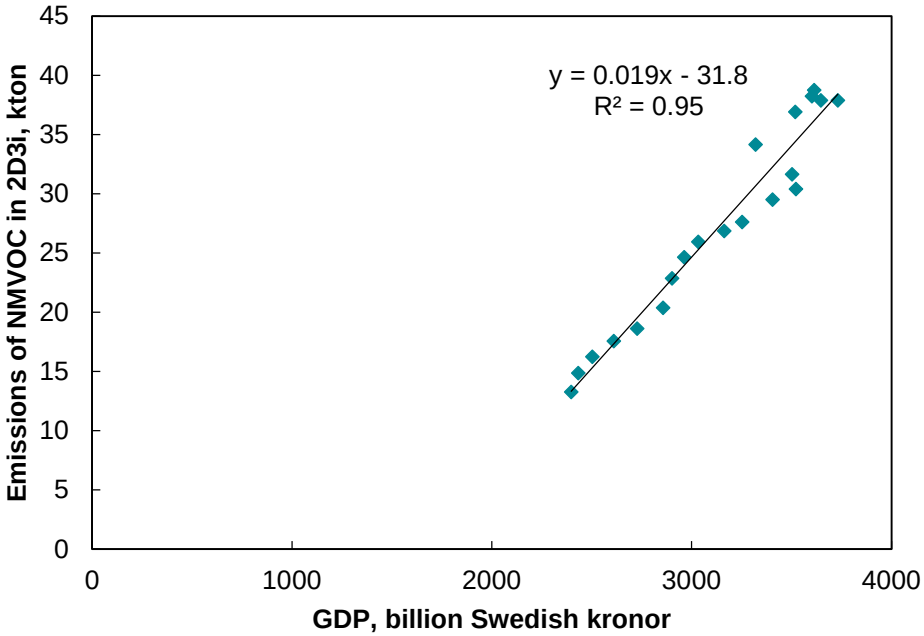

Figure 14. Correlation between GDP (gross domestic product) and emissions of NMVOC, 1995 – 2013.

The emissions for 1991-1994 have been interpolated based on the available information for1990 and the known data for 1995. In order to align with the reporting guidelines, some activities (degreasing, domestic solvent use, and textile and leather industry) have been reallocated from NFR 2D3i. In previous estimates the overall used emission factor for other solvent use was set to 0.95. Due to the reallocation to other NFR codes with mostly lower emission factors, the revised emission estimates of NMVOC and CO_2 for the activity is much lower than in previous estimates. The reallocation to other activities is the major explanation to the large difference in the estimates between the new and the old model (see Figure 2).

Furthermore, the introduction of a specific emission factor (0.275) for products that are diluted with water (see chapter 2.3) instead of using the emission factor of 0.95 for all products used within the activity, has clearly decreased the emissions for the activity.

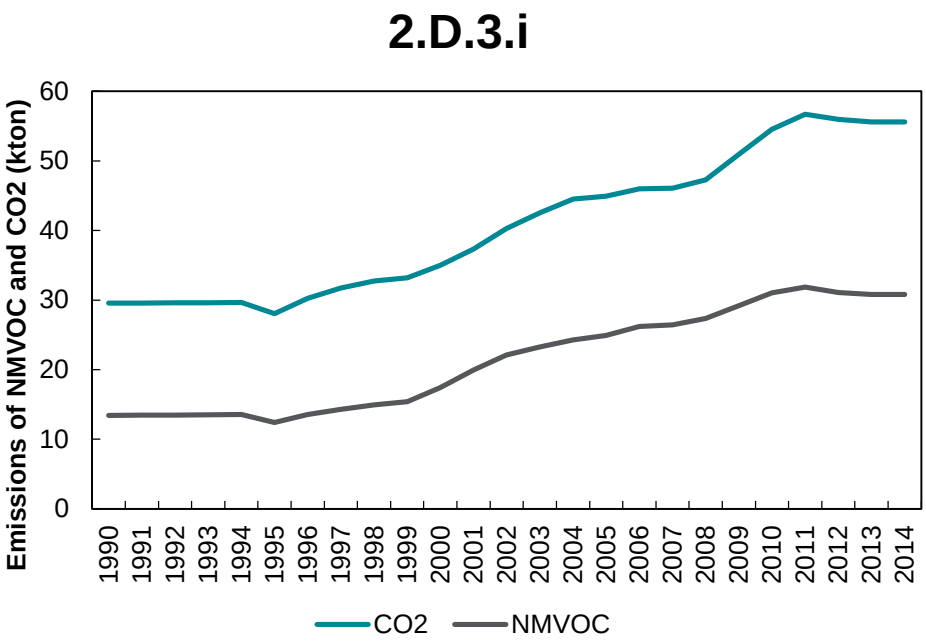

Figure 15. Emissions of NMVOC and CO_2 from other solvent use for the period 1990-2014.

3.3 Use categories and Product groups

In Figure 16 the emissions of NMVOC from the three different use categories can be seen. For later years the non-industrial sector contributes most to the overall emissions.

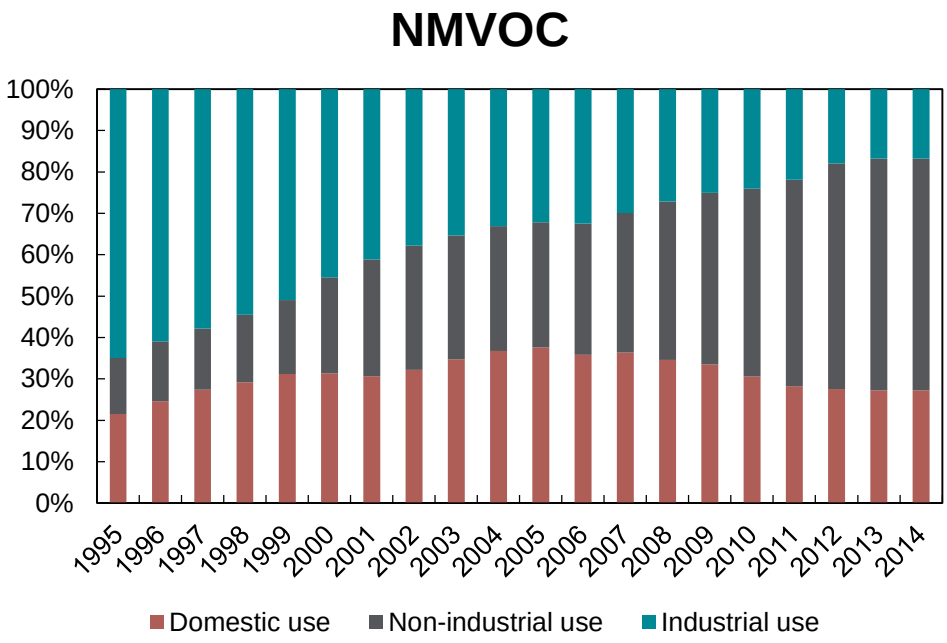

Figure 16. Different use categories contribution, as percentage, to the emissions of NMVOC from solvent use.

In Figure 17 it is shown that the five product groups that contribute by approximately 50% of the emissions of NMVOC from solvent use for 2013 are paints, refrigerants, preservatives, degreasing agents and coolants/antifreeze.

