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Estimating emissions of NMVOC from solvent and other product use

Revised model

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Abstract

This report is the end product of a project revising the Norwegian emission calculations of NMVOCs[1] from the use of solvents and other products. The development of a new emission model started in 2007, and the results will be used for reporting from the year 2008.

According to international emission reporting guidelines, emissions shall be recalculated if new information about emission factors or improved calculation methods is available. The emissions of NMVOC from solvents and other product use were previously calculated using data on import, export and production of solvent-containing substances. The previous solvent balance was developed in 1995, and by the year 2000 the method was considered obsolete. It was thus decided to keep the emission estimates at the year 2000 level until a revised method was developed. A replacement of the solvent balance was due because the assumptions about solvent content and the emission factors were out of date.

The new model uses a new data source, namely the Norwegian Product Register. The data includes information on a substance level of the product type in which the substance enters into and the industrial sector in which the product is used (including private households). Because the data are given on a substance level, no assumptions about solvent content must be made. A list of substances satisfying the NMVOC criteria has been developed as part of the project, and these substances form the basis for the data selection from the Product Register.

The emission of NMVOCs to air is calculated by multiplying the amount consumed of an NMVOC by an emission factor. The consumption is expressed as the sum of production and import, minus export, declared to the Product Register. The emission factor represents the fraction of the substance emitted to air, and takes into account if a substance is incorporated in another product, transformed into a new compound, or handled in some other way (e.g. as waste). The fraction of an NMVOC emitted is dependent both on the type of product used and the industrial sector (including private households) in which it is used. The emission factors are specific for the combination of product type and industrial sector (including private households), and are mainly gathered from two Swedish reports.

The total NMVOC emissions in Norway was 199 000 tonnes in 2007, of which NMVOC emissions from solvent and other product constituted 48 570 tonnes. The use of solvents and other products was thus responsible for about 25 per cent of the total emissions. The lion's share of the emissions from solvents and other product use took place within the NFR[2]/CRF[3] category "Other", which is NMVOC emissions from sources other than paint application, degreasing and dry cleaning and manufacture and processing of chemical products.

The new solvent model makes it possible to study emissions of NMVOC at a detailed level. The substance with the highest emissions in 2007 is ethanol, followed by hydrodesulfurized heavy naphta and ethylene glycol. Emissions were highest within construction, households, and sale, maintenance and repair of motor vehicles and motorcycles and retail sale of automotive fuel. The product types leading to the largest emissions of NMVOC were biocides, cleaning agents and degreasers, paint and varnish, and solvents.

International reporting requires the time series of NMOVC emissions to be consistent from 1989. The Product Register data were only deemed of sufficient

[1] Non-Methane Volatile Organic Compounds

[2] Reporting format in which emissions are reported to the Convention on Long-Range Transboundary Air Pollution (Gothenburg protocol)

[3] Reporting format in which emissions are reported to the UNFCCC according to the Kyoto protocol

quality from the year 2005, however, and the time series from the previous solvent balance was thus adjusted in order to obtain as much consistency as possible in the time series. This resulted in an elevation of emission estimates of between 3 500 to 5 500 tonnes per year for the years 1989 to 2004.

Conclusion

The new calculation method for emissions of NMVOC from solvents and other product use covers a wide range of substances and a wide range of industrial sectors and product types at a much more detailed level than the previous solvent balance. The coverage is deemed to be better for the new than for the previous model, and sufficient for reporting requirements. In addition, the new model makes no assumptions about solvent content in products, as the calculations are based on amounts of the substances deemed to be NMVOC. The new model is thus more accurate than the previous model.

Acknowledgements: This work was carried out in cooperation with Mette Follestad (the Norwegian Product Register), Jan Kraft (the Norwegian Product Register) and Kathrine Loe Hansen (Statistics Norway). The uncertainty analysis was performed by Marie Lillehammer (Statistics Norway).

The project received financial support from the Norwegian Pollution Control Authority (SFT). Eilev Gjerald and Hans Kolshus at the Norwegian Pollution Control Authority made important consultative contributions during the work process.

Sammendrag

Denne rapporten er sluttproduktet fra et prosjekt som hadde som mål å revidere beregningene av utslipp av NMVOC[4] fra bruk av løsemidler og andre produkter. Utviklingen av den nye modellen startet i 2007, og resultatene vil bli brukt i rapportering fra og med 2008.

Ifølge internasjonale retningslinjer for rapportering av utslipp skal utslippsestimatene rekalkuleres dersom man får ny informasjon om utslippsfaktorer eller hvis bedre beregningsmetoder foreligger. Utslippene av NMVOC fra bruk av løsemidler og andre produkter ble tidligere beregnet ved hjelp av import-, eksport- og produksjonsdata for løsemiddelholdige produkter. Den forrige løsemiddelbalansen ble utviklet i 1995, og i år 2000 ble metoden ansett for å være utdatert. Det ble derfor besluttet å holde utslippsestimatene på 2000-nivå inntil revidert beregningsmodell var på plass. En utskifting av løsemiddelbalansen var nødvendig fordi antagelsene om løsemiddelinnholdet i produkter og utslippsfaktorene ikke lenger var av tilstrekkelig god kvalitet.

Den nye modellen henter data fra en ny datakilde; Produktregisteret. Dataene inneholder informasjon på stoffnivå om produkttypen hvor stoffet inngår og den industrielle sektoren (inkludert private husholdninger) hvor produktet blir brukt. Fordi informasjonen blir gitt på stoffnivå, er det ikke nødvendig med antagelser angående løsemiddelinnhold i produkter. En liste over stoffer som tilfredsstiller kriteriene for NMVOC har blitt utviklet som en del av prosjektet, og disse stoffene danner basisen for utvelgelsen av aktuelle stoffer i Produktregisteret.

Utslipp av NMVOC til luft er beregnet ved å multiplisere forbruksmengden av et stoff med en utslippsfaktor. Stoffmengden brukt er summen av produksjon og import minus eksport, i henhold til deklarasjoner til Produktregisteret. Utslippsfaktoren er den andelen av stoffmengden som slippes ut, og tar høyde for at en andel kan inngå i nye produkter, omdannes til andre stoffer eller håndteres på en måte som forhindrer utslipp (f.eks. avfallshåndtering). Andelen av et stoff som slippes ut antas å avhenge av både typen produkt stoffet inngår i og i hvilken næring (private husholdninger inkludert) produktet brukes. Utslippsfaktorene er både produkt- og næringsspesifikke, og er hovedsakelig hentet fra to svenske studier.

De totale utslippene av NMVOC i Norge i 2007 ble beregnet til å være 199 000 tonn, hvorav utslippene av NMVOC fra løsemidler og andre produkter stod for 48 570 tonn. Utslipp fra løsemidler og andre produkter står dermed for om lag 25 prosent av de total NMVOC-utslippene. Brorparten av utslippene fra bruk av løsemidler og andre produkter plasseres i NFR[5]/CRF[6]-kategorien ”Andre”, som er NMVOC-utslipp fra andre kilder enn bruk av maling, avfetting og renserivirksomhet og fremstilling og foredling av kjemiske produkter.

Den nye løsemiddelmodellen gjør det mulig å studere utslippene av NMVOC på et detaljert nivå. Etanol var det stoffet som hadde de høyeste utslippene i 2007, fulgt av nafta (tung, avsvovlet) og etylenglykol. Næringene som stod for de største utslippene var bygge- og anleggsvirksomhet, private husholdninger og allmennheten, vedlikehold og reparasjon av motorkjøretøyer og motorsykler og detaljhandel av drivstoff. Produkttypene med de største utslippene av NMVOC var biocider, rengjøringsmidler og avfettingsmidler, maling og lakk og løsemidler.

[4] Flyktige organiske forbindelser untatt metan

[5] Rapporteringsformat benyttet til rapportering til konvensjonen for langtransporterte luftforurensninger (Gøteborgprotokollen)

[6] Rapporteringsformat benyttet til rapportering FN i forbindelse med Kyotoavtalen

Internasjonale rapporteringsretningslinjer krever at tidsserien for utslipp av NMVOC er konsistent fra 1989. Data fra Produktregisteret ble funnet å ha tilstrekkelig kvalitet fra 2005. Tidsserien fra den foregående løsemiddelmodellen ble justert for å oppnå så mye konsistens som mulig i tidsserien. Dette førte til en oppjustering av tidsserien på mellom 3 500 og 5 500 tonn per år i perioden 1989 til 2004.

Konklusjon

Den nye beregningsmetoden for utslipp av NMVOC fra bruk av løsemidler og andre produkter dekker et vidt spekter av stoffer, industrielle sektorer og produkttyper på et mer detaljert nivå enn i den foregående metoden. Dekningsgraden er vurdert til å være bedre for den nye enn for den foregående modellen, og tilstrekkelig for rapporteringskravene. I tillegg bygger den nye modellen ikke på antagelser om løsemiddelinnhold i produkter fordi beregningen gjøres direkte på deklarerte mengder av stoffer som regnes som NMVOC. Dette gjør den nye modellen mer sikker enn den foregående modellen.

Takk til: Dette arbeidet ble gjennomført i samarbeid med Mette Follestad (Produktregisteret), Jan Kraft (Produktregisteret) og Kathrine Loe Hansen (Statistisk sentralbyrå). Usikkerhetsanalysen ble utført av Marie Lillehammer (Statistisk sentralbyrå).

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Contents

1. Introduction

1.1. Environmental effects of NMVOC

While ozone in the stratosphere protects life on Earth from detrimental ultraviolet radiation, ozone at ground level can be harmful to humans, animals and plants. Ground-level ozone can cause respiratory problems, damage vegetation and weaken constructions. At ground level, ozone is formed when nitrogen oxides (NO_x) or volatile organic components (VOC) are exposed to sunlight. Although concentrations of ground-level ozone are lower in Norway than in most parts of Europe, pollution episodes where ozone concentrations exceed recommended limit values occur every year, usually in spring and early summer. Furthermore, as carbon dioxide (CO_2) is formed when VOC break down in the atmosphere, VOC emissions are considered to be indirect emissions of the greenhouse gas CO_2.

1.2. Solvents and reporting requirements

The use of solvents is an important source of emissions of non-methane volatile organic components (NMVOC). Solvent use contributes to around 25 per cent of the anthropogenic NMVOC emissions in Europe (European Environment Agency 2007). Solvents include cleaning substances used for e.g. metal degreasing, dry cleaning, printing, ingredients of solvent-containing products like paints, thinners and lacquers, pesticides, glues and adhesives, as well as raw materials for products not containing solvents, such as rubber and plastics.

Estimates on emissions of NMVOC from solvent use are included in the national emission inventories that are prepared and submitted to the secretariat of the UNECE-Convention on Long-Range, Transboundary Air Pollution (LRTAP), in order to fulfil national obligations under the Gothenburg-protocol. In addition, NMVOC emissions are included in the National Emission Inventory for greenhouse gas emissions, set by the United Nations Framework Convention on Climate Change (UNFCCC). In the future, information on NMVOC emissions from diffuse sources will also be included in the reporting to UNECE-Aarhus Convention Protocol on Pollutant Release and Transfer Registers (PRTR) (Economic Commission for Europe 2007). Moreover, there is a desire to make emission inventories comparable to results from the GAINS model developed under the Atmospheric Pollution and Economic Development program at The International Institute for Applied Systems Analysis (IIASA). Reporting follows chapter 6 in the EMEP/CORINAIR Emission Inventory Guidebook 2007 (European Environment Agency 2007), and the revised 2006 Guidelines for National Greenhouse gas Inventories (IPCC 2006a). According to the EMEP/CORINAIR Guidebook, solvents that are inventoried must represent at least 90 % of the NMVOC emissions. NMVOC emissions from solvent use must be allocated to several different source categories (see section 3.3).

1.3. Previous solvent model

A model of NMVOC emissions from solvent use was first developed in 1995 (Rypdal 1995). In this model, emissions were calculated using data on solvent-containing products obtained from trade, manufacture and waste statistics. The disadvantage of this model is that its accuracy depends on the validity of certain assumptions that are known to vary over time. Most important are the assumptions regarding the solvent content of products that constitute the input data, and that the emission factors only depend on type of product, not industrial sector of use. Furthermore, allocation to source categories had to be made using surrogate data. Thus, by 2000 some principal model parameters were considered to be outdated, and so updating of the input data for the mass balance was discontinued. Since then, the need for a revised model has become an increasingly dire necessity.

In addition, calculations were previously done using Excel spreadsheets, which rendered the production process unnecessarily comprehensive and sensitive to manual errors. Recalculations following new information were especially difficult and increasingly so for every year added to the time series.

1.4. Objectives of this project

This report is the end product of a revision of the calculations of NMVOC emissions from all solvent source categories in Norway. The main objectives of this project have been to find the best available data source, improve emission factors and construct a model for emission calculations. While the level of detail of the previous model was on the CRF source level, it has been a goal for this project to fascilitate emission reporting on the more detailed NFR source level.

The model was to have the following attributes:

- Be complete, i.e. fulfilling the requirements of the international guidelines
- Register the effects of new legislations and other emissions reducing efforts
- Rely on a minimum of assumptions (to maximize robustness)
- Be easily updated annually, with a SAS-based technical solution
- Give detailed results, comparable to results form e.g. GAINS
- Be transparent and consistent

The use of solvents and other products may be considered a minor source of emissions in Norway. Even so, considerable effort has been put into improving the emission estimates from this source. The justification for this is that the overall Norwegian emission inventory to a large extent is built on emissions from many small sources, and the quality of the overall inventory is enhanced by improving each of these sources.

1.5. Structure of this report

An overview of some of the abbreviations and definitions used in the report is given in chapter 2, followed by a chapter describing the new model, emission factors and uncertainties (chapter 3). Chapter 4 contains information regarding the substances included in this study, the activity data used for estimating the emissions and the recalculation of the time series from the previous model. The resulting time series on use and emission patterns of NMVOC from the use of solvents and other products are presented in chapter 5. Chapter 6 discusses the results, with comparisons to other countries using a similar emission model for solvent use. Chapter 7 focuses on areas for potential methodological improvement.