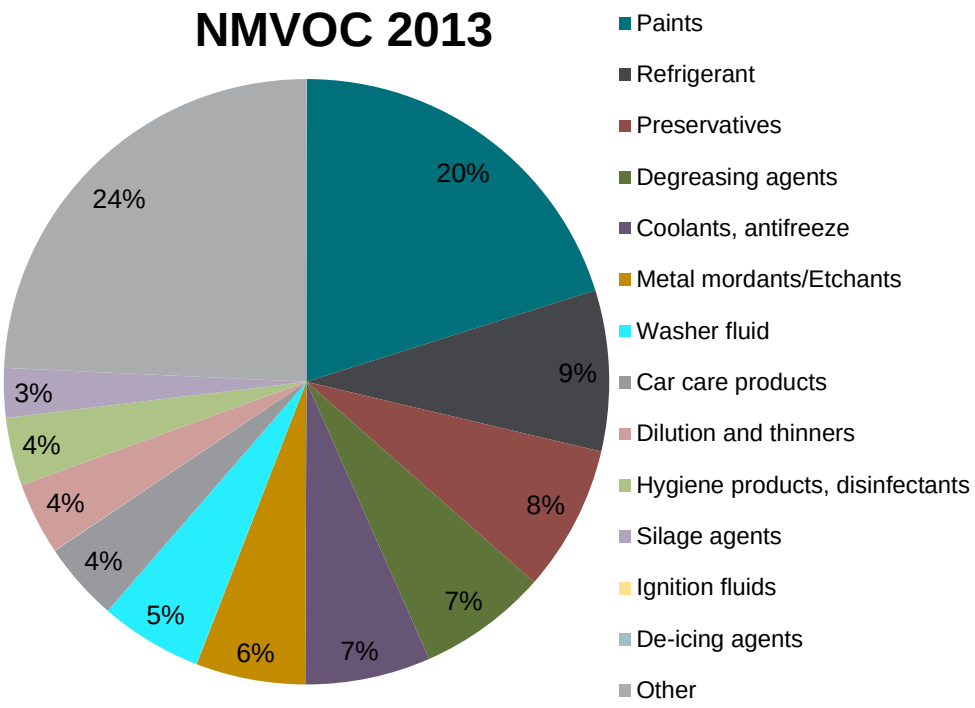

Figure 17. Product groups contribution, as percentage, to the emissions of NMVOC from solvent use 2013.

In Figure 18 the emissions of NMVOC (2013) per use category for those five products groups can be seen. Out of those five product groups, paints and degreasing products dominate the emissions from domestic use. Within the industry category the emissions from the use of paints are dominated by the coil coating industry. All five product groups are used in the non-industry use category, and the following sectors contribute the most to the emissions from the use of the following product groups:

- Paints mainly used in the construction and buildings sector.
- Refrigerants mainly used in the construction and buildings sector and in facilities producing electricity, gas, heat and cold.
- Preservatives mainly used in the agriculture and forestry sector.
- Degreasing agents mainly used in car repairing, cleaning companies/ chimney sweepers.

- Coolants, antifreeze mainly used in car repairing and in the construction and building sector.

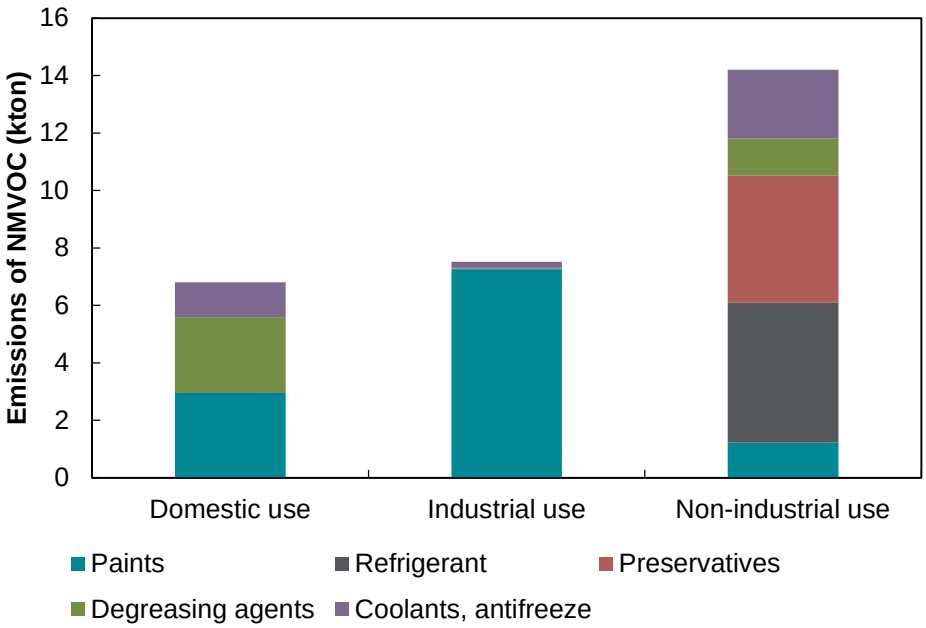

Figure 18. The five product groups that contributes the most to the emissions for 2013 from solvent use (given in different use categories).

Remaining product groups ("Other" excluded) per use category sums up to approximately 27% of the emissions of NMVOC from solvent use (see Figure 17) are the following:

- Industrial use:
  - Dilution and thinners mainly used in the printing-, paints and wood industry.
- Non-industrial:
  - Metal mordants/ Etchants
  - Hygiene products, disinfectants De-icing agents
- Domestic use category:
  - Washer fluids
  - Dilution and thinners
  - Ignition fluids
  - Car care products

4 Uncertainty Analysis

Uncertainty quantification is useful in identifying problems and setting priorities for inventory improvement. The uncertainty estimates have been performed for NMVOC and CO_2. The uncertainties (%) on activity data (AD) and emission factors (EF) have been set on CRF-code 2.D.3. Other-solvent use.

The uncertainty for emissions of NMVOC and CO_2 for 1990 - 1994 is unchanged compared to the previous estimates (± 25%).

For activity data (1995 and onwards) the uncertainty is not revised compared to the previous estimates (± 15%). The uncertainties have been discussed and assigned in co-operation with the Swedish Chemicals Agency. Uncertainty estimates for the emission factors were estimated by expert judgement. The uncertainty for 1995 and onwards is judged to be lower in the new estimates due to reallocation and to the introduction of the new emission factor for products that are used diluted in water. Furthermore, information available in environmental reports, in the GAINS model and in the EMEP/EEA guidebook has been taken into account when developing the emission factors. Consequently the uncertainty from 1995 and onwards has been lowered from 20% to 15%.

The combined uncertainty is calculated according to equation 3.1 in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 1 General Guidance and Reporting, chapter 3 (IPPC, 2006) (see below).

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

Where U = uncertainty, AD = activity data and EF = emission factor. U_{total} *represents the combined uncertainty.*

5 Conclusions

The revised model for estimating national NMVOC and CO_2 emissions from solvent use:

- meets international reporting requirements according to CLRTAP and UNFCCC,
- makes it possible to test different sets of emission factors within the solvent use sector,
- can be used to assess different actions and emission reduction potentials,
- can generate emissions per user category and product group. This information can be used when following-up the Swedish environmental quality objectives.