2. Abbreviations and definitions

NMVOC **N**on-**m**ethane **v**olatile **o**rganic **c**ompound. The term "volatile organic compound" (VOC) refers to any organic compound having a vapour pressure of 0.01 kPa or more at 293.15 degrees K, or having a corresponding volatility under the particular conditions of use (European Commission 1999).

GAINS The **G**reenhouse Gas and **A**ir Pollution **In**teractions and **S**ynergies (GAINS) model is an analytic tool for assessing co-benefits reduction strategies from air pollution and greenhouse gas sources in Europe.

CAS number An identification number for substances described in the literature, assigned by **C**hemical **A**bstract **S**ervices, a division of the American Chemical Society (American Chemical Society 2007). Most CAS numbers refer to individual substances, but some are mixtures, such as petroleum solvents, e.g. naphtha.

UCN **U**se **C**ode **N**ordic. The Nordic Product Registers' classification system for products (Product Register 2007).

NACE International nomenclature system for industrial classification (industrial sectors). Codes according to Statistics Norway *Standard Industrial Classification* (Statistics Norway 2002b), based on EU's international industrial standard NACE Rev.1.1., 2002 update.

CRF **C**ommon **R**eporting **F**ormat. Category classification in which emissions should be reported under the United Nations Framework Convention on Climate Change (UNFCCC) according to the Kyoto protocol.

NFR **N**omenclature **F**or **R**eporting. Category classification in which emissions should be reported under the convention on Long Range Transboundary Air Pollution (LRTAP) according to the Gothenburg protocol.

3. Methodology

3.1. Overview

The general model is a simplified version of the detailed methodology described in chapter 6 of the EMEP/CORINAIR Guidebook 2007 (European Environment Agency 2007). It represents a mass balance *per substance*, where emissions are calculated by multiplying relevant activity data with an emission factor, according to the equation:

consumption = production + import - export
emission = consumption x emission factor (fraction emitted)

total emission = sum of all emissions

When used in the simplest form, all activities that can lead to or prevent emissions, i.e. waste management, are included in the one emission factor. The general model can be modified so as to integrate various pieces of information on the life cycle of different products. For some products we might have data on the fraction converted into other chemical compounds or the fraction destroyed during waste treatment. This can be expressed through variations of the simple equation, e.g.:

emission = consumption x (1 - (factor1 + factor2 + factor3))

where *factor1* is the fraction converted to other chemical compounds, *factor2* is the fraction that becomes part of a new product (without being converted) and *factor3* is the fraction destroyed during waste management.

Some emissions generated by the use of declared products may be delayed, relative to the time of declaration. Firstly, the data from the Product Register contain no information on whether products are used the year of registration or stored for later use (so-called hold up). Therefore it is assumed that *all products are used the same year as they are registered*. Secondly, the possibility that substances may accumulate in long-lived products is not taken into account. In other words, it is presupposed that *all emissions generated by the use of a given product during its lifetime take place in the same year as the product is declared* to the Product Register. In sum, this leads to emission estimates that do not fully reflect the actual emissions taking place in a given year. Emissions that in real life are spread out over several years all appear in the emission estimate for the year of registration. However, this systematic overestimation for a given year probably more or less compensates for emissions due to previously accumulated amounts not being included in the estimate figures.

Despite data and model limitations, it is believed that the resulting emission estimates are a relatively good indicator of the level and trend in the emissions of NMVOC caused by products use.

3.2. Emission factors

Emission factors are specific for combinations of product type and industrial sector. The source of the emission factor values for volatile organic compounds is the Swedish model for estimating NMVOC emissions from solvent and other product use (Skårman *et al.* 2006). During several studies, Sweden has developed emission factors that take into account different application techniques, abating measures and alternative pathways of release (e.g. waste or water). These country-specific emission factors apply to 12 different industries or activities that correspond to sub-divisions of the four major emission source categories for solvents used in international reporting of air pollution (European Environment Agency 2007).

It was deemed that the factors developed for Sweden are representative for Norwegian conditions, as we at present have no reasons to believe that product types, patterns of use or abatement measures differ significantly between the two countries. However, a few adjustments had to be made:

1. In the Swedish model, a series of industrial sectors are excluded from the calculations, in order to avoid double counting. As fewer industrial sectors report emissions of NMVOC to the Norwegian inventory, fewer exclusions from the solvent model is necessary. In fact, it is desirable to include as many unreported industrial sectors as possible. It was deemed that the emission factors given for industries included in the Swedish model were representative for similar industries included in the Norwegian model (cf. Appendix A8).
2. The emission factor for ensilage means was set specifically based on expert judgment, as the emission factor given in the Swedish model seemed unsuitable for describing the usage of ensilage in Norway (cf. Appendix A8).
3. The emission factor for anti-freezing agents from the Swedish model was only used for commercial land, water and air transport (NACE 60-62) (value of 0.1, cf. Appendix A8). The radiator in a car is a closed system. However, when anti-freezing agent must be refilled in a private car, this entails that some of it has evaporated or otherwise been emitted. Thus, the emission factor for anti-freezing agents was set higher industrial sectors and private households in the Norwegian model.
4. For each emission source category, two emission factors are applied, one for NMVOCs used as raw materials and one for other uses. Emission factors for raw materials are generally low, since most of the substance will be converted or end up in the product with only small emissions during this process. Products with a high content of the substance will themselves be declared to the product register, thus being included in the activity data and in most cases being assigned a higher emission factor. However, there are two problems concerning the identification of raw material:
   i. Some products are declared with a product code for raw material, although they are not used as raw material. This problem is solved by combining the product type codes for raw materials with a list of VOC that are considered "true" raw materials (Fischer *et al.* 2005) (cf. Appendix A4). Hence, the emission factors for raw materials are only applied to products declared as raw materials when in combination with these substances.
   ii. Some products that are used as raw materials are declared as other product types. This second problem was solved by applying the emission factor for raw materials to other product types assumed to be used as raw materials in the industrial sectors "Manufacture of chemicals and chemical products" (NACE 24) and "Manufacture of rubber and plastic products" (NACE 25).

In accordance with the Swedish model, emission factors were set to zero for a few products that are deemed to be completely converted through combustion processes, such as EP-additives (product type E20100), soldering agents (product type group L15), and welding auxiliaries (product type group S75). Quantities that have not been registered to industrial sector or product type are given emission factor 0.95 (maximum). Emission factors may change over time, and such changes may be included in this model. However, all emission factors are constant for the 2005 to 2007 period.

A collaboration project between the Nordic countries, sponsored by the Nordic Council of Ministers, took place in 2008 in order to compare and possibly improve the emission factors and source allocations of emissions from solvent use in the Nordic countries (Fauser *et al.* In prep). This project included a discussion about allocation, and led to improvements in some emission factors in the Norwegian emission model.

The emission factor matrix is designed so that information on individual substances can be integrated. i.e. that factors can be made product, industrial sector and substance specific. For a summary of the industrial sector and product specific emission factors, see Appendix A8.

3.3. Source allocation

NMVOC emissions are allocated to eleven different source categories (see Appendix A5 and A6), according to the reporting requirements under LRTAP (NFR codes with extentions). These categories aggregate to the four sources for which emissions must be reported under UNFCCC (CRF 3A-D). The NFR and CRF reporting format is coordinated (see Appendix A5), such that the NMVOC emissions reported to the aggregated NFR (3A-D) are the same as reported to CRF 3A-D. The extentions in the CRF and NFR reporting formats are however somewhat diverging, but this has no practical implications for the reporting of NMVOC emissions from solvents and other product use, as the CRF 3A-D has no extentions.

The model also includes an opportunity for the Norwegian Pollution Control Authority to study the emissions on the level of the source definitions given in the GAINS model. However, due to rules of confidentiality, results can generally not be published for all GAINS source codes.

The matrix of the product and industrial sector specific emission factors was used as a basis for the source allocation matrix. The product and industrial sector code combinations were compared to the source descriptions of the GAINS model given in the Interim report from 2000 (Klimont *et al.* 2000) and the source allocation of the Swedish model. A few differences exist between the Norwegian and the Swedish model, in most cases equivalent to the adjustments to the emission factor matrix.

In order to avoid double counting, substance quantities that cause NMVOC emissions, and which are reported elsewhere, are excluded from the source allocation of emissions. These quantities were identified by industrial sector and product code. It was assumed that only emissions due to the use of these specified products are reported in other source categories. Emissions generated from the use of other products were not excluded. The exclusions are given in Appendix A7.

Note that quantities that have not been assigned a product type are allocated to source category 3D iv. Quantities that have not been registered to an industrial sector are allocated to source category 3A iii for all paints and varnishes and 3D iv for all other product types.

3.4. Model completeness

The model estimates NMVOC emissions generated by the use of products that are subject to the duty of declaration in all industrial sectors as well as private households. Manufacture where the selected substances are used as raw materials are included. However, emissions during primary production of the substances are not included in this model, as these are not covered by the Product Register data.

Some manufacture using NMVOCs as raw materials may produce NMVOC-containing products that are not subject to the duty of declaration. In such cases emissions from the resulting products can be included by increasing the emission factor used on the manufacturing process or by using side models to produce supplementary time series.

Double counting is potentially a problem in any account following the path of a product from production to disposal. For NMVOC, there are however potentially emissions in any part of the life cycle. This means that emissions during production

do not contradict emissions during later life stages, and double counting of emissions does not pose a problem. However, emissions from some products may be reported in other parts of the Norwegian inventory (e.g. point source emissions and emissions from the oil industry), and these potential sources of double counting must be avoided, and are dealt with in this model.

3.5. Methods in other countries

By deciding to use data per substance instead per solvent-containing product, the Norwegian model for NMVOC emissions from the use of solvents is similar to the models used by Sweden, Germany and the UK. This facilitates between-country comparison of both model and the resulting emission estimates.

3.6. Analogy to statistics on use and emissions of hazardous substances

The NMVOC emissions are estimated in concert with calculations of use and emissions of hazardous substances (Kittilsen & Hansen 2008). The methodology and the source of activity data are the same for the two models, and some scale advantages are obtained by these merged calculations. In addition, there is some overlap in emission factors for the two statistics, and improvements of emission factors for one of the statistics may lead to improved emission factors for the other. However, the selection of substances is only partially overlapping, and thus only some of the revisions of activity data and emission factors are relevant for both statistics.

3.7. Conversion to CO_2

According to UNFCCC Reporting Guidelines (IPCC 2006b), indirect emissions of CO_2 from atmospheric oxidation of emitted NMVOC are to be included in the national emission inventory. The average amount of carbon in NMVOC is assumed to be 82 per cent. This leads to an emission factor for indirect CO_2 release of 3 kg CO_2/kg NMVOC (0.82*44/12 = per cent carbon in NMVOC*molecular weight [carbon dioxide]/atomic weight [carbon]).

Not all NMVOC are of fossil origin, e.g. some are the products of wood conversion. However, an attempt to exclude the substances of non-fossil origin has not been made in this project (section 7.1.7).

3.8. Technical solution

The process of estimating emissions of substances employs both Excel and the SAS system software (SAS Institue Inc. 1999a, b). Data from the Product Register are provided once a year as flat files that are converted directly into a SAS data matrix. The emission factor matrix and the source allocation matrix are revised in Excel and transferred to SAS. Generation of the complete activity dataset, data revision, emission estimation and source allocation and production of result tables are all done using SAS.

3.9. Uncertainties

When an uncertainty analysis was performed for LRTAP pollutants by Statistics Norway in 2000 (Rypdal & Zhang 2000), the source category “Solvent use” was one of the highest ranked NMVOC sources with regard to uncertainty. The amount of raw material used and the fraction emitted was pointed out as contributing most to the uncertainty of the emission figures.

A comparison to the previous solvent balance provides an indication of the relative uncertainty. Firstly, the amount of raw materials used and thus extracted from the calculations was more uncertain in the previous solvent balance, since data for the new model are provided annually from the Product Register, while the previous

model used data from one survey. Secondly, the emission factor applied in the previous model included assumptions on the solvent content of the products included in the mass balance. In the new model (except for the cosmetics side model), no assumptions need to be made on solvent content, since calculations are performed on a substance level.

A mass balance model identical to the previous Norwegian model is the reference for the uncertainty estimate in the EMEP/CORINAIR Guidebook (European Environment Agency 2006). According to the Guidebook, overall uncertainty per capita for the detailed methodology is estimated to be factor 1.25 to 2, depending on completeness and quality of the mass balance data and the quality of production, import, export, disposal, destruction and hold-up data.

As described in sections 4.3.1 and 3.2, both errors in activity data and emission factors contribute to uncertainty in the estimates. For the activity data, the simplified declarations and the negative figures due to exports lead to known overestimations, for which the uncertainty to a large extent is known. The negative figures due to export is not taken into account in this uncertainty analysis; these constitute a very small fraction of the activity data (see section 4.4.8).

A more elaborate problem in calculations of uncertainty is estimating the level of omissions in declaration for products where the duty of declaration does apply. In addition, while declarations with large, incorrect consumption figures are routinely identified during the QA/QC procedure, faulty declarations with small consumption figures will only occasionally be discovered. There is however no reason to believe that the Product Register data are more uncertain than the data source used in the previous model (statistics on production and external trade), as similar QA/QC routines are used for these statistics. The emission factors are more detailed in the new NMVOC model than in the previous model, as this model can take into account that emissions are different in different industrial sectors and products, even when the substance is the same. However, for this to be correct, a thorough evaluation of each area of use is desirable, but not possible within a limited time frame. Thus, the emission factor is set with general evaluations, which leads to uncertainty.

The calculations of NMVOC emissions are performed in concert with calculations of emissions of dangerous substances (Kittilsen & Hansen 2008). An uncertainty analysis was performed for both these analyses for the years 2005 to 2007. The uncertainty (defined as two standard deviations) is calculated for the main data source (i.e. the Product Register data), and uncertainty in the emissions from the cosmetics side model and from point sources is not included. The uncertainty is dependent both on uncertainty in emission factors and in activity data.

3.9.1. Uncertainty in emission factors

The emission factors are gathered from several different sources, with different level of accuracy (see section 3.2). The uncertainties in emission factors depend on how detailed assessment has been undertaken when the emission factor was established. Some emission factors are deemed to be unbiased, while others are set close to the expected maximum of the range of probable emission factors. This, together with the fact that the parameter range is limited, gives us a non-symmetrical confidence interval around some of the emission factors. For each emission factor we thus have two uncertainties; one negative (n) and one positive (p). These are aggregated separately, and the aggregated uncertainty is thus not necessarily symmetrical. The aggregated uncertainties are calculated using standard formulas.

Most emission factors were gathered from Skårman *et al.* (2006). An uncertainty of 20 per cent was stated in this source, and this is assumed in this uncertainty analysis as well. The uncertainty is thus calculated as emission factor*0.2 for both

n and *p*. The confidence intervals are truncated where they would exceed the limit value 1. For the substances assumed to be raw materials, only small amounts are emitted, and the uncertainty in emission factor is assumed to be very low. This also holds for emission factors set specifically for a substance or a combination of industry and product type.

3.9.2. Uncertainty in activity data

The errors in activity data are not directly quantifiable. Any undercoverage in the Product Register is not taken into account. Skårman *et al.* (2006) found that the activity data from the Swedish Product register had an uncertainty of about 15 per cent. The Norwegian Product Register is deemed to be comparable to the Swedish, and thus the uncertainty in the activity data is set to be 15 per cent. For some products, simplified declarations (cf. section 4.4.7) give an indication of maximum and minimum possible amounts. In these cases, the maximum amount is used, and the positive uncertainty is set to 15 per cent as for other activity data, while the negative uncertainty is assumed to be the interval between maximum and minimum amount. All activity data are set to zero if negative.

3.9.3. Aggregated uncertainty in level

The variance of the activity data and emission factors is combined by the formula

$$Var(U) = Var(f) \times E(A)^2 + Var(A) \times E(f)^2 + Var(f) \times Var(A)$$

where U is the emissions, f is the emission factor and A is the activity data. It is assumed that the emission factors and activity data are independent of one another. The uncertainty is calculated to

$$us = 2 \times \sqrt{Var(U)}$$

Both variance and uncertainty is calculated separately for negative and positive variance/uncertainty, as many of the confidence intervals are one sided or biased. The variance of the total emission is calculated as the sum of the variances of all the substances. It is presupposed that an emission from one substance is independent of the emissions from the other substances.

3.9.4. Aggregated uncertainty of trend

There are no changes in emission factors between years in the 2005-2007 period. Variation in emissions is thus a result of changes in activity data within each combination of industrial sector and product type. The uncertainty of the difference between years is then connected to the uncertainty in the variance in activity:

$$Var(f(A_2 - A_1)) = f^2(Var(A_2)) + f^2(Var(A_1))$$

The variance of the trend is calculated for each substance and summed in the same manner as for the uncertainty in level.

4. Activity data

4.1. Overview

The Norwegian Product Register was chosen as the primary data source. The Product Register is the Norwegian government's central register on chemical products that are subject to duty of declaration[7] and labelling, such as paint, adhesives and cleaning products (Kraft & Follestad 2007). The Product Register was considered to be a data source that could easily provide activity data of relatively high quality, with much appurtenant information and fairly good coverage of emission sources.

4.2. Substance list

Although reporting requirements refer to the term "solvents", no official definition of solvents exists. Furthermore, solvents cannot be easily identified in the product codes of the Product Register. Since the aim of the LRTAP is to reduce the emissions of NMVOC, and data from the Product Register can be extracted for individual substances, the data selection was based on a substance list containing as many NMVOC not reported elsewhere in the Norwegian inventory as possible.

The Product Register data themselves could not be used for compilation of such a list, as these data contain no information on physical or chemical properties of the registered substances. Therefore, the substance list used in the Swedish NMVOC inventory (Skårman *et al.* 2006) was used as a basis. This substance list is based on the definition stated in the UNECE Guidelines[8].

However, the Swedish list is limited to the substances found in the Swedish Product register. As Norwegian industry differs somewhat from the industry in Sweden, due to the importance of the oil industry, the substance list was supplemented by NMVOC reported in the UK's National Atmospheric Emissions Inventory (NAEI) (AEA Energy and Environment 2007). However, not all NMVOC on the NAEI list are supplied with a CAS number. Hence, the supplement from NAEI was limited to the substances with given CAS numbers.

The resulting list was comprised by 678 substances. Of these, 355 were found in the Norwegian Product Register for one or more years in the period 2005-2007 (Appendix A1). Creosote was not defined as a NMVOC and is therefore not included. In addition, five substances were found to be hydrofluorocarbons (HFCs) for which emissions are reported in other parts of the emissions inventory (CRF 2F).

Although some substances on the NAEI list are not included in our data selection, the coverage was considered to be sufficient in relation to the reporting requirements.

4.3. Product Register data

The Product Control Act (Miljøverndepartementet 1976), the Working Environment Act (Arbeids- og inkluderingsdepartementet 2005) and the Fire Prevention Act (Justis- og politidepartementet 2002) form the basis for the central regulations on classification and labelling of dangerous chemicals. Additional rules for declarations to the Norwegian Product Register are stipulated in the Act on Declaration and labelling of microbiological products (Miljøverndepartementet 1998). Any person placing dangerous chemicals on the Norwegian market for

[7] Cosmetics and health care products are examples of products not subject to the duty of declaration.

[8] "Volatile compound (VOC) shall mean any organic compound having at 293.15 degrees K a vapor pressure of 0.01 kPa or more, or having a corresponding volatility under the particular conditions of use."

professional or private use has duties pursuant to these regulations. The duty of declaration applies annually to import, export and manufacturing. The only exception is when the amount of a given product placed on the market by a given importer/producer is less than 100 kg per year.

Around 25 000 declarations of products are updated annually, of which 15 000 are obliged to report according to regulations (Kraft & Follestad 2007). These 15 000 mandatory declarations form the basis for these analyses. One declaration can include several closely comparable products belonging to the same product series. Furthermore, the same product may be declared more than once if imported by several importers (rarely more than three). Thus, 15 000 declarations correspond to about 40 000 products being declared. A total of 3 000-4 000 declarations are omitted each year, as products leave the market. Nevertheless, the total number of declarations increases by about 500 every year, indicating an increasing number of products on the market and/or reflecting changes in the regulations. In addition, some declarations are submitted to the Product Register even though the products are not under the duty of declaration.

When a product is declared to the Product Register, information about the registrant and the product must be reported. Most importantly, the chemical composition and the appurtenant volume of individual components are disclosed to the Product Register. Statistics Norway is authorised to use the net quantity of import, export and manufacture of individual components, given by CAS number (classification by Chemical Abstract Services (American Chemical Society 2007)).

The appurtenant information includes:

- Intended use/type of product, given by a code for product type (UCN; (Product Register 2007))
- Area of use, given by industrial sector to which the product is sold (following standard industrial classification – NACE; (Statistics Norway 2002)), including private households (using specific Product Register codes;(Product Register 2007))
- Number of declarations

The information pertained in the data from the Product Register makes it possible to present results on a substance level, distributed over product types, industrial sectors or a combination of both. As a consequence, the identification of specific substances, products or industrial sectors that have a major influence on the emissions is greatly facilitated.

NACE codes and UCN codes are listed in Appendix A2 and A3, respectively.

4.3.1. Data completeness

The duty of declaration to the Product Register does not apply to all solvent-containing products. Some product groups are not covered by the regulations, while other product groups are covered only when the solvent content is above a certain level. The basis for the duty of declaration is that the product is labelled according to the Act on classification, labelling etc. of dangerous chemicals (Arbeids- og inkluderingsdepartementet & Miljøverndepartementet 2002), and the weight percentage of the substances in the product determines wether the product is to be labelled or not. Unless these solvent-containing products have been declared due to regulations concerning other ingredients than the solvent, these NMVOC quantities are not included in the activity data. NMVOC emissions from such products can be estimated using manufacturing statistics and external trade statistics.

Using an average solvent content as well as emissions factors, emissions can be calculated (i.e. the method used in the previous solvent balance). For two product groups such estimates were calculated, in order to check the completeness of the

Product Register data and, if necessary, supplement the emission estimates based on the primary data source:

1. Cosmetics are not subject to the duty of declaration, and may contain considerable amounts of NMVOCs. Estimates obtained as described above revealed that such products constitute a relatively large emission source. Thus, a supplementary time series of NMVOC emissions from cosmetics was produced (cf. section 4.7.2).
2. VOC levels in paint and varnish are regulated through the Product Control act. For water based paints, limits are set from 50 to150 grams per litre, depending on paint type (Miljøverndepartementet 2004). Water based paint can thus contain some organic solvent, but the solvent content is below the limit for the duty of declaration and labelling to apply. Consumption volumes of water-based paints are so significant that these products were suspected to constitute a considerable source of NMVOC emissions. However, the solvent content of water based paint from the major paint producer in Norway is far below this limit. Based on mean solvent contents declared on technical data sheets from a range of water based paints, emissions from this source were considered negligible, compared to the estimates for other product groups included in the Product Register data.

It is considered unlikely that other products containing only small amounts of solvents, i.e. not subject to the duty of declaration, and at the same time not covered by regulations on other ingredients, represent a large source of NMVOC emissions. Still it is important to be aware of this limitation of the data source, especially if the use of solvent-containing products not liable for declaration increases substantially. In such cases, these products can be included by using data from the trade and manufacture statistics.

Changes to the regulations for classification and labelling will lead to changes in the coverage of the Product Register. For instance, the duty to label solvent-containing products was abolished in 2005. The effect of this specific regulatory change on the coverage of the Product Register is believed to be limited, as most of the products in question are subject to the duty of labelling for other reasons, such as flammability (J. Kraft, Product Register, *pers. comm*. 2008).

Some of products not covered by the duty of declaration are in fact declared to the Product Register voluntarily. In order to avoid random effects known to be related to voluntary declarations, most of these declarations, representing approximately 10 000 products, were excluded from this study. Including the voluntary declarations would introduce more variability without adding considerable quantities, and these quantities are omitted.

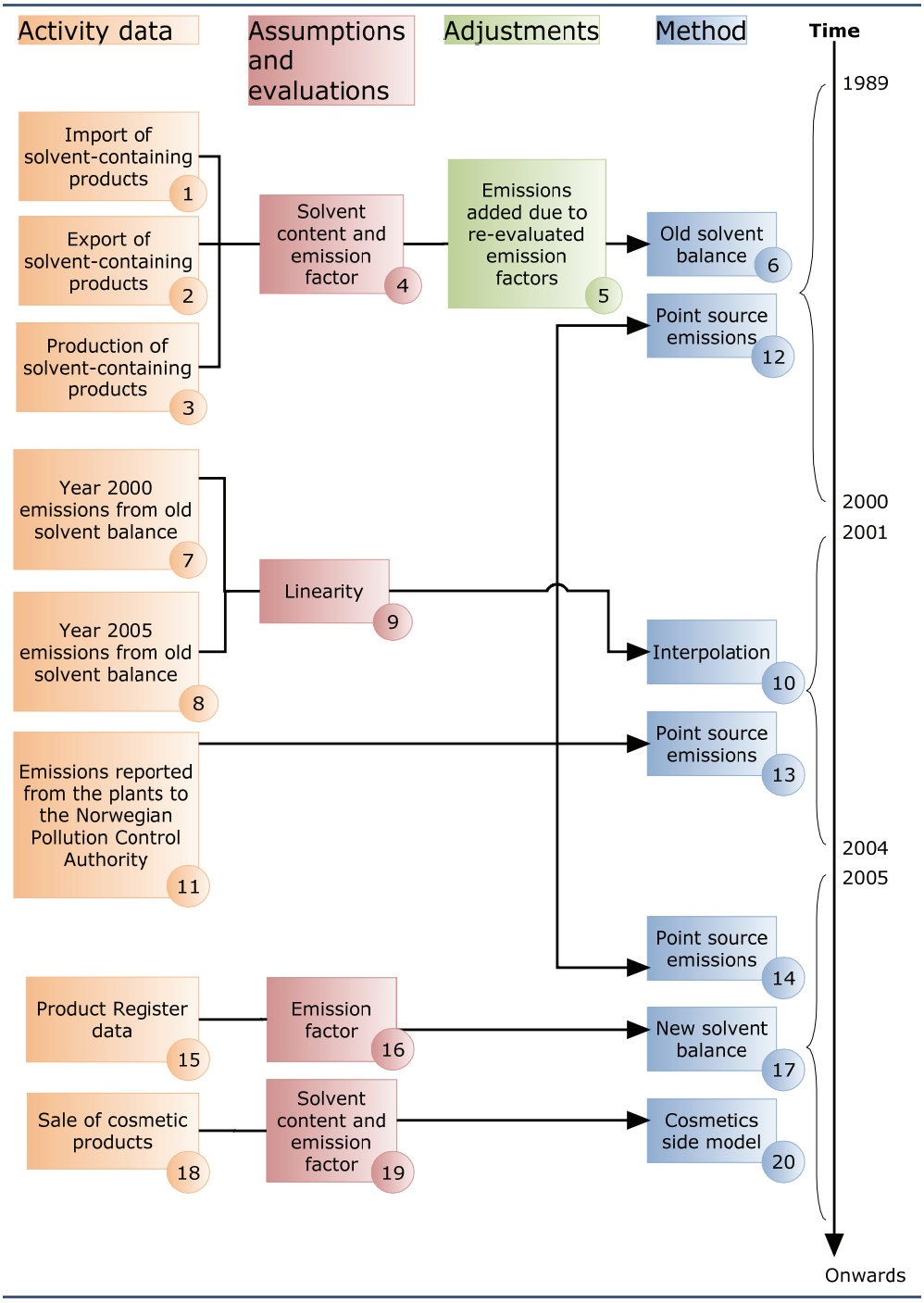
4.3.2. Time series in the Product Register

The duty of declaration forms the basis for data in the Product Register. It was first passed in 1981 and has since been extended to include more effects and products several times. Thus, the coverage and data quality of the Product Register has changed dramatically over time:

Before 1997: Coverage and data quality of NMVOC is very low.