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Appendix I, substances

Cas-nr	Substance name	Carbon share	Formula
100-37-8	Ethanol, 2-(diethylamino)-	0.61	C6H15NO
100-41-4	Benzene, ethyl-	0.91	C8H10
100-42-5	Benzene, ethenyl-	0.92	C8H8
100-51-6	Benzenemethanol	0.78	C7H8O
100-52-7	Benzaldehyde	0.79	C7H6O
100-66-3	Benzene, methoxy-	0.78	C7H8O
100-97-0	1,3,5,7-Tetraazatricyclo[3.3.1.13,7]decane	0.51	C6H12N4
101-68-8	Benzene, 1,1'-methylenebis[4-isocyanato-	0.72	C15H10N2O2
101-84-8	Benzene, 1,1'-oxybis-	0.85	C12H10O
102110-13-4	Hydrocarbons, C4-7	0.85	Mixture
102-76-1	1,2,3-Propanetriol, triacetate	0.50	C9H14O6
103-11-7	2-Propenoic acid, 2-ethylhexyl ester	0.72	C11H20O2
103-76-4	1-Piperazineethanol	0.55	C6H14N2O
103-83-3	Benzenemethanamine, N,N-dimethyl-	0.80	C9H13N
104-68-7	Ethanol, 2-(2-phenoxyethoxy)-	0.66	C10H14O3
104-75-6	1-Hexanamine, 2-ethyl-	0.74	C8H19N
104-76-7	1-Hexanol, 2-ethyl-	0.74	C8H18O
105-59-9	Ethanol, 2,2'-(methylimino)bis-	0.50	C5H13NO2
105-60-2	2H-Azepin-2-one, hexahydro-	0.64	C6H11NO
106-42-3	Benzene, 1,4-dimethyl-	0.91	C8H10
106-65-0	Butanedioic acid, dimethyl ester	0.49	C6H10O4
1068-27-5	Peroxide, (1,1,4,4-tetramethyl-2-butyne-1,4-diyl)bis[(1,1-dimethylethyl)	0.67	C16H30O4
106-89-8	Oxirane, (chloromethyl)-	0.39	C3H5ClO
106-91-2	2-Propenoic acid, 2-methyl-, oxiranylmethyl ester	0.59	C7H10O3
106-92-3	Oxirane, [(2-propenyloxy)methyl]-	0.63	C6H10O2
106-97-8	Butane	0.83	C4H10
106-98-9	1-Butene	0.86	C4H8
106-99-0	1,3-Butadiene	0.89	C4H6
107-00-6	1-butyne	0.89	C4H6
107-01-7	2-Butene	0.86	C4H8
107-05-1	1-Propene, 3-chloro-	0.47	C3H5Cl
107-06-2	Ethane, 1,2-dichloro-	0.24	C2H4Cl2
1070-70-8	2-Propenoic acid, 1, 4-butanediyl ester	0.61	C10H14O4
107-11-9	2-Propen-1-amine	0.62	C3H7N
107-13-1	2-Propenenitrile	0.68	C3H3N
107-15-3	1,2-Ethanediamine	0.40	C2H8N2

Cas-nr	Substance name	Carbon share	Formula
107-21-1	1,2-Ethanediol	0.39	C2H6O2
107-22-2	Ethanedial	0.41	C2H2O2
107-41-5	2,4-Pentanediol, 2-methyl-	0.61	C6H14O2
107-83-5	Pentane, 2-methyl-	0.84	C6H14
107-92-6	Butanoic acid	0.55	C4H8O2
107-98-2	2-Propanol, 1-methoxy-	0.53	C4H10O2
108-01-0	Ethanol, 2-(dimethylamino)-	0.54	C4H11NO
108-05-4	Acetic acid ethenyl ester	0.56	C4H6O2
108-10-1	2-Pentanone, 4-methyl-	0.72	C6H12O
108-21-4	Acetic acid, 1-methylethyl ester	0.59	C5H10O2
108-24-7	Acetic acid, anhydride	0.47	C4H6O3
108-31-6	2,5-Furandione	0.49	C4H2O3
108-32-7	1,3-Dioxolan-2-one, 4-methyl-	0.47	C4H6O3
108-38-3	Benzene, 1,3-dimethyl-	0.91	C8H10
108-39-4	Phenol, 3-methyl-	0.78	C7H8O
108-46-3	1,3-Benzenediol	0.65	C6H6O2
108-65-6	2-Propanol, 1-methoxy-, acetate	0.55	C6H12O3
108-67-8	Benzene, 1,3,5-trimethyl-	0.90	C9H12
108-78-1	1,3,5-Triazine-2,4,6-triamine	0.29	C3H6N6
108-83-8	4-Heptanone, 2,6-dimethyl-	0.76	C9H18O
108-87-2	Cyclohexane, methyl-	0.86	C7H14
108-88-3	Benzene, methyl-	0.91	C7H8
108-91-8	Cyclohexanamine	0.73	C6H13N
108-94-1	Cyclohexanone	0.73	C6H10O
108-95-2	Phenol	0.77	C6H6O
109-01-3	Piperazine, 1-methyl-	0.60	C5H12N2
109-52-4	Pentanoic acid	0.59	C5H10O2
109-55-7	1,3-Propanediamine, N,N-dimethyl-	0.59	C5H14N2
109-60-4	Acetic acid, propyl ester	0.59	C5H10O2
109-66-0	Pentane	0.83	C5H12
109-81-9	1,2-Ethanediamine, N-methyl-	0.49	C3H10N2
109-83-1	Ethanol, 2-(methylamino)-	0.48	C3H9NO
109-86-4	Ethanol, 2-methoxy-	0.47	C3H8O2
109-87-5	Methane, dimethoxy-	0.47	C3H8O2
109-99-9	Furan, tetrahydro-	0.67	C4H8O
110-12-3	2-Hexanone, 5-methyl-	0.74	C7H14O
110-15-6	Butanedioic acid	0.41	C4H6O4
110-17-8	2-Butenedioic acid (E)-	0.41	C4H4O4

Cas-nr	Substance name	Carbon share	Formula
110-19-0	Acetic acid, 2-methylpropyl ester	0.62	C6H12O2
110-43-0	2-Heptanone	0.74	C7H14O
110-54-3	Hexane	0.84	C6H14
110-62-3	Pentanal	0.70	C5H10O
110-63-4	1,4-Butanediol	0.53	C4H10O2
11070-44-3	1,3-Isobenzofurandione, tetrahydromethyl	0.65	C9H10O3
110-80-5	Ethanol, 2-ethoxy-	0.53	C4H10O2
110-82-7	Cyclohexane	0.86	C6H12
110-85-0	Piperazine	0.56	C4H10N2
110-86-1	Pyridine	0.76	C5H5N
110-91-8	Morpholine	0.55	C4H9NO
110-94-1	Pentanedioic acid	0.45	C5H8O4
110-98-5	2-Propanol, 1,1'-oxybis-	0.54	C6H14O3
111109-77-4	Propane, oxybis[methoxy-	0.59	C8H18O3
111-15-9	Ethanol, 2-ethoxy-, acetate	0.55	C6H12O3
111-27-3	1-Hexanol	0.71	C6H14O
111-30-8	Pentanedial	0.60	C5H8O2
111-40-0	1,2-Ethanediamine, N-(2-aminoethyl)-	0.47	C4H13N3
111-41-1	Ethanol, 2-[(2-aminoethyl)amino]-	0.46	C4H12N2O
111-42-2	Ethanol, 2,2'-iminobis-	0.46	C4H11NO2
111-46-6	Ethanol, 2,2'-oxybis-	0.45	C4H10O3
111-65-9	Octane	0.84	C8H18
111-76-2	Ethanol, 2-butoxy-	0.61	C6H14O2
111-77-3	Ethanol, 2-(2-methoxyethoxy)-	0.50	C5H12O3
111-87-5	1-Octanol	0.74	C8H18O
111-90-0	Ethanol, 2-(2-ethoxyethoxy)-	0.54	C6H14O3
1119-40-0	Pentanedioic acid, dimethyl ester	0.52	C7H12O4
111-96-6	Ethane, 1,1'-oxybis[2-methoxy-	0.54	C6H14O3
112-05-0	Nonanoic acid	0.68	C9H18O2
112-07-2	Ethanol, 2-butoxy-, acetate	0.60	C8H16O3
112-15-2	Ethanol, 2-(2-ethoxyethoxy)-, acetate	0.55	C8H16O4
112-24-3	1,2-Ethanediamine, N,N'-bis(2-aminoethyl)-	0.49	C6H18N4
112-27-6	Ethanol, 2,2'-[1,2-ethanediylbis(oxy)]bis-	0.48	C6H14O4
112-34-5	Ethanol, 2-(2-butoxyethoxy)-	0.59	C8H18O3
112-35-6	Ethanol, 2-[2-(2-methoxyethoxy)ethoxy]-	0.51	C7H16O4
112-42-5	1-Undecanol	0.77	C11H24O
115-07-1	1-Propene	0.86	C3H6
115-10-6	Methane, oxybis-	0.52	C2H6O