- *1997-1999:* Coverage of NMVOC is low, except for 1999, and quantities can only be extracted as the sum over all products and industrial sectors for a given substance used in a given year.
- *2000-2004:* Coverage is considered to be sufficiently good, however due to the nature of the registrations, quantities can only be extracted as the sum of over all industrial sectors for a given substance in a given product used in a given year or as the sum of all products for a given substance used in a given industrial sector a given year.
- *2005 and onwards:* Coverage is considered to be good, and quantities of given substances a given year can be extracted from the register for combinations of products and industrial sectors.

Figure 4.1. **Activity data and method used and adjustments, assumptions and evaluations made in the model for estimating emissions of NMVOC from solvent and other product use, 1989 onwards**



The emission factors are both product- and sector specific (cf. section 3.2), and information about both these characteristics is necessary in order to effectively assign an emission factor to the activity data. Ideally, there should be an overlap between the time series from the new and the previous model in order to assess differences in emissions and source allocations. The previous model was last updated in 2000, and the times series in the new model should thus preferably start in this year. Modelling the distribution of the Product Register data from 2000 to 2004 based on product type and industrial sector marginals and the mean distributions in 2005 to 2007 was attempted, but the resulting activity data had serious faults, and the modelling added an extra level of uncertainty to the activity data. Thus, the Product Register data was deemed of sufficient quality from 2005, and modified emission estimates from the previous solvent balance was used for the preceding years (cf. section 4.8). The data sources used in different periods of

the time series is given in Table 4.1, and the overall statistics production is shown schematically in Figure 4.1.

Table 4.1. Data used in calculation of NMVOC emission time series

Years	1989-2000	2001-2004	2005-onwards
Model used	Old solvent balance (Rypdal 1995)	None	New model
Data source	Import, export and production	Interpolation between 2000 and 2005	Product register
Modifications	Adjustments due to new model	Point sources	Cosmetics side model
	Point sources		Point sources
Numbers in Figure 1	1-6, 11-12	7-11, 13	11, 14-20

4.4. Possible sources for error relating to the activity data

The following can potentially be the source of over- or underestimation of use and/or emissions based on Product Register data:

4.4.1. Products subject to the duty of declaration not being declared

Not all products subject to the duty of declaration are declared. Importers/ producers may be unaware of the regulation or may deliberately avoid mandatory declaration. This entails underestimation of emissions. Sample surveys carried out by the Norwegian Pollution Control Authority have indicated that as much as 25 per cent of products subject to the duty of declaration are not declared. However, the potential error is considered to be relatively small, as it is likely that this problem mainly concerns products with small consumption volumes (Kraft and Follestad, Product Register, *pers. com.* 2008). This error may however lead to an underestimation of the emissions.

4.4.2. Changes in the duty of declaration

As mentioned above, changes in the regulations for classification and labelling will lead to changes in the coverage of the Product Register, but the effect of this regulatory change on the coverage of the Product Register is believed to be limited. If a change in the duty of declaration is suspected to produce a false emission trend, the activity data may be adjusted, in order to reflect the true emission development (cf. section 4.5.2). This source of error may lead to abrupt changes in the time series.

4.4.3. Double counting

Double counting of quantities can occur when declared substances are used to make products that are also declared to the Product Register. This source of error is handled by identifying the combinations of product type and industrial sector that most likely represent use of the substances as raw materials and applying the appurtenant emission factors (cf. section 3.2), and this problem is thus considered to be under control. However, some of these cases might go undetected, resulting in an overestimation of emissions.

4.4.4. Errors in quantity figures

Declarants may sometimes give erroneous quantity figures. The most common error is to give numbers in kilos instead of in tonnes (Kraft & Follestad 2007). These errors may be difficult to detect, and several internal checks are performed in order to identify and correct potential errors in the quantity figures extracted from the Product Register (cf. section 4.5.1). The declaration of substances in kilos instead of tonnes leads to an overestimation of emissions.

4.4.5. Incomplete or erroneous industrial sector distribution

When a product is registered with several product codes in the same declaration, the quantity pertaining to each product code is evenly distributed to each of the registered industrial categories to which the product has been sold. This may not reflect the true distribution of the products among industrial sectors. These sources

of error in the industrial sector distribution of the data are considered to be negligible, as most products are sold to only one industrial sector (J. Kraft and M. Follestad, Product Register, *pers. comm.* 2008). However, erroneous distributions may lead to faulty emission factors being applied, and the emissions may be over- or under- estimated.

4.4.6. Missing product type codes

Some declarations are missing codes for product type. This might lead to an overestimation of consumption of some products and underestimation for others. However, these incomplete declarations constitute a minute contribution to the total consumption figures.

4.4.7. Quantities given in intervals (simplified declarations)

For some so-called simplified declarations, substance quantities are given in intervals. The maximum quantity is used for these substances, as it is expected that there is a higher probability that the true quantity will be close to the maximum value than to the minimum value. Internal checks are performed in order to identify intervals where the quantity figure used is substantially higher than the lower limit of the interval, in order to prevent overestimation (cf. section 4.5.1).

4.4.8. Negative figures

When declared quantities imported or produced one year are declared as exported the next, net quantities for the latter year are negative. This is currently handled by setting these figures to zero, resulting in an overestimation of intra-country emissions. The negative figures that are set to zero amount to approximately 6 400 tonnes for the whole period (2005-2007). Setting these figures to zero lead to an increase of the activity data of 0.4 per cent. The resulting overestimation of emissions is dependent on the product type and industrial sector in which the negative figures appear (due to different emission factors).

4.5. Quality Control (QC)

The current QC procedures conducted by Statistics Norway include the following:

4.5.1. Internal checks for data consistency

- Large between-year discrepancies in the time series of substance quantities are routinely identified and investigated, in order to correct errors in consumption figures.
- Large within-year discrepancies between minimum and maximum quantities in simplified declarations are routinely identified and investigated, in order to prevent overestimation for substances where consumption figures are given in intervals. For 2005-2007 the potential overestimation of emission figures generated by the use of maximum quantities were estimated. When using the mean of the interval values instead of the maximum, total emissions were reduced by approximately 3 400 tonnes (i.e. 6.8 per cent) in 2005, 1 900 tonnes (i.e. 4.3 per cent) in 2006, and 950 tonnes (i.e. 2.1 per cent) in 2007.
- Large within-year discrepancies between totals for industrial sectors (NACE) and totals for products (UCN) are routinely identified and investigated, in order to detect erroneous or incomplete industrial sectoral and product type distribution.

No corrections made on individual data sets are reported back to the Product Register.

4.5.2. Check for possible effects of changes in the duty of declaration

The trend in declared volume of substances that are expected to be affected by changes in the duty of declaration to the Product Register is analysed subsequent to substantial changes in the regulations. This is done in order to remove false emission trends. If changes in the duty of declaration lead to substantial changes in

volumes of the substances in concern, the time series prior to the change in duty of declaration may be adjusted in order to avoid false emissions trends due to the duty of declaration. Currently, the data have been analysed with respect to changes in the duty of declaration taking place prior to 2005 (Kittilsen & Hansen 2008). This gives us an indication of possible effects of regulatory changes on the activity data. No changes in the duty of declaration have taken place since 2005.

4.6. Confidentiality

According to § 2-6 of the Statistics Act (Finansdepartementet 1989), figures shall not be published in such a way that they can be traced to a particular respondent. Under Statistics Norway's rules regarding confidentiality, in order for the statistics to be publishable, aggregated data must consist of at least three observations. In this study one observation corresponds to one declaration. As a consequence, some results are grouped into a less detailed level in order to conceal confidential information.

4.7. Point sources and side models

4.7.1. Point sources

For the sake of coverage, data on emissions from nine point sources reported from the plants to the Norwegian Pollution Control Authority are added to the emissions estimates of NFR/CRF source 3C (see Appendix A5). NMVOC emissions are reported for additional four point sources that are already included in NFR/CRF 2 (see Appendix A5). These emissions are not presented in this report. The Norwegian Pollution Control Authority provides the point source data.

All point sources of NMVOC from the use of solvents that are included in either NFR/CRF 3 or NFR/CRF 2 belong to the industrial sector "Manufacture of chemicals and chemical products" (NACE 24). In order to avoid double counting, NMVOC used as raw material in this sector are excluded from the emission estimates.

Point source emissions are reported to the Norwegian Pollution Control Authority as total NMVOC emissions. While the results from the main model are available on a substance level, distributed on various product types and industrial sectors, the point source emissions are reported total NMVOC emissions. The plants reporting the emissions can be allocated to an industrial sector, but no information on substances or product types is available. Thus, the point source emissions must be omitted when emissions are analyzed on the substance or product type level.

4.7.2. Cosmetics side model

Estimates obtained on NMVOC emissions from cosmetics revealed that emissions from such products, which are not subject to the duty of declaration, were significant. Thus, a supplementary time series of NMVOC emissions from cosmetics was produced.

The Norwegian Pollution Control Authority calculated the consumption of pharmaceuticals and cosmetics in 2004, based on sales figures (given in Norwegian kroner) from the Norwegian Association of Cosmetics, Toiletries and Fragrance Suppliers (KLF) and Swedish turnover numbers (given in tonnes) (Norwegian Pollution Control Authority 2005). The consumption was calculated for product groups such as shaving products, hair dye, body lotions and antiperspirants. A consumption time series (in tonnes) from 2005 to 2007 was calculated from the the relationship between consumption in Norwegian kroner and in tonnes in 2004, and a consumption (in Norwegian kroner) from 2005 to 2007 from KLF (Norwegian Association of Cosmetics Toiletries and Fragrance Suppliers (KLF) 2008). Figures on VOC content and emission factors for each product group were taken for the

most part from a study in the Netherlands (IVAM 2005), with some supplements from the previous Norwegian solvent balance (the previous NMVOC model). Cosmetics have product type codes in the Product register, although they are not subject to the duty of declaration. The emissions from this product group were allocated to these product type codes. Because of lack of on sector distribution of cosmetics consumption, the emissions were divided equally between the sectors private households (no NACE) and "Other personal services" (NACE 93), where sectors such as hairdressers and beauty salons are included.

4.8. Time series from the previous model (1989-2000) and interpolation 2001-2004

According to the 2005 Gothenburg Protocol on the Control of Emissions of NMVOC, the base year for the Norwegian reporting of NMVOC is 1989. Hence, the first year in the time series presented in this report is 1989. However, data from the Product Register cannot be used to produce the complete time series back to this year. The Product register was deemed of sufficient quality for the NMVOC emissions model from 2005 (cf. section 4.3.2), and will consequently be used as the data source from this year onwards. Prior to this year the declared amounts were only available as sums over all product types within each sector or sums over all sectors within each product type. Due to the nature of our emission factor matrix, this information is not sufficient to produce good emission estimates.

4.8.1. Substances with emission factor zero in the previous model: Consumption and emissions

The trend in the previous solvent balance was considered reliable, but the emission level was lower than results from the new model. Differences in emission factors between the two models may be one explanation for this discrepancy. While the old model had emission factors set to zero for a range of substances, the new model assumes that emissions are completely eliminated only for a few product groups (cf Appendix A6) and never on a substance level. The substances with emission factor set to zero in the previous model contribute considerably to the emissions estimated using the new model. The consumption and emissions for each of the substances were investigated in order to pinpoint areas where the previous solvent balance should be adjusted. The substances with emission factor zero in the previous solvent balance are given in Table 4.2. For some of these substances, CAS numbers could not be found.

Table 4.2. Substances with emission factor zero in the previous solvent balance

Name	Cas number	Commodity number [1]	Prodcom code [2]
Formic acid	64-18-6	29.15.1100	24.14.32.53
Saturated cyclic hydrocarbons	Several	29.01.1000	24.14.11.20
Acetic acid	64-19-7	29.15.2100	24.14.32.71
Acetylene	74-86-2	29.01.2910	24.14.11.67
Esters from acetic acid	Several	29.15.3000	24.14.31.15/17/19
Esters from formic acid	Several	29.15.1300	24.14.32.55
Ethylene	74-85-1	29.01.2100	24.14.11.30
Propene	115-07-1	29.01.2200	24.14.11.40
Buta-1,3-diene og isoprene	106-99-0	29.01.2400	24.14.11.65
Octanol	111-87-5	29.05.1600	24.14.22.63
Naphta (crude oil)	Several	27.10.0016	
Other unsaturated acyclic hydrocarbons	Several	29.01.2990	24.14.11.90

[1] From the commodity list for external trade (Statistcs Norway 2007a)
[2] Eurostats's standard for production of manufactured goods (European Commission 2009)

Formic acid

Formic acid (CAS number 64-18-6) had emission factor zero in the old model, and contributes considerably to the emissions in the new model. This substance is used as ensilage means in ensiling processes in agriculture, and has an emission factor of 0.1 for this use in the new model. The formic acid is not transformed during the ensilage process, and can evaporate both when the grass is wrapped and unwrapped. An emission factor of zero is not likely for this process (O. Kjus, Addcon Nordic, *pers. comm.* 2007). The mean consumption of formic acid (raw

materials not included) in 2005-2007 was 30 000 tonnes, while the mean emission per year was 3 200 tonnes. Formic acid explains a discrepancy in emissions of 1 000-3 000 tonnes between the new and the previous model.

Saturated acyclic hydrocarbons
For some substances, including the saturated acyclic hydrocarbons, the old solvent balance assumed that the substance was used in combustion processes only. For instance, pentane (CAS number 109-66-0) was incorporated in the collective term saturated acyclic hydrocarbons in the old model. This is however a substance that, in addition to being combusted, also is used in insulation materials. An emission factor of zero thus seems unrealistic for this substance. From the substance list, 85 substances could be classified to be included in the group saturated acyclic hydrocarbons. Of these, 20 were found in our emission estimates. They comprised a mean consumption of 8 446 tonnes and mean emission of 1 080 tonnes.

Acetic acid
Acetic acid (CAS number 64-19-7) had a mean consumption of 6 949 tonnes per year in 2005 to 2007. The mean emission per year from this substance was 362 tonnes.

Acetylene
Acetylene (CAS number 74-86-2) had a mean consumption of 794 tonnes per year in 2005 to 2007. The mean emission per year from this substance was 77 tonnes.

Esters of acetic acid
From the substance list, 18 substances were identified as esters of acetic acid. Of these, 14 were found in our emission estimates. The mean consumption of these substances was 3 983 tonnes per year from 2005 to 2007, and the mean emission was 1 100 tonnes per year.

Esters of formic acid
Only one substance in the substance list was found that could be included in this category. This was methyl formate (CAS number 107-31-3), and there were no declared amounts of this substance in our data.

Ethylene, propene, buta-1,3-diene and octanol
Ethylene (CAS number 74-85-1), propene (CAS number 115-07-1), buta-1,3-diene and isoprene (CAS number 106-99-0), and octanol (CAS number 111-87-5) has negligible consumption levels in the new model. This is considered to be representative for the time period 1989-2000 as well, and the time series from the previous model is not adjusted with emissions from these substances.

For naphta (crude oil) and other unsaturated acyclic hydrocarbons it was deemed difficult to find the relevant CAS numbers, and thus no estimates of consumption and emissions was made.

4.8.2. Substances with emission factor zero in the previous model: Emission time series

The investigation described above indicates that the most important consequences in the differences in emission factors between old and new models are for formic acid, saturated acyclic hydrocarbons and esters from acetic acid. For these substances, the emission estimates added to the old time series (1989-2000) should ideally be adjusted according to import, export and production figures for each year in the time series. However, due to lack of data, the following procedure was chosen:

Formic acid production and import
The net import of formic acid has increased dramatically during the 1989-2007 period. There has been little or no production of formic acid in Norway during the

period (J. H. Kingsrød, Norwegian agricultural purchasing and marketing cooperation, *pers. comm.*). Small volumes may have been produced in Norway in the beginning of the period, but the majority was imported from BP in England. Thus, the net import was used to calculate the emission time series for formic acid from 1989-2000. The calculated emissions are in the range 850-2 400 tonnes each year.

Other substances with emission factor set to zero in the previous solvent balance
It has proven difficult to get reliable production numbers for the other substances with emission factor set to zero in the previous solvent balance. Import and export numbers alone do not give a reliable indication of the trend in the consumption time series. We have no information available that indicates that there is a conspicuous trend in the consumption of these substances. Thus, the mean emissions from the new model for the time period 2005 to 2007 were added to each year from 1989 to 2000. The sum of these emissions amounts to about 2 622 tonnes.

The time series from the previous model (1989-2000) is thus adjusted with emissions in the range of 3 500 to 5 000 tonnes each year. The adjustments are composed of one fixed part, and one share that vary over time, depending on the level of the calculated emission time series from the use of ensilage means.

4.8.3. Source allocation of adjusted emissions

The sector allocation within each source was redefined for the old time series, based on the mean allocation within the years 2005-2007 (cf. section 4.8.4).This implies that it was only necessary to allocate the calculated extra emissions to the source level, and these numbers where then included in the new sector allocation.

In the new model, more than 99.8 per cent of the formic acid emissions are placed in 3D. Thus, the calculated formic acid emission time series for 1989-2000 is placed in this source category.

The 2 622 tonnes of emissions from the substances that were distributed with the same emissions for the years 1989-2000 are distributed among sources according to their mean distributions in 2005-2007. The distribution of these emissions is given in Table 4.3.

Table 4.3. NFR/CRF sector allocation of emissions from saturated acyclic hydrocarbons, acetic acid, acetylene and esters of acetic acid

NFR/CRF sector	NFR sector with extentions	Emissions allocated (tonnes)
Paint application (3A)	Decorative paint application (3A i) Industrial paint application (3A ii) Other paint application (3A iii)	789
Degreasing and dry cleaning (3B)	Degreasing (3B i) Dry cleaning (3B ii) Other (industrial cleaning) (3B iii)	130
Chemical products, manufact. & proc. (3C)	Chemical products, manufact. & proc. (3C)	10
Other product use (3D)	Printing (3D i) Wood preservation (3D ii) Domestic solvent use (3D iii) Other (3D iv)	1693
Total		2622

4.8.4. Sector allocation 1989-2004

In the previous solvent balance, the allocation to sectors and sources were done according to a set pattern. The source distribution from the previous model was retained, while the sector distribution within each source was redistributed, to obtain consistency within the subdivided source categories. First, the emission time series for formic acid and the set emissions from the other substances with emission factor zero were added to the 1989-2000 time series according to their

2005-2007 source allocation. Second, the sources were divided into sectors based on the mean distribution of sectors within each source for the years 2005-2007. The widest distribution of sectors is seen within the CRF source category 3D. This is to be expected, as this is least specific source, including both industrial and domestic solvent use. The narrowest spread in allocations is in the 3C source category, which includes only the chemical industry.

The reported point sources included in the previous solvent balance were allocated to CRF sectors by the same set pattern as the as the estimated emissions. These reported point source emissions are all moved to CRF sector 3C, as they are all reported from sources within the chemical industry (NACE 24).

The CRF source categories were kept as in the previous model. The emissions from 1989 to 2000 were previously not allocated to the more detailed NFR source allocation, and are now allocated to the general "other" category within each CRF source, i.e within paint application (3A), the emissions are allocated to 3A iii "Other paint application", within degreasing and dry cleaning they are allocated to 3B iii, and within other solvent use (3D) the emissions are allocated to 3D iv (Other). Within the CRF source category 3C there is no further division according to the NFR regime.

The emissions for the years 2001 to 2004 were calculated for each sector within each source, as a linear interpolation between emissions in 2000 from the previous model and 2005 from the new model. For those source-sector combinations that did not have a value for 2005, the emissions for 2006 (or 2007) were used as a measuring point. The calculated emissions from the cosmetics side model were added to the 2005-2007 time series prior to interpolation, as emission estimates from the previous solvent balance included emissions from cosmetics.

5. Results

5.1. Emission trends

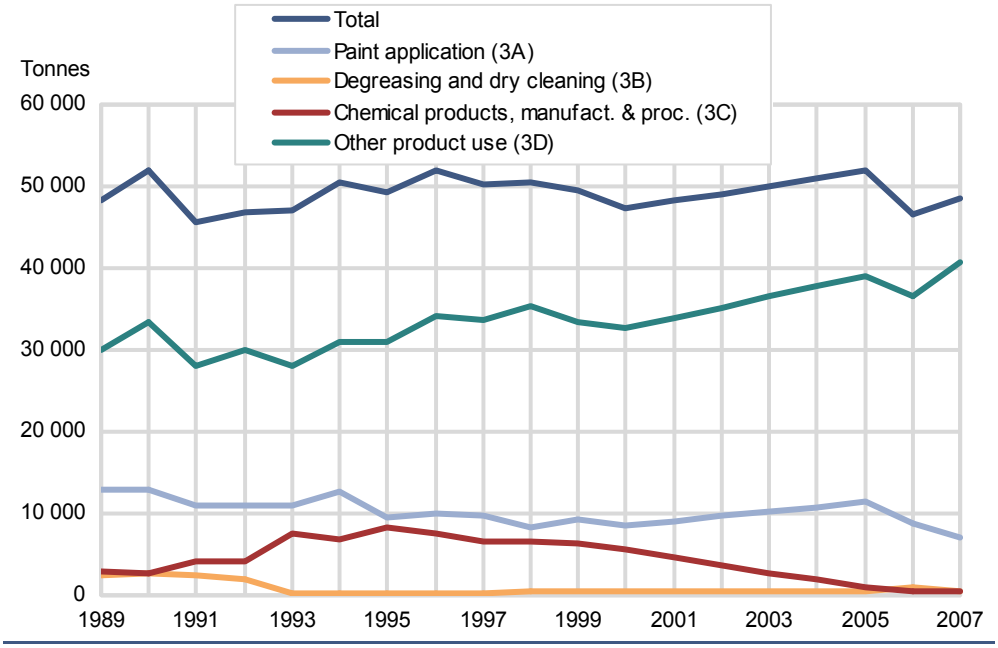
In 2007, the emissions of NMVOC from solvent and other product use totalled 48 570 tonnes, including point sources and estimates of emissions from cosmetics. The grand total of NMVOC emissions from all sources in Norway in 2007 was 199 000 tonnes, and the emissions from the use of solvents and other products thus constitute 24 per cent of the total. The largest source of overall NMVOC emissions are the evaporation of hydrocarbons by loading and unloading of crude oil (Statistics Norway 2009a).

The 1989-2007 time series includes adjusted emission figures from the previous time series (1989-2000), interpolated emission estimates (2001-2004), and emission estimates from the new emission model (2005-2007) (cf. section 4.3.2). The overall emission estimates presented below are based on this time series, including emissions from reported point sources and emission estimates for cosmetics.

5.1.1. Overall emission time series

The 1989-2007 time series of total NMVOC emissions shows that the emissions are relatively stable around 50 000 tonnes per year (Figure 5.1). There is an emission increase during the interpolated period 2001-2004, due to the fact that the emission level in 2005 was higher than in 2000. The emissions are however lower in 2006 and 2007 than in 2005, and the emissions are now at approximately the same level as in 2000. We have no reason to believe that the high emission figures in 2005 are misleading. The time series from 1989-2007 of emissions of NMVOC from solvent and other product use, by NFR source category, is given in Appendix B1.

Figure 5.1. NMVOC emissions from solvent and other product use, by NFR/CRF category, including emissions from point sources and cosmetics, 1989-2007. Tonnes



In the beginning of the NMVOC emission time series there are some abrupt between-year changes in estimated emissions. This is particularly noticeable for 1990, which had higher estimated emissions than both 1989 and 1991. This difference was mainly due to an unusually large net import of white spirit in 1990. In addition there was an increase from 1989 in the import and production of ethers and halogen derivates of hydro carbons. This increase was partly counteracted by a decrease in emissions from complex solvents, aromates and oils and cosmetics. Besides the decrease in white spirit import, the decrease from 1990 to 1991 was also caused by a decrease in import and production of polyester paint and varnish, ethanol and other alcohols.

5.1.2. Adjustment of time series from previous model

The time series from the previous model was adjusted within all source categories. The adjustments were due to additions from substances with emission factor set to zero in the previous model and from reallocation of reported point source emissions (cf. section 4.8.2) (Table 5.1). From 2001 onwards, no adjustments are made, since the old model has been rejected for these years.

Table 5.1. Emissions added within each NFR/CRF source category due to adjustments of the time series from the previous modell, 1989-2000. Tonnes

CRF source category	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total	3 486	3 721	3 869	3 731	3 984	4 306	4 192	4 455	4 477	4 934	4 912	5 064
Paint application (3A) ..	790	790	572	551	577	571	602	652	664	675	654	659
Degreasing and dry cleaning (3B)	129	129	82	88	124	126	127	126	126	125	125	124
Chemical products, manufact. & proc. (3C)	10	11	813	934	757	749	806	618	566	762	736	727
Other product use (3D)	2 557	2 791	2 402	2 158	2 525	2 859	2 658	3 060	3 121	3 373	3 396	3 553

5.2. Reported source specific emissions

Source category 3D ("Other product use") is by far the most predominant of the four main source categories (Figure 5.1). A general increase in emissions from this source from 1989 to 2007 is counteracted by a decline in emissions from source category 3C ("Chemical products, manufacture and processing"). The diverging trends for sources 3C and 3D occur when converting from the previous to the new model. The source allocations in the new and previous model are, however, not directly comparable; for instance may some emissions previously included in 3C now be included in 3D. Thus, the consistency in the complete time series is most reliable on the total emissions level. From 2005, the four source categories NFR/CRF 3A-D can be studied in more detailed using the NFR extentions. The results presented below are the emissions reported within each of the NFR extentions according to the 2008 NFR reporting format.