Cas-nr	Substance name	Carbon share	Formula
115-11-7	1-Propene, 2-methyl-	0.86	C4H8
115-77-5	1,3-Propanediol, 2,2-bis(hydroxymethyl)-	0.44	C5H12O4
115-84-4	1,3-Propanediol, 2-butyl-2-ethyl-	0.68	C9H20O2
121-44-8	Ethanamine, N,N-diethyl-	0.71	C6H15N
123-05-7	Hexanal, 2-ethyl-	0.75	C8H16O
123-31-9	1,4-Benzenediol	0.65	C6H6O2
123-38-6	Propanal	0.62	C3H6O
123-42-2	2-Pentanone, 4-hydroxy-4-methyl-	0.62	C6H12O2
123-54-6	2,4-Pentanedione	0.60	C5H8O2
123-63-7	1,3,5-Trioxane, 2,4,6-trimethyl-	0.55	C6H12O3
123-72-8	Butanal	0.67	C4H8O
123-86-4	Acetic acid, butyl ester	0.62	C6H12O2
123-91-1	1,4-Dioxane	0.55	C4H8O2
124-17-4	Ethanol, 2-(2-butoxyethoxy)-, acetate	0.59	C10H20O4
124-40-3	Methanamine, N-methyl-	0.53	C2H7N
124-68-5	1-Propanol, 2-amino-2-methyl-	0.54	C4H11NO
125451-23-2	Ethane, mixt. with methane	0.78	C2H6.CH4
126-30-7	1,3-Propanediol, 2,2-dimethyl-	0.58	C5H12O2
126-98-7	2-Propenenitrile, 2-methyl-	0.72	C4H5N
127-18-4	Ethene, tetrachloro-	0.14	C2Cl4
127-19-5	Acetamide, N,N-dimethyl-	0.55	C4H9NO
127-91-3	Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-	0.88	C10H16
1300-71-6	Phenol, dimethyl-	0.79	C8H10O
1319-77-3	Phenol, methyl-	0.78	C7H8O
1320-67-8	Propanol, methoxy-	0.53	C4H10O2
1321-94-4	Napthalene, methyl-	0.93	C11H10
1330-20-7	Benzene, dimethyl-	0.91	C8H10
1338-23-4	2-Butanone, peroxide	0.55	C8H16O4
13466-78-9	Bicyclo[4.1.0]hept-3-ene, 3,7,7-trimethyl-	0.88	C10H16
13475-82-6	Heptane, 2,2,4,6,6-pentamethyl-	0.85	C12H26
137-32-6	1-Butanol, 2-methyl-	0.68	C5H12O
13822-56-5	1-Propanamine, 3-(trimethoxysilyl)-	0.40	C6H17NO3Si
138-86-3	Cyclohexene, 1-methyl-4-(1-methylethenyl)-	0.88	C10H16
140-31-8	1-Piperazineethanamine	0.56	C6H15N3
140-88-5	2-Propenoic acid, ethyl ester	0.60	C5H8O2
141-32-2	2-Propenoic acid, butyl ester	0.66	C7H12O2
141-43-5	Ethanol, 2-amino-	0.39	C2H7NO
141-78-6	Acetic acid ethyl ester	0.55	C4H8O2

Cas-nr	Substance name	Carbon share	Formula
142-82-5	Heptane	0.84	C7H16
1477-55-0	1,3-Benzenedimethanamine	0.71	C8H12N2
149-57-5	Hexanoic acid, 2-ethyl-	0.67	C8H16O2
15206-55-0	Benzeneacetic acid, .alpha.-oxo-, methyl ester	0.66	C9H8O3
1569-01-3	2-Propanol, 1-propoxy-	0.61	C6H14O2
1569-02-4	2-Propanol, 1-ethoxy-	0.58	C5H12O2
15821-83-7	1-Propanol, 2-butoxy-	0.64	C7H16O2
1589-47-5	1-Propanol, 2-methoxy-	0.53	C4H10O2
16111-62-9	Peroxydicarbonic acid, bis(2-ethylhexyl) ester	0.62	C18H34O6
1634-04-4	Propane, 2-methoxy-2-methyl-	0.68	C5H12O
1694-31-1	Butanoic acid, 3-oxo-, 1,1-dimethylethyl ester	0.61	C8H14O3
17832-28-9	1-Butanol, 4-(ethenyloxy)-	0.62	C6H12O2
19089-47-5	1-Propanol, 2-ethoxy-	0.58	C5H12O2
1965-29-3	Ethanol, 2-[[2-[(2-aminoethyl)amino]ethyl]amino]-	0.49	C6H17N3O
1975-78-6	Decanenitrile	0.79	C10H19N
2163-42-0	1,3-Propanediol, 2-methyl-	0.53	C4H10O2
22113-87-7	Methanamine, nitrate	0.13	CH6N2O3
23235-61-2	1,3-Propanediol, 2,2'-[oxybis(methylene)]bis[2-ethyl-	0.58	C12H26O5
25013-15-4	Benzene, ethenylmethyl-	0.92	C9H10
25103-58-6	tert-Dodecanethiol	0.71	C12H26S
25155-25-3	Peroxide, [phenylenebis(1-methylethylidene)]bis[(1,1-dimethylethyl)	0.71	C20H34O4
25167-67-3	Butene	0.86	C4H8
2517-43-3	1-Butanol, 3-methoxy-	0.58	C5H12O2
25265-71-8	Propanol, oxybis-	0.54	C6H14O3
25339-17-7	Isodecanol	0.76	C10H22O
25498-49-1	Propanol, [2-(2-methoxymethylethoxy)methylethoxy]-	0.58	C10H22O4
2612-29-5	1,3-Propanediol, 2-ethyl-	0.58	C5H12O2
26266-68-2	Hexenal, 2-ethyl-	0.76	C8H14O
26447-40-5	Benzene, 1,1'-methylenebis[isocyanato-	0.72	C15H10N2O2
26748-41-4	Neodecaneperoxoic acid, 1,1-dimethylethyl ester	0.69	C14H28O3
2687-91-4	2-Pyrrolidinone, 1-ethyl-	0.64	C6H11NO
27215-95-8	Nonene	0.86	C9H18
27458-94-2	Isononanol	0.75	C9H20O
2768-02-7	Silane, ethenyltrimethoxy-	0.41	C5H12O3Si
280-57-9	1,4-Diazabicyclo[2.2.2]octane	0.64	C6H12N2
2807-30-9	Ethanol, 2-propoxy-	0.58	C5H12O2
2809-21-4	Phosphonic acid, (1-hydroxyethylidene)bis-	0.12	C2H8O7P2
2855-13-2	Cyclohexanemethanamine, 5-amino-1,3,3-trimethyl-	0.71	C10H22N2