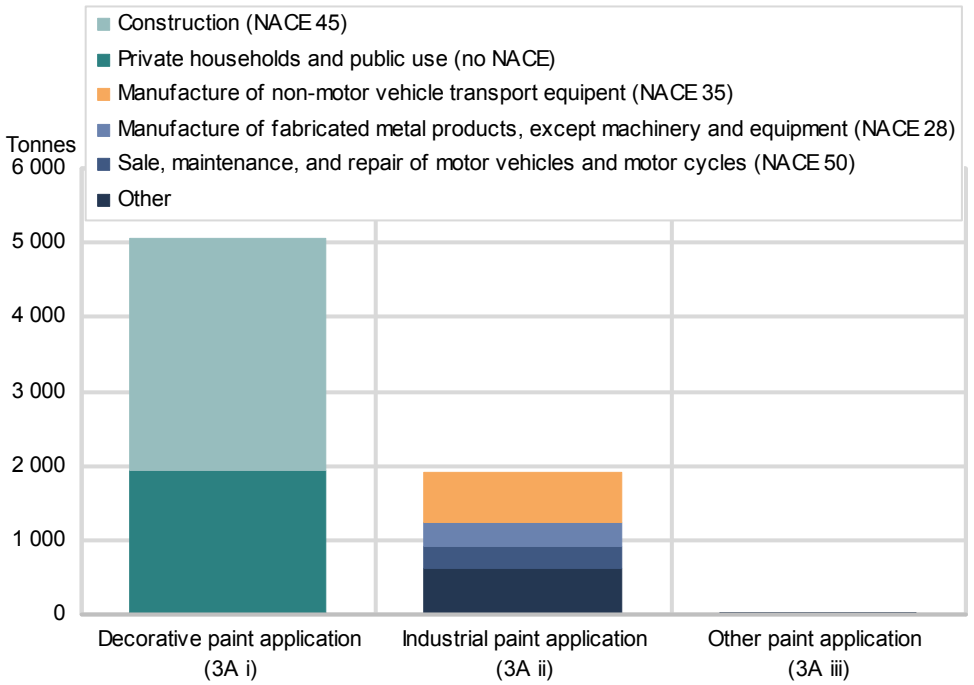
5.2.1. Paint application (3A)

The emissions of NMVOC from paint application have been quite stable between 1989 and 2007. There was a decrease from 2005-2007, presumably due to a shift toward water-based paint and varnish, and consequently lower consumption of solvent-based products. In 2007, the emissions in this source category were calculated to be the lowest since 1989. A side model calculating emissions from water-based paint not subject to the duty of declaration was deemed not necessary, but there are still some NMVOC in water-based paint, and thus the emissions from 2005 are slightly underestimated.

Decorative paint application (NFR ectention 3A i, see Appendix A5) is by far the largest of the three extentions within the NFR paint source codes (Figure 5.2). Paint and varnish used in construction (NACE 45), in private households and for public use (no NACE) is allocated to this NFR code. Industrial paint application (NFR extention 3A ii) includes the use of paint and varnish in manufacture of motor equipment, motor vehicles and wood products, among others. The largest emissions from this group are estimated to stem from the use of paint and varnish in the manufacture of non-motor vehicles (NACE 35), manufacture of fabricated metal products other than motor vehicles (NACE 28), and sale, repair and maintenance of motor vehicles and motor cycles (NACE 50) (Figure 5.2).

The consumed amount in decorative paint application (NFR extention 3A i) and industrial paint application (NFR extention 3A ii) were approximately the same in 2007, and the difference in emissions is due to different emission factors.

Figure 5.2. NMVOC emissions in NFR extentions 3A i-iii, by industrial sector, 2007. Tonnes

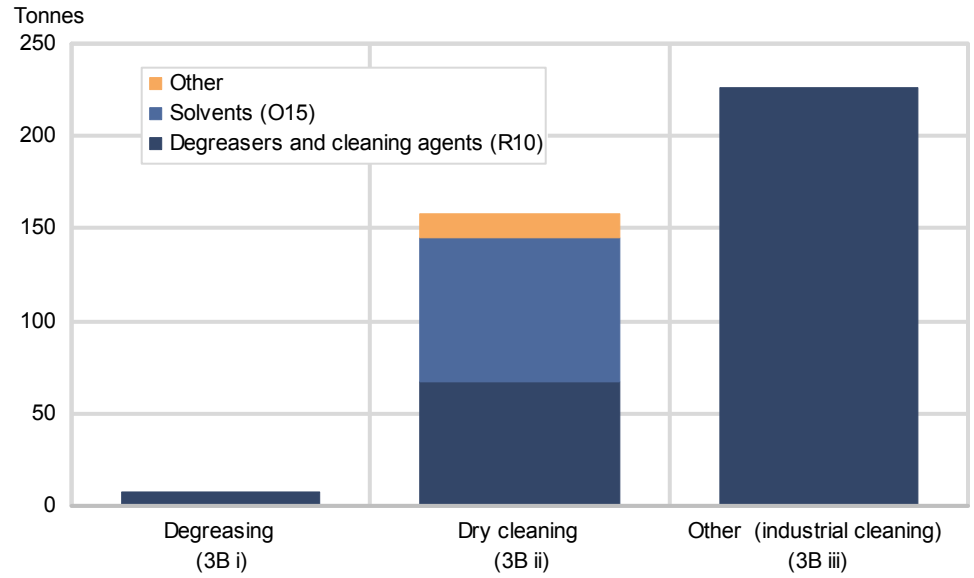


5.2.2. Degreasing and dry cleaning (3B)

The emissions of NMVOC from degreasing and dry cleaning are very low, and have been consistently so since 1993. There was a considerable fall in emissions from 1992-1993. In the mid-90's, the CFC machinery used in dry cleaning was phased out (Thorud *et al.* 1997). Such a change in machinery used might also have led to a reduction in emissions of non-CFC gases.

Degreasing (NFR extention 3B i, see Appendix A5) is the smallest of the three NFR extentions within this NFR/CRF code (Figure 5.3). Here, degreasers used in the manufacturing industries (NACE 27-35) are allocated. Degreasers and other cleaning agents used in other sectors than the manufacturing industries are placed in source category 3B iii. Dry cleaning (NFR extention 3B ii) include cleaning agents, solvents and some other product types used in NACE 93 and 93.1.

Figure 5.3. Emissions of NMVOC in NFR extentions 3B i-iii, by product type, 2007. Tonnes



5.2.3. Chemical products, manufature and processing (3C)

According to the previous model, there was a considerable increase in the emissions of NMVOC from the chemical industry in the early 1990's. As mentioned above, the dramatic decline from 2000 to 2005 is probably due to differences in source allocation between the new and previous model.

The source category "Chemical products, manufacture and processing" (3C) does not have any further division into extentions according to the NFR reporting scheme.

Included in this sector are emissions from substances consumed in manufacture of chemicals and chemical products (NACE 24) and manufacture of rubber and plastic products (NACE 25). In addition, styrene (CAS number 100-42-5) used as a solvent declared to public use (no NACE) and raw materials used in NACE 17-19 are included here. Styrene has no known area of application in private and public use, and it is assumed that this substance declared for this use is actually used in the manufacture of chemical products.

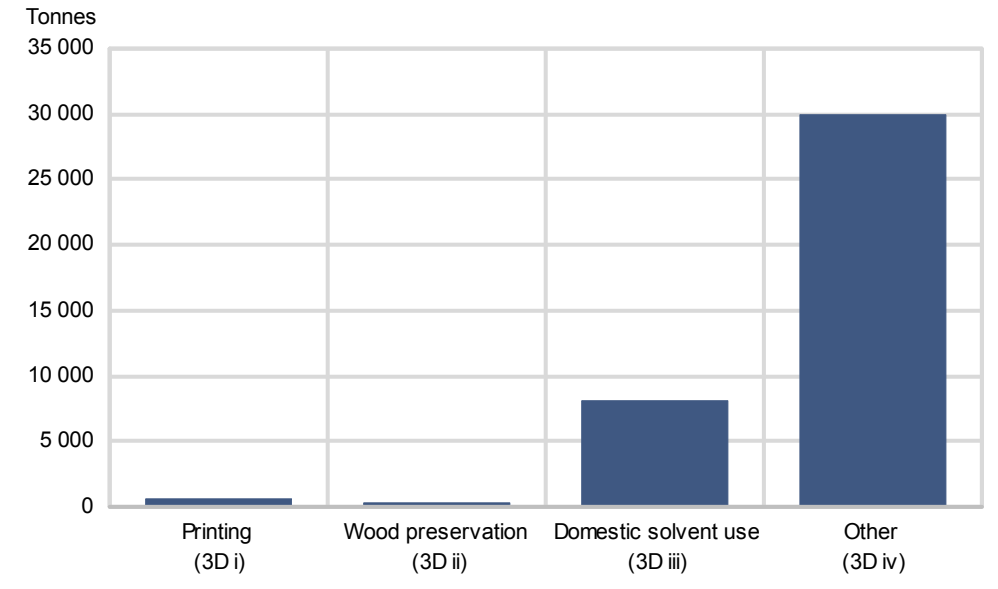
All point source emissions (reported to the Norwegian Pollution Control Authority) from solvent and other product use are included in this source category. The emissions from point sources were reported to be the highest in the time series in 1992, with approximately 1 000 tonnes, while the reported emissions were the lowest in the time series in 2007, with only 270 tonnes.

5.2.4. Other- including products containing HMs and POPs (3D)

The time series from 1989 to 2000 was adjusted both with the time series for NMVOC emissions from formic acid consumption, amounting to 1 000 to 3 000 tonnes per year, and with the emissions from the other substances with emission factor zero in the previous model, amounting to 1 693 tonnes per year (cf. section 4.8.2). In addition, the calculated emissions from the cosmetics side model were added to this source category for the years 2005 to 2007.

The source category 3D is divided into four extentions according to the NFR reporting scheme (see Appendix A5). This source category is the largest of the CRF source categories, and the NFR source category 3D iv ("Other") is the largest within this again (Figure 5.4).

Figure 5.4. Emissions within the NFR/CRF category 3D, by NFR extention, 2007. Tonnes



The source category "printing" (NFR category 3D i) includes emissions from solvents and other products used in the printing and publishing industry (NACE 22). The most important product types are printing ink, solvents, and moisturisers.

Preservation of wood (NFR category 3D ii) includes emissions from solvents and other products used in the manufacture of wood and of products of wood and cork (except furniture) (NACE 20). The most important product types are wood preservatives and wood impregnation agents.

Domestic solvent use (NFR category 3D iii) includes emissions from solvents and other products deemed to be consumed in private households. This includes products declared used in retail sale of automotive fuel (NACE 50.5), retail trade (except motor vehicles) (NACE 52), recreational, cultural and sporting activities (NACE 92), private households and for public use (no NACE). The most important product types are degreasers and cleaning agents, anti-freezing agents, as well as biocides (Figure 5.5).

Figure 5.5. Emissions from most important product types within each sector in NFR extention 3D iii, 2007. Tonnes

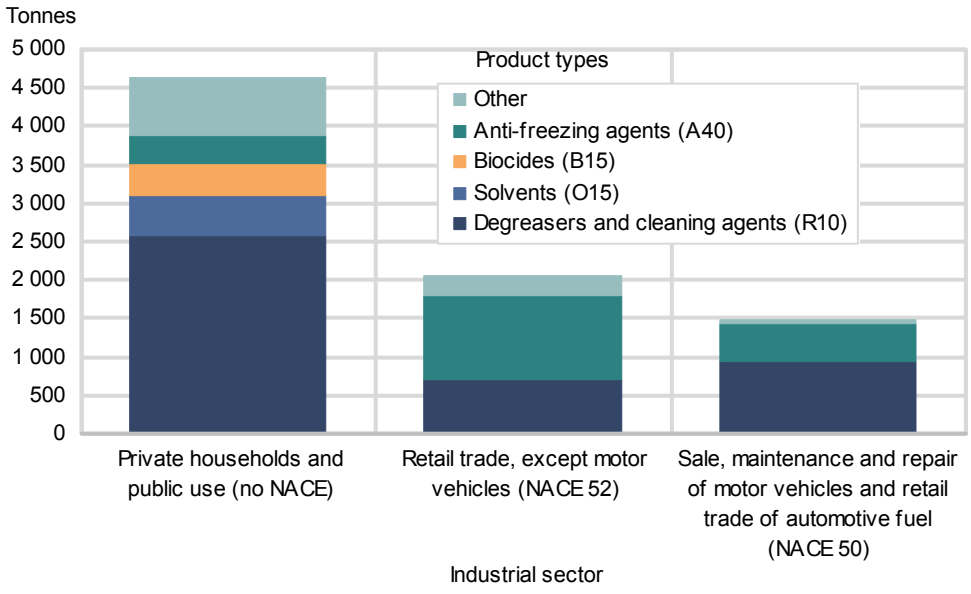
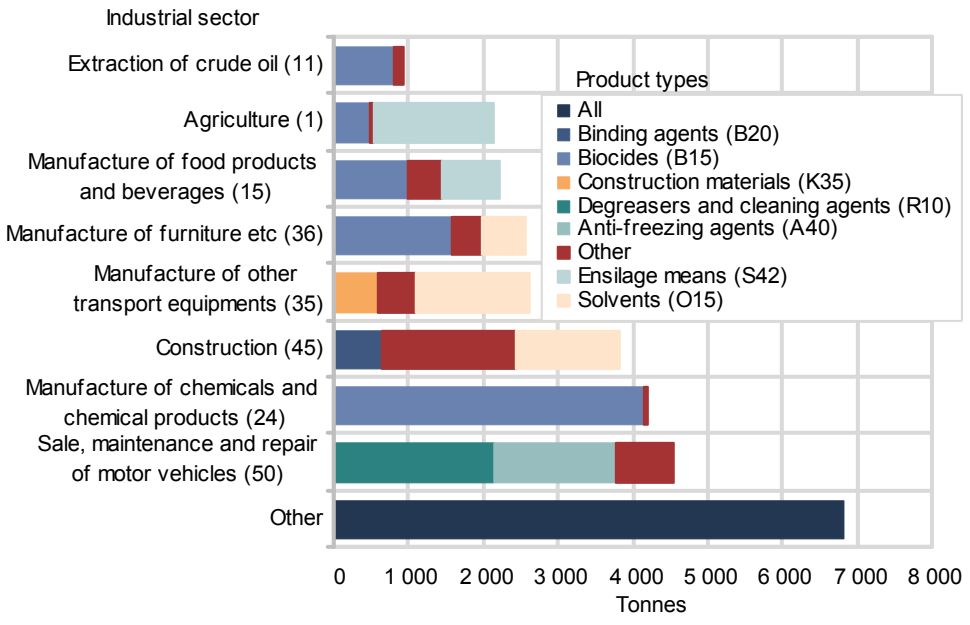


Figure 5.6. Emissions from most important product types within dominant sectors in NFR extention 3D iv, 2007. Tonnes



The NFR source extention 3D iv has the largest emissions of the four extentions within 3D (Figure 5.6). This group includes emissions that do not have a natural place in any other source category, such as biocides used in chemical industry (NACE 24) and the manufacture of furniture (NACE 36), solvents used in the manufacture of other transport equipment (NACE 35) and construction (NACE 45), degreasers and other cleaning agents used in sale, maintenance and repair of motor vehicles and retail trade of automotive fuel (NACE 50), ensilage means used in agriculture (NACE 1) and manufacture of food product and beverages (NACE 15), and cooling agents used in the sale, maintenance and repair of motor vehicles and retail trade of automotive fuel (NACE 50).