Cas-nr	Substance name	Carbon share	Formula
287-92-3	Cyclopentane	0.86	C5H10
29387-86-8	Propanol, butoxy-	0.64	C7H16O2
298-12-4	Acetic acid, oxo-	0.32	C2H2O3
29911-27-1	2-Propanol, 1-(1-methyl-2-propoxyethoxy)-	0.61	C9H20O3
29911-28-2	2-Propanol, 1-(2-butoxy-1-methylethoxy)-	0.63	C10H22O3
3047-32-3	3-Oxetanemethanol, 3-ethyl-	0.62	C6H12O2
30525-89-4	Paraformaldehyde	0.40	(CH2O)x
30899-19-5	Pentanol	0.68	C5H12O
31295-54-2	1,4-Piperazinediethanamine, N-(2-aminoethyl)-	0.56	C10H25N5
31807-55-3	Isododecane	0.85	C12H26
3437-84-1	Peroxide, bis(2-methyl-1-oxopropyl)	0.55	C8H14O4
34590-94-8	Propanol, (2-methoxymethylethoxy)-	0.57	C7H16O3
35435-21-3	Silane, triethoxy(2,4,4-trimethylpentyl)-	0.61	C14H32O3Si
3586-55-8	Methanol, [1,2-ethanediylbis(oxy)]bis-	0.39	C4H10O4
3710-30-3	1,7-Octadiene	0.87	C8H14
37187-22-7	2,4-Pentanedione, peroxide	0.60	Unspecified
37971-36-1	1,2,4-Butanetricarboxylic acid, 2-phosphono-	0.31	C7H11O9P
4253-34-3	Silanetriol, methyl-, triacetate	0.38	C7H12O6Si
4497-92-1	Bicyclo[4.1.0]hept-2-ene, 3,7,7-trimethyl-, (1S-cis)-	0.88	C10H16
4767-03-7	Propanoic acid, 3-hydroxy-2-(hydroxymethyl)-2-methyl-	0.45	C5H10O4
50-00-0	Formaldehyde	0.40	CH2O
50-21-5	Propanoic acid, 2-hydroxy-	0.40	C3H6O3
51200-87-4	Oxazolidine, 4,4-dimethyl-	0.59	C5H11NO
5131-66-8	2-Propanol, 1-butoxy-	0.64	C7H16O2
51774-11-9	Isoheptanol	0.72	C7H16O
5187-23-5	1,3-Dioxane-5-methanol, 5-ethyl-	0.58	C7H14O3
52125-53-8	1,2-Propanediol, monoethyl ether	0.58	C5H12O2
540-59-0	Ethene, 1,2-dichloro-	0.25	C2H2Cl2
540-84-1	Pentane, 2,2,4-trimethyl-	0.84	C8H18
54839-24-6	2-Propanol, 1-ethoxy-, acetate	0.58	C7H14O3
55934-93-5	Propanol, [(butoxymethylethoxy)methylethoxy]-	0.63	C13H28O4
56-23-5	Methane, tetrachloro-	0.08	CCl4
5625-90-1	Morpholine, 4,4'-methylenebis-	0.58	C9H18N2O2
565-75-3	Pentane, 2,3,4-trimethyl-	0.84	C8H18
57018-52-7	2-Propanol, 1-(1,1-dimethylethoxy)-	0.64	C7H16O2
57350-24-0	1-Propanol, 2-ethoxy-, acetate	0.58	C7H14O3
57-55-6	1,2-Propanediol	0.47	C3H8O2
584-84-9	Benzene, 2,4-diisocyanato-1-methyl-	0.62	C9H6N2O2

Cas-nr	Substance name	Carbon share	Formula
590-29-4	Formic acid, potassium salt	0.14	CHO2K
592-41-6	1-Hexene	0.86	C6H12
598-50-5	Urea, methyl-	0.32	C2H6N2O
5989-27-5	Cyclohexene, 1-methyl-4-(1-methylethenyl)-, (R)-	0.88	C10H16
60-29-7	Ethane, 1,1'-oxybis-	0.65	C4H10O
6032-29-7	2-Pentanol	0.68	C5H12O
610-39-9	Benzene, 4-methyl-1,2-dinitro-	0.46	C7H6N2O4
616-38-6	Carbonic acid, dimethyl ester	0.40	C3H6O3
61641-74-5	Butane, mixt. with propane	0.85	Mixture
616-45-5	2-Pyrrolidinone	0.56	C4H7NO
623-84-7	1,2-Propanediol, diacetate	0.52	C7H12O4
624-92-0	Disulfide, dimethyl	0.26	C2H6S2
627-82-7	1,2-Propanediol, 3,3'-oxybis-	0.43	C6H14O5
627-93-0	Hexanedioic acid, dimethyl ester	0.55	C8H14O4
629-40-3	Octanedinitrile	0.71	C8H12N2
629-82-3	Octane, 1,1'-oxybis-	0.79	C16H34O
63231-51-6	Aromatic hydrocarbons	0.85	Mixture
637-92-3	Propane, 2-ethoxy-2-methyl-	0.71	C6H14O
64-17-5	Ethanol	0.52	C2H6O
64-18-6	Formic acid	0.26	CH2O2
64-19-7	Acetic acid	0.40	C2H4O2
64741-41-9	Naptha (petroleum) heavy straight-run	0.85	Mixture
64741-42-0	Naphtha (petroleum), full-range straight-run	0.85	Mixture
64741-44-2	Distillates (petroleum), straight-run middle	0.85	Mixture
64741-52-2	Distillates (petroleum), light naphthenic	0.85	Mixture
64741-63-5	Naphtha (petroleum), light catalytic reformed	0.85	Mixture
64741-64-6	Naphtha (petroleum), full-range alkylate	0.85	Mixture
64741-65-7	Naphtha (petroleum), heavy alkylate	0.85	Mixture
64741-70-4	Naphtha (petroleum), isomerization	0.85	Mixture
64741-73-7	Distillates (petroleum), alkylate	0.85	Mixture
64741-92-0	Naphtha (petroleum), solvent-refined heavy	0.85	Mixture
64742-47-8	Distillates (petroleum), hydrotreated light	0.85	Mixture
64742-48-9	Naphtha (petroleum), hydrotreated heavy	0.85	Mixture
64742-49-0	Naphtha (petroleum), hydrotreated light	0.85	Mixture
64742-80-9	Distillates (petroleum), hydrodesulfurized middle	0.85	Mixture
64742-81-0	Kerosine (petroleum), hydrodesulfurized	0.85	Mixture
64742-82-1	Naphtha (petroleum), hydrodesulfurized heavy	0.85	Mixture
64742-83-2	Naphtha (petroleum), light steam-cracked	0.85	Mixture

Cas-nr	Substance name	Carbon share	Formula
64742-88-7	Solvent naphtha (petroleum), medium aliph.	0.85	Mixture
64742-89-8	Solvent naphtha (petroleum), light aliph.	0.85	Mixture
64742-94-5	Solvent naphtha (petroleum), heavy arom.	0.85	Mixture
64742-95-6	Solvent naphtha (petroleum), light arom.	0.85	Mixture
64742-96-7	Solvent naphtha (petroleum), heavy aliph.	0.85	Mixture
64771-72-8	Paraffins (petroleum), normal C5-20	0.85	Mixture
65996-78-3	Light oil (coal), coke-oven	0.85	Mixture
65996-89-6	Tar, coal, high-temp.	0.85	Mixture
66455-17-2	Alcohols, C9-11	0.75	C9H20O-C11H24O
67-56-1	Methanol	0.37	CH4O
67-63-0	2-Propanol	0.60	C3H8O
67-64-1	2-Propanone	0.62	C3H6O
67-66-3	Methane, trichloro-	0.10	CHCl3
67-68-5	Methane, sulfinylbis-	0.31	C2H6OS
67762-38-3	Fatty acids, C16-18 and C18-unsatd., Me esters	0.77	ca C19H36O2
68-12-2	Formamide, N,N-dimethyl-	0.49	C3H7NO
682-09-7	1-Butanol, 2,2-bis[(2-propenyloxy)methyl]-	0.67	C12H22O3
682-11-1	1,3-Propanediol, 2-ethyl-2-[(2-propenyloxy)methyl]-	0.62	C9H18O3
68333-88-0	Aromatic hydrocarbons, C9-17	0.85	Mixture
68334-30-5	Petroleum products, diesel oil	0.85	Mixture
68409-99-4	Distillates (petroleum), catalytic cracked overheads	0.85	Mixture
68475-59-2	Alkanes, C3-4	0.85	Mixture
68476-32-4	Fuel oil, residues-straight-run gas oils, high-sulfur	0.85	Mixture
68476-40-4	Hydrocarbons, C3-4	0.85	Mixture
68476-85-7	Petroleum products, liquefied gas	0.85	Mixture
68477-33-8	Distillates (petroleum), C3-4, isobutane-rich	0.85	Mixture
68477-97-4	Gases (petroleum), hydrogen-rich	0.85	Mixture
68511-50-2	1-Propene, 2-methyl-, sulfurized	0.60	Mixture
68512-91-4	Hydrocarbons, C3-4 rich, petroleum distillate	0.85	Mixture
68513-69-9	Residues (petroleum), steam-cracked light	0.85	Mixture
68514-15-8	Gasoline, vapor-recovery	0.85	Mixture
68514-36-3	Hydrocarbons, C1-4, sweetened	0.85	Mixture
68526-55-6	Alkenes, C9-rich	0.85	Mixture
68527-16-2	Hydrocarbons, C1-3	0.85	Mixture
68527-27-5	Naphtha (petroleum), full-range alkylate, butane-contg.	0.85	Mixture
68551-07-5	Alcohols, C8-18	0.77	C8H18O-C18H38O
68603-15-6	Alcohols, C6-12	0.85	Mixture

Cas-nr	Substance name	Carbon share	Formula
68606-11-1	Gasoline, straight-run, topping-plant	0.85	Mixture
68783-66-4	Hydrocarbons, C3-6, sweetened	0.85	Mixture
68937-41-7	Phenol, isopropylated, phosphate (3:1)	0.66	C27H24O7P
68938-03-4	Alcohols, C9-iso-, distn. overheads	0.75	C9H20O
68951-72-4	2-Propanol, 1,1'iminobis-, N-tallow alkyl derivs.	0.85	Mixture
68955-28-2	Destillates (petroleum), light steam-cracked, butadien conc.	0.85	Mixture
689-97-4	1-Buten-3-yne	0.92	C4H4
691-37-2	1-Pentene, 4-methyl-	0.86	C6H12
70657-70-4	1-Propanol, 2-methoxy-, acetate	0.55	C6H12O3
71-23-8	1-Propanol	0.60	C3H8O
71-36-3	1-Butanol	0.65	C4H10O
71-41-0	1-Pentanol	0.68	C5H12O
71-43-2	Benzene	0.92	C6H6
71-55-6	Ethane, 1,1,1-trichloro-	0.18	C2H3Cl3
7397-62-8	Acetic acid, hydroxy-, butyl ester	0.55	C6H12O3
7473-98-5	1-Propanone, 2-hydroxy-2-methyl-1-phenyl-	0.73	C10H12O2
74-84-0	Ethane	0.80	C2H6
74-85-1	Ethene	0.86	C2H4
74-86-2	Ethyne	0.92	C2H2
74-87-3	Methane, chloro-	0.24	CH3Cl
74-89-5	Methanamine	0.39	CH5N
74-98-6	Propane	0.82	C3H8
75-00-3	Ethane, chloro-	0.37	C2H5Cl
75-01-4	Ethene, chloro-	0.38	C2H3Cl
75-05-8	Acetonitrile	0.59	C2H3N
75-07-0	Acetaldehyde	0.55	C2H4O
75-08-1	Ethanethiol	0.39	C2H6S
75-09-2	Methane, dichloro-	0.14	CH2Cl2
75-15-0	Carbon disulfide	0.16	CS2
75-21-8	Oxirane	0.55	C2H4O
75-28-5	Propane, 2-methyl-	0.83	C4H10
75-31-0	2-Propanamine	0.61	C3H9N
75-35-4	Ethene, 1,1-dichloro-	0.25	C2H2Cl2
75-52-5	Methane, nitro-	0.20	CH3NO2
75-56-9	Oxirane, methyl-	0.62	C3H6O
75-65-0	2-Propanol, 2-methyl-	0.65	C4H10O
75-77-4	Silane, chlorotrimethyl-	0.33	C3H9ClSi
76-05-1	Acetic acid, trifluoro-	0.21	C2HF3O2