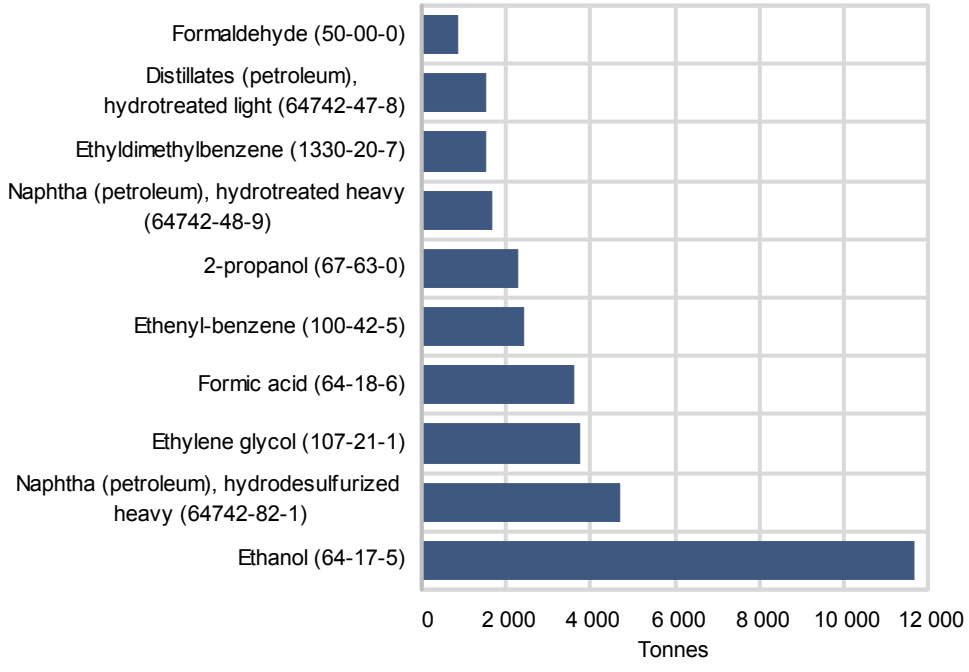
5.3. Main emission sources 2005-2007

For a more detailed analysis of the emissions from specific products and sectors, figures from 2005-2007 are used, as only the new model provides information on this level. The emissions of NMVOC are spread over a wide variety of substances, product types and sectors. The following analyses are based on emissions calculated from the main model, and are, if not stated otherwise, excluding emissions from point sources or the cosmetics side model. The total emissions from solvent and other product use are here disaggregated on a sector and product level, and do not follow the NFR reporting scheme.

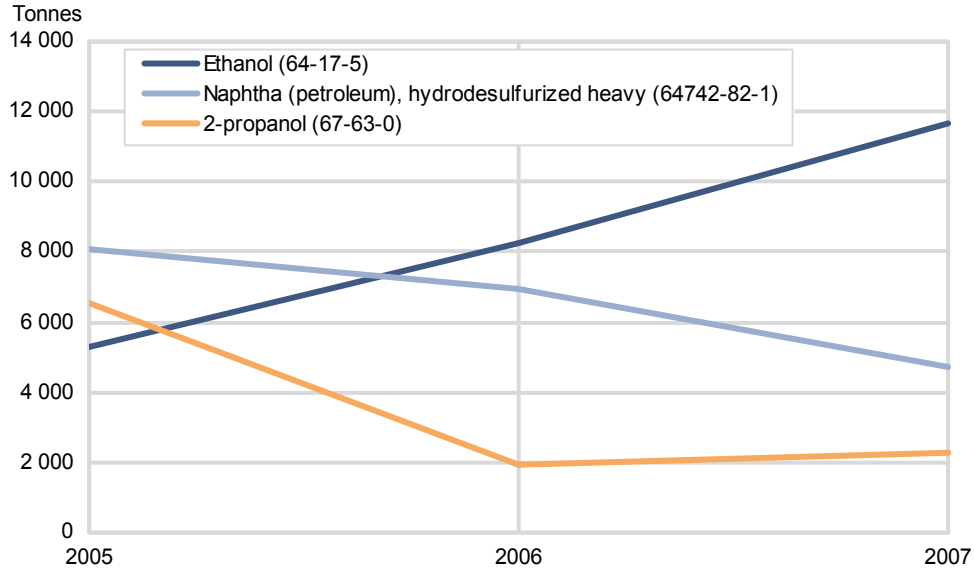
5.3.1. Dominant substances

To account for 95 per cent of the total NMVOC emissions from solvent and other product use in 2007, 57 substances need to be included (Appendix B2). Ethanol (CAS number 64-17-5) was the predominant substance, amounting to 25 per cent of total emissions, followed by naphtha (hydrodesulfurized heavy) (CAS number 64742-82-1) and ethylene glycol (CAS number 107-21-1) (Figure 5.7).

Figur 5.7. Substances contributing most to emissions of NMVOC from solvent and other product use, 2007. CAS number in parenthesis. Tonnes

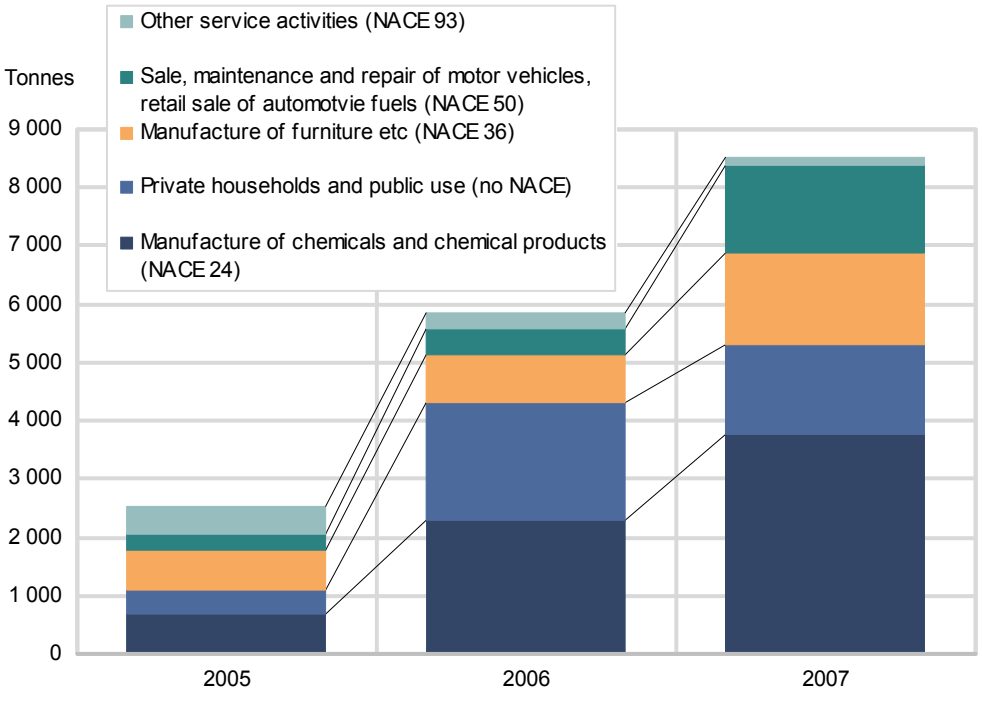


Figur 5.8. **Emissions of NMVOC by substance, 2005-2007. CAS number in parenthesis. Tonnes**



Ethanol (cas number 64-17-5) emissions increased considerably from 2005 to 2007, while naphtha (hydrodesulfurized heavy) (cas number 64742-82-1) and 2-propanol (cas number 67-63-0) had the largest reductions in emissions during this time period (Figure 5.8). The decrease in emissions of naphtha (hydrodesulfurized heavy) was most prominent in paint and varnish used in private households (no NACE) and construction (NACE 45). The decrease in consumption of 2-propanol was largest for cleaning agents used in private households and public use, polishing agents in sale, maintenance and repair of motor vehicles and retail sale of automotive fuels (NACE 50) and as solvents used in publishing, printing and reproduction of recorded media (NACE 22).

Figur 5.9. **Emissions of NMVOC from ethanol in cleaning agents and biocides, by sector, 2005-2007. Tonnes**

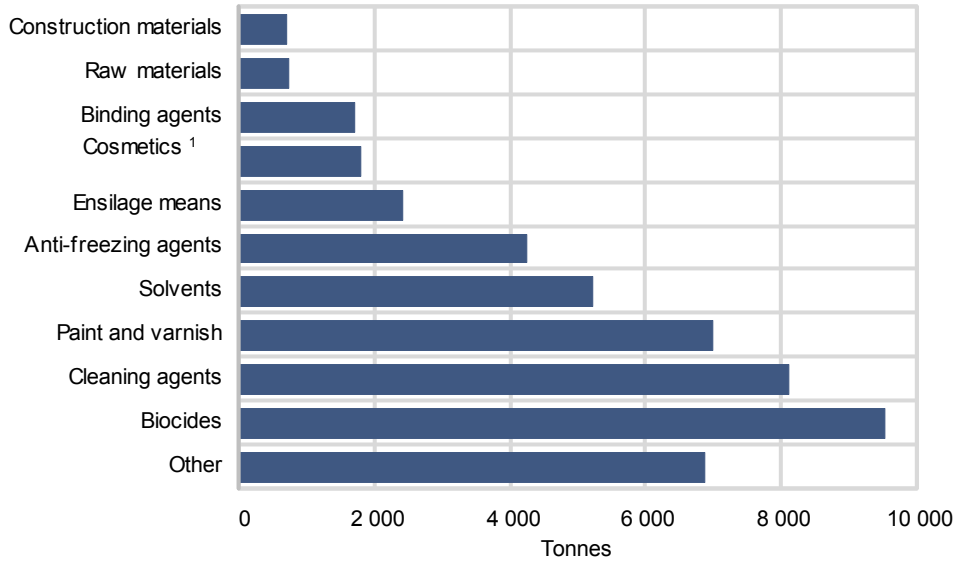


Ethanol emissions increased most from the use of biocides and cleaning agents in the manufacture of chemicals and chemical products (NACE 24), manufacture of furniture etc. (NACE 36), private and public purposes (no NACE) and in sale, maintenance and repair of motor vehicles and retail sale of automotive fuels (NACE 50). This was partly counteracted by a decrease in use of these product types within other service activities (NACE 93) (Figure 5.9).

5.3.2. Dominant product types

To account for 95 per cent of the total NMVOC emissions from solvent and other product use in 2007, 23 product type groups need to be included (Appendix B3). The ten most dominant of these product type groups are shown in Figure 5.10. In 2007, biocides was the product group contributing most to the emissions of NMVOC from solvent and other product use, followed by cleaning agents and paint and varnish (Figure 5.11). Cosmetics is a distinct product type group, and is included in Figure 5.11, even though these emission estimates do not stem from the main model (cf. section 4.7.2).

Figur 5.10. Product types contributing most to emissions of NMVOC, 2007. Tonnes



[1] The emission estimate for cosmetics is based on production and import figures, as cosmetics are not subject to the duty of declaration.

The three product groups with the largest emissions are also the groups with the biggest numeric changes in emissions between 2005 and 2007 (Figure 5.11). The emissions from cleaning agents and paint and varnish have decreased during this period, while the emissions from biocides have increased. Biocides became subject to the duty of declaration in 2004, and it often takes some time before such changes in the duty of declaration are completely incorporated in the declaration routines of the declarants (Mette Follestad, Norwegian Product Register, *pers. Comm* 2008).

At the same time the declarations of antifouling agents (growth inhibiting paint) were transferred from paint and varnish to biocides for paint containing biocides, and cleaning agents with an active component were moved from cleaning agents to biocides.

These changes in declaration rules may account for some of the decrease in emissions from paint and varnish and cleaning agents and the concurrent increase in emissions from biocides.

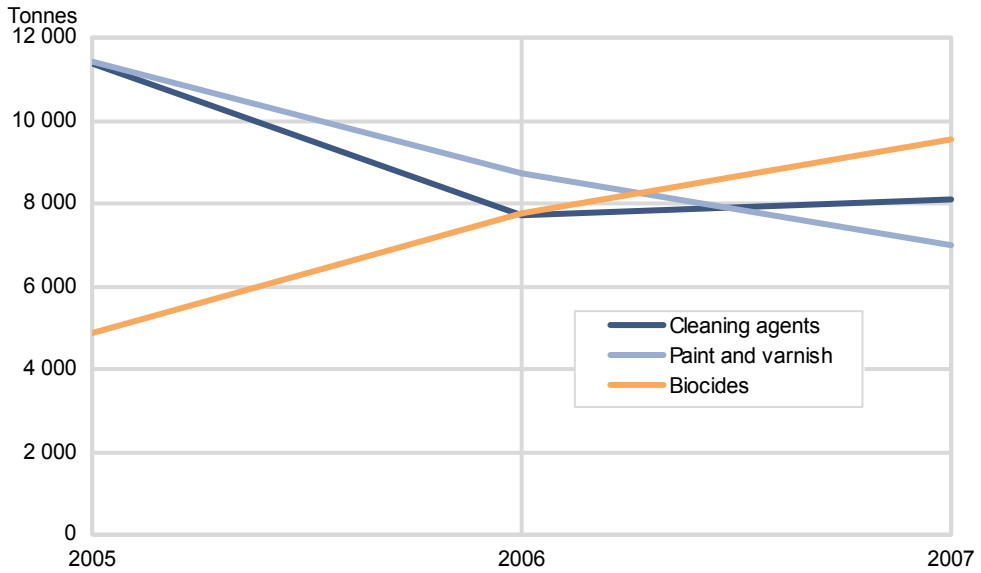
For cleaning agents, it is the consumption in private households and general use that has decreased. 2-propanol is the substance with the largest decrease in this

product group. The amount of cleaning agents declared for use in maintenance and repair of motor vehicles, except for motor cycles (NACE 50.2), has also declined. Increased emissions of ethanol partly counteract this trend.