Cas-nr	Substance name	Carbon share	Formula
763-69-9	Propanoic acid, 3-ethoxy-, ethyl ester	0.58	C7H14O3
7658-03-9	1,3-Propanediol, 2-ethyl-2-(methoxymethyl)-	0.57	C7H16O3
770-35-4	2-Propanol, 1-phenoxy-	0.71	C9H12O2
77-73-6	4,7-Methano-1H-indene, 3a,4,7,7a-tetrahydro-	0.91	C10H12
77-99-6	1,3-Propanediol, 2-ethyl-2-(hydroxymethyl)-	0.54	C6H14O3
78-00-2	Plumbane, tetraethyl-	0.30	C8H20Pb
78-08-0	Silane, ethenyltriethoxy-	0.51	C8H18O3Si
78-59-1	2-Cyclohexen-1-one, 3,5,5-trimethyl-	0.78	C9H14O
78-67-1	Propanenitrile, 2,2´-azobis[2-methyl-	0.59	C8H12N4
78-78-4	Butane, 2-methyl-	0.83	C5H12
78-83-1	1-Propanol, 2-methyl-	0.65	C4H10O
78-84-2	Propanal, 2-methyl-	0.67	C4H8O
78-92-2	2-Butanol	0.65	C4H10O
78-93-3	2-Butanone	0.67	C4H8O
79-01-6	Ethene, trichloro-	0.18	C2HCl3
79-09-4	Propanoic acid	0.49	C3H6O2
79-10-7	2-Propenoic acid	0.50	C3H4O2
79-11-8	Acetic acid, chloro-	0.25	C2H3ClO2
79-14-4	Acetic acid, hydroxy-	0.32	C2H4O3
79-20-9	Acetic acid, methyl ester	0.49	C3H6O2
79-33-4	Propanoic acid, 2-hydroxy-, (S)-	0.40	C3H6O3
79-34-5	Ethane, 1,1,2,2-tetrachloro-	0.14	C2H2Cl4
79-41-4	2-Propenoic acid, 2-methyl-	0.56	C4H6O2
79-43-6	Acetic acid, dichloro-	0.19	C2H2Cl2O2
8006-61-9	Gasoline, natural	0.85	Mixture
8006-64-2	Turpentine, oil	0.60	Mixture
8008-20-6	Kerosine	0.85	Mixture
80-15-9	Hydroperoxide, 1-methyl-1-phenylethyl	0.71	C9H12O2
8032-32-4	Ligroine	0.85	Mixture
80-43-3	Peroxide, bis(1-methyl-1-phenylethyl)	0.80	C18H22O2
8052-41-3	Stoddard solvent	0.85	Mixture
80-56-8	Bicyclo[3.1.1]hept-2-ene, 2,6,6-trimethyl-	0.88	C10H16
80-62-6	2-Propenoic acid, 2-methyl-, methyl ester	0.60	C5H8O2
84540-57-8	Propanol, methoxy-, acetat	0.55	C6H12O3
84-66-2	1,2-Benzenedicarboxylic acid, diethyl ester	0.65	C12H14O4
84852-15-3	Phenol, 4-nonyl-, branched	0.85	Mixture
85116-56-9	Naptha (petroleum), catalytic reformed, C8-arom. fraction	0.85	Mixture

Cas-nr	Substance name	Carbon share	Formula
85566-12-7	Alcohols, C8-10	0.75	C8H18O-C10H22O
85586-25-0	Fatty acids, rape-oil, Me esters	0.77	ca C19H36O2
86290-81-5	Gasoline	0.85	Mixture
868-77-9	2-Propenoic acid, 2-methyl, 2-hydroxyethyl ester	0.55	C6H10O3
872-50-4	2-Pyrrolidinone, 1-methyl-	0.61	C5H9NO
87-69-4	Butanedioic acid, 2,3-dihydroxy- [R-(R*,R*)]-	0.32	C4H6O6
9004-70-0	Cellulose, nitrate	0.60	Mixture
9005-90-7	Turpentine	0.60	Mixture
90-12-0	Naphthalene, 1-methyl-	0.93	C11H10
90622-50-7	Alkanes, C4-10-branched and linear	0.85	Mixture
90622-53-0	Alkanes, C12-26-branched and linear	0.85	Mixture
90622-56-3	Alkanes, C7-10-iso-	0.85	Mixture
90622-57-4	Alkanes, C9-12-iso-	0.85	Mixture
90622-58-5	Alkanes, C11-15-iso-	0.85	Mixture
90669-79-7	Paraffins (petroleum), normal C5-20, acid- and clay-treated	0.85	Mixture
91-17-8	Naphthalene, decahydro-	0.87	C10H18
91-57-6	Naphthalene, 2-methyl-	0.93	C11H10
91722-33-7	Tar, wood	0.60	Mixture
91770-15-9	Kerosine (petroleum), sweetened	0.85	Mixture
92045-23-3	Hydrocarbons, C4, steam-cracker distillate	0.85	Mixture
92045-36-8	Kerosine (petroleum), solvent-refined sweetened	0.85	Mixture
92045-37-9	Kerosine (petroleum), straight-run wide-cut	0.85	Mixture
92045-49-3	Naphtha (petroleum), C4-12 butane-alkylate, isooctane-rich	0.85	Mixture
92045-50-6	Naphtha (petroleum), heavy catalytic cracked, sweetened	0.85	Mixture
92045-53-9	Naphtha (petroleum), hydrodesulfurized light, dearomatized	0.85	Mixture
92045-58-4	Naphtha (petroleum), isomerization, C6-fraction	0.85	Mixture
92045-59-5	Naphtha (petroleum), light catalytic cracked sweetened	0.85	Mixture
92062-15-2	Solvent naphtha (petroleum), hydrotreated light naphthenic	0.85	Mixture
924-42-5	2-Propenamide, N-(hydroxymethyl)-	0.48	C4H7NO2
928771-01-1	Alkanes, C10-20-branched and linear	0.85	Mixture
93572-35-1	Hydrocarbons, C7-12, C>9-arom.-rich, reforming heavy fraction	0.85	Mixture
93-58-3	Benzoic acid, methyl ester	0.71	C8H8O2
93763-36-1	Hydrocarbons, C5-7, C6-rich, heat-soaked, steam-cracked ethylene manufg. by-product	0.85	Mixture
93924-07-3	Alkanes, C10-14	0.85	Mixture

Cas-nr	Substance name	Carbon share	Formula
93924-37-9	Hydrocarbons, C7	0.85	Mixture
93924-42-6	Hydrocarbons, C10-14	0.85	Mixture
94-36-0	Peroxide, dibenzoyl	0.69	C14H10O4
95-13-6	1H-Indene	0.93	C9H8
95-47-6	Benzene, 1,2-dimethyl-	0.91	C8H10
95-63-6	Benzene, 1,2,4-trimethyl-	0.90	C9H12
96-29-7	2-Butanone, oxime	0.55	C4H9NO
96-48-0	2(3H)-Furanone, dihydro-	0.56	C4H6O2
96-49-1	1,3-Dioxolan-2-one	0.41	C3H4O3
96733-38-9	Tripropylene glycol, butyl ether	0.63	C13H28O4
97593-01-6	Alkenes, C8-10-branched, C9-rich	0.60	Mixture
97-64-3	Propanoic acid, 2-hydroxy-, ethyl ester	0.51	C5H10O3
97-88-1	2-Propenoic acid, 2-methyl-, butyl ester	0.68	C8H14O2
98-00-0	2-Furanmethanol	0.61	C5H6O2
98-01-1	2-Furancarboxaldehyde	0.63	C5H4O2
98219-64-8	Residues, steam-cracked, thermally-treated	0.85	Mixture
99-99-0	Benzene, 1-methyl-4-nitro-	0.61	C7H7NO2

Appendix II, emission factors

Table II- 1. Country specific emission factors for SNAP codes in NFR 2.D.3.a. Emission factor references given at the end of Appendix II. EFs in italic are interpolated.

	2D3a									
Year	060408ei	060408eii	060408fi	060408fii	060408gi	060408gii	060408hi	060408hii	060408i	060411
1995	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
1996	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
1997	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
1998	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
1999	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2000	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2001	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2002	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2003	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2004	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2005	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2006	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2007	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2008	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2009	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2010	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2011	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2012	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2013	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]
2014	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.275[2]	0.95[1]	0.95[1]

Table II- 2. Country specific emission factors for SNAP codes in NFR 2.D.3.d. Emission factor references given at the end of Appendix II. EFs in italic are interpolated.

	2D3d								
Year	**060101**	**060102**	**060103**	**060104**	**060105**	**060106**	**060107**	**060108**	**060109**
1995	0.95[1]	0.95[1]	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.29[1]	0.95[1]	0.95[1]
1996	*0.92*	*0.92*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.29[1]	*0.93*	0.95[1]
1997	*0.89*	*0.89*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.29[1]	*0.90*	0.95[1]
1998	*0.86*	*0.86*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.29[1]	*0.88*	0.95[1]
1999	*0.83*	*0.83*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.21[3]	*0.86*	0.95[1]
2000	*0.79*	*0.79*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.83*	0.95[1]
2001	*0.76*	*0.76*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.81*	0.95[1]
2002	*0.73*	*0.73*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.78*	0.95[1]
2003	0.70[3]	0.70[3]	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.76*	0.95[1]
2004	*0.68*	*0.68*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.74*	0.95[1]
2005	*0.65*	*0.65*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.71*	0.95[1]
2006	*0.63*	*0.63*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.69*	0.95[1]
2007	*0.61*	*0.61*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.67*	0.95[1]
2008	*0.59*	*0.59*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.64*	0.95[1]
2009	*0.56*	*0.56*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.62*	0.95[1]
2010	*0.54*	*0.54*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.59*	0.95[1]
2011	*0.52*	*0.52*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.57*	0.95[1]
2012	*0.50*	*0.50*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.55*	0.95[1]
2013	*0.47*	*0.47*	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	*0.52*	0.95[1]
2014	0.45[3]	0.45[3]	0.95[1]	0.95[1]	0.25[4]	0.84[3]	0.17[3]	0.50[3]	0.95[1]

Table II- 3. Country specific emission factors for SNAP codes in NFR 2.D.3.e, 2.D.3.f and 2.D.3.h. Emission factor references given at the end of Appendix II. EFs in italic are interpolated.

	2D3e			2D3f	2D3h
Year	060201	060203	060204	060202	060403
1995	0.61[5]	0.61[5]	0.61[5]	0.30[6]	0.65[1]
1996	*0.58*	*0.58*	*0.58*	0.30[6]	*0.64*
1997	*0.55*	*0.55*	*0.55*	0.30[6]	*0.63*
1998	*0.53*	*0.53*	*0.53*	0.30[6]	*0.61*
1999	*0.50*	*0.50*	*0.50*	0.30[6]	*0.60*
2000	0.47[5]	0.47[5]	0.47[5]	0.30[6]	*0.59*
2001	*0.44*	*0.44*	*0.44*	0.30[6]	0.58[1]
2002	*0.41*	*0.41*	*0.41*	0.30[6]	*0.55*
2003	*0.39*	*0.39*	*0.39*	0.30[6]	*0.53*
2004	*0.36*	*0.36*	*0.36*	0.30[6]	*0.51*
2005	0.33[5]	0.33[5]	0.33[5]	0.30[6]	*0.49*
2006	*0.30*	*0.30*	*0.30*	0.30[6]	*0.47*
2007	*0.27*	*0.27*	*0.27*	0.30[6]	*0.45*
2008	*0.25*	*0.25*	*0.25*	0.30[6]	*0.43*
2009	*0.22*	*0.22*	*0.22*	0.30[6]	*0.41*
2010	0.19[5]	0.19[5]	0.19[5]	0.30[6]	*0.39*
2011	0.19[5]	0.19[5]	0.19[5]	0.30[6]	*0.36*
2012	0.19[5]	0.19[5]	0.19[5]	0.30[6]	*0.34*
2013	0.19[5]	0.19[5]	0.19[5]	0.30[6]	*0.32*
2014	0.19[5]	0.19[5]	0.19[5]	0.30[6]	0.30[3]

Table II- 4. Country specific emission factors for SNAP codes in NFR 2.D.3.g. Emission factor references given at the end of Appendix II. EFs in italic are interpolated.

Year	2D3g 060305	060307	060308	060309	060311	060312	060313	060314
1995	0.30[1]	0.004[1]	0.004[1]	0.004[1]	0.004[1]	0.03[3]	0.010[1]	0.50[1]
1996	0.29[1]	*0.003*	*0.003*	*0.003*	*0.003*	0.03[3]	0.010[1]	0.46[1]
1997	0.29[1]	*0.003*	*0.003*	*0.003*	*0.003*	0.03[3]	0.010[1]	0.42[1]
1998	0.28[1]	*0.003*	*0.003*	*0.003*	*0.003*	0.03[3]	0.008[1]	0.38[1]
1999	0.28[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.008[1]	0.33[1]
2000	0.27[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.008[1]	0.29[1]
2001	0.26[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.25[1]
2002	0.26[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2003	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2004	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2005	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2006	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2007	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.004[3]	0.20[1]
2008	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.003[3]	0.20[1]
2009	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.003[3]	0.20[1]
2010	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.003[3]	0.20[1]
2011	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.003[3]	0.20[1]
2012	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.003[3]	0.20[1]
2013	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.002[3]	0.20[1]
2014	0.25[1]	0.003[3]	0.003[3]	0.003[3]	0.003[3]	0.03[3]	0.002[3]	0.20[1]

Table II- 5. Country specific emission factors for SNAP codes in NFR 2.D.3.i. Emission factor references given at the end of Appendix II. EFs in italic are interpolated.

Year	2D3i 060405	060406	060407	060409	060412i	060412ii
1995	0.56[7]	0.64[1]	0.95[1]	0.95[1]	0.95[1]	0.275[2]
1996	0.56[7]	*0.63*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
1997	0.56[7]	*0.62*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
1998	0.56[7]	*0.61*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
1999	0.56[7]	*0.60*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2000	0.56[7]	*0.59*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2001	0.56[7]	0.58[1]	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2002	0.56[7]	*0.55*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2003	0.56[7]	*0.52*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2004	0.56[7]	*0.50*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2005	0.56[7]	*0.47*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2006	0.56[7]	*0.44*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2007	0.56[7]	*0.41*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2008	0.56[7]	*0.39*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2009	0.56[7]	*0.36*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2010	0.56[7]	*0.33*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2011	0.56[7]	*0.30*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2012	0.56[7]	*0.28*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2013	0.56[7]	*0.25*	0.95[1]	0.95[1]	0.95[1]	0.275[2]
2014	0.56[7]	0.22[3]	0.95[1]	0.95[1]	0.95[1]	0.275[2]

[1] Skårman, T., Danielsson, H., Henningsson, E., Östman, M. 2006. Revised Method for Estimating Emissions of NMVOC from Solvent and Other Product Use in Sweden. SMED Report no 75
[2] EMEP/EEA air pollutant emission inventory guidebook - 2013. 2.D.3.a Domestic solvent use including fungicides.
[3] Environmental reports
[4] EMEP/EEA air pollutant emission inventory guidebook - 2013. 2.D.3.d Coating applications. Table 3-20.
[5] EMEP/EEA air pollutant emission inventory guidebook - 2013. 2.D.3.e Degreasing. Table 3-4. Abatement efficiency from the GAINS model.
[6] EMEP/EEA air pollutant emission inventory guidebook - 2013. 2.D.3.f Dry cleaning. Table 3-3.
[7] EMEP/EEA air pollutant emission inventory guidebook - 2013. 2.D.3.i, 2.G Other solvent and product use. Table 3-1.