For paint and varnish, the decrease in emissions is spread over a wide variety of sectors. The most prominent decline is found in private households, construction (NACE 45), and maintenance and repair of motor vehicles, except for motor cycles (NACE 50). This is probably due to a transition from use of solvent-based paint to use of water-based paint. This could possibly be a false trend, caused by the fact that the small amounts of NMVOCs in water-based paint are not included in the data (cf section 4.3.1), giving the impression that emissions were reduced when they were actually just transferred to water-based paints. However, the number of declarations in the product group paint and varnish increases within each of the sectors where we find a reduction in emissions during the time period in question, and thus it seems unlikely that this is the cause of the reduction in emissions.

The increase in emissions from biocides is mainly caused by increased use of ethanol (CAS number 64-17-5) in the manufacturing industries (NACE 24 and 36).

Figur 5.11. Emissions of NMVOC by product type group, 2005-2007. Tonnes

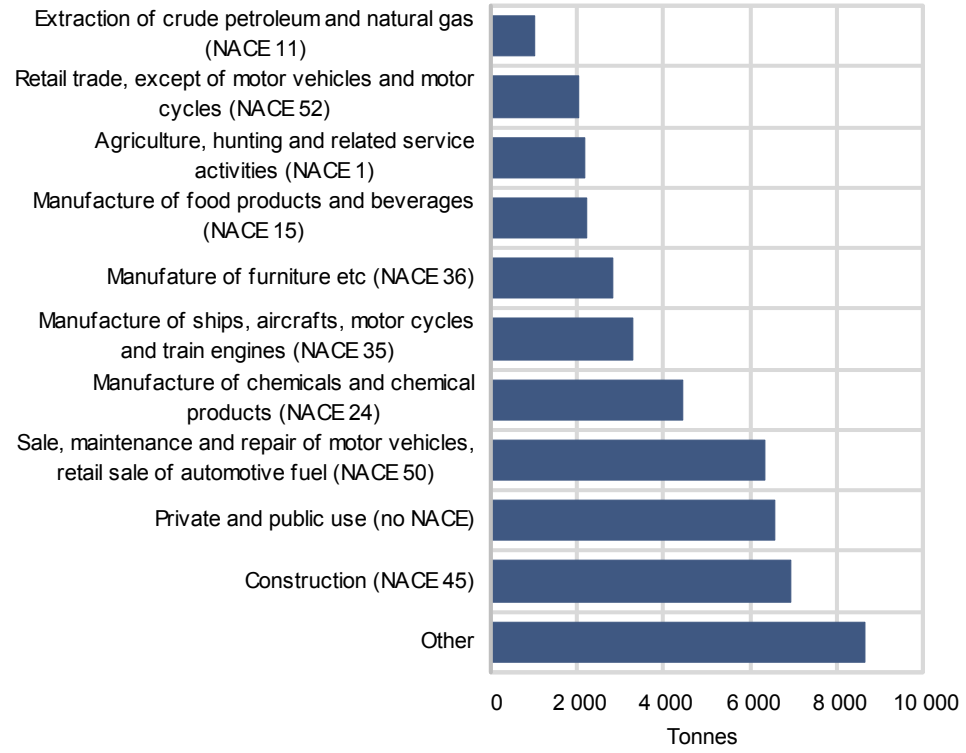


5.3.3. Dominant industrial sectors

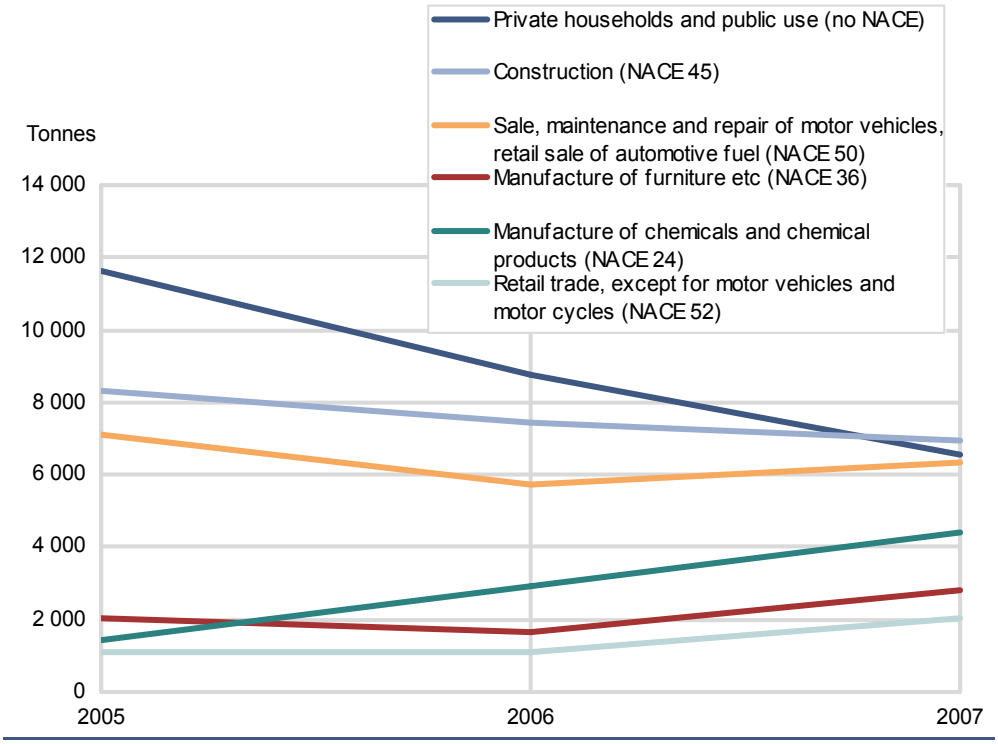
To account for 95 per cent of the total NMVOC emissions from solvent and other product use in 2007 (not including point source emissions and emissions from cosmetics), 22 industrial sectors need to be included (Appendix B4). The ten most dominant of these sectors are shown in Figure 5.12. There are emissions of NMVOC from a large array of sectors, but the most predominant are construction (NACE 45), private households (no NACE), sale, maintenance and repair of motor vehicles and retail sale of automotive fuels (NACE 50), and manufacture of chemicals and chemical products (NACE 24).

There is a large decrease in emissions of NMVOC from private and public use of solvents (no NACE), construction (NACE 45) and from sale, maintenance and repair of motor vehicles and retail sale of automotive fuel (NACE 50), while the emissions increase in manufacture of furniture, manufacturing n.e.c. (NACE 36), manufacture of chemicals and chemical products (NACE 24), and retail trade, except motor vehicles and motor cycles (NACE 52) (Figure 5.13).

Figur 5.12. Industrial sectors contributing most to NMVOC emissions, 2007. Tonnes



Figur 5.13. Emissons of NMVOC by industrial sector, 2005-2007. Tonnes



5.4. Uncertainty

The uncertainty in level in the total NMVOC emissions are given in Table 5.2, and the uncertainty in trend is given in Table 5.3. The uncertainty in absolute numbers is similar for both level and trend. The uncertainty for level is calculated to be percentually low, between 2.5 and 4.6 per cent. The 95 per cent confidence intervals for the trend do not include the value zero for any years, and all between-year changes in emissions are thus significant. The uncertainty analysis is performed only for the new data source, and thus the time series is quite short. The uncertainty in trend is thus not an estimate of the uncertainty in the long-term trend in NMVOC emissions.

Table 5.2. Uncertainty estimates for level in NMVOC emissions, 2005-2007. Tonnes and per cent

Uncertainty in level	Negative (*n*) (tonnes)	Negative (*n*) (per cent of total emissions)	Positive (*p*) (tonnes)	Positive (*p*) (per cent of total emissions)
2005	2 288	4.58	1 437	2.88
2006	1 651	3.70	1 103	2.47
2007	1 299	2.79	1 168	2.51

Table 5.3. Uncertainty estimates for trend in NMVOC emissions, 2005-2007. Tonnes and per cent

Uncertainty in trend	Negative (*n*) (tonnes)	Negative (*n*) (per cent of cange in emissions)	Positive (*p*) (tonnes)	Postive (*p*) (per cent of change in emissions)	95 per cent confidence interval for change (tonnes)
2005-2006	2 135	40.8	1 067	20.4	(-7 366, -4 164)
2006-2007	1 420	77.7	947	51.8	(407, 2 774)
2005-2007	1 882	55.3	1 076	31.6	(-5 286, -2 328)

6. Discussion

By signing the Gothenburg-protocol of the LRTAP in 1999, Norway has committed to reducing emissions of NMVOC to 195 000 tonnes per year by 2010. Preliminary emission calculations showed that Norwegian emissions of NMVOC totalled approximately 191 000 tonnes in 2007. This figure included emission estimates from solvent and other product use from the previous model. According to these results, approximately 22 per cent was attributed to the use of volatile, organic solvents. For 2007, the total NMVOC emissions are calculated to be around 199 000 tonnes, of which 48 570 tonnes (i.e. 24 per cent) stem from solvent and other product use estimated using the new model.

The increase in percentual share of emissions from solvent and other product use from the new solvent model compared to the previous model indicates that the new model has a higher coverage than the previous solvent balance. However, many emission factors have also been modified during this project, and the increased emissions can thus not be seen as a direct quantification of the difference in coverage between the two models.

Several abrupt changes in the time series for NMVOC emissions from solvent and other product use is expected, due to changes in the regulations relating to restrictions on the manufacture, import, export, sale and use of chemicals and other products in order to protect health and the environment (Product Regulations). However, there is reason to believe that for most of the substances in question, estimated emissions are so small compared to the overall figures that this effect is masked.

The simplified declarations represent a challenge in the estimation of emissions, as the actual quantities of NMVOC substances are not known. The difference between the lower and the upper boundaries of the simplified declarations have decreased in the 2005-2007 period. In 2005, the overall difference in consumption figures was 24 000 tonnes, while it in 2007 was less than 8 000 tonnes. The potential difference in emissions is much smaller.

6.1. Comparison to results from the previous model

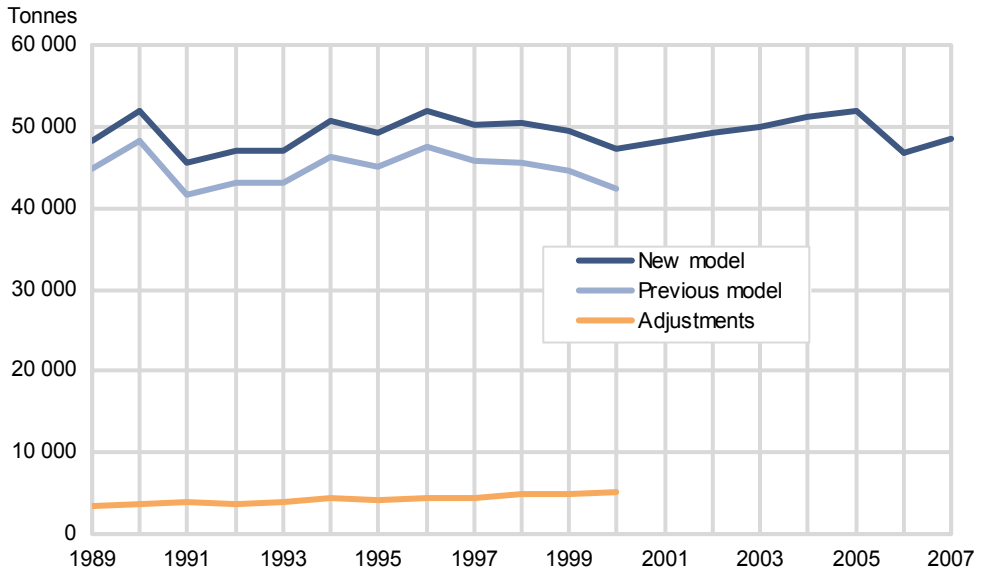
Completeness of the previous model depended on the correct identification of solvent-containing products. It is possible that more products are included when using a substance specific mass balance. While some product types are easily identified as NMVOC-containing, such as paints and cleaning agents, others are more non-intuitive as sources of emissions of NMVOC, as for example some construction materials.

Discrepancies in emission factors were calculated to account for a difference in emissions of 3 000 to 4 000 tonnes between the previous and the new solvent balance (Figure 6.1). The time series from the previous model was adjusted accordingly, as it is considered unlikely that the use of acyclic hydrocarbons, ethylene, propene, formic acid, esters of acetic acid, and esters of formic acid never entails emissions. Previously, complete combustion or conversion of these substances was assumed. This is now considered unlikely for the wide range of product types these substances occur in. In this study, conversion of substances is assumed when used as raw materials, and in such cases emission factors are very low. Complete combustion is however still deemed correct for a few product types.

The activity data in the new and previous solvent balances are of very different natures. While the previous solvent balance utilized import, export and production figures for NMVOC-containing products, the new model uses Product Register data (also import, export and production) for the NMVOCs themselves. This entails that while the previous solvent balance registered activity data for approximately 100 different products, the new model has activity data for 355

substances. The comparison between these two methods is thus not straightforward, and a thorough assessment of discrepancies in emission factors between the two models has not been performed.

Figur 6.1. NMVOC emissons from solvent and other product use in the new and the previous model and adjustments made to the previous model, 1989-2007. Tonnes



One of the substances for which the emission factor was erroneously set to zero in the previous model is formic acid. In the old model, it was assumed that all formic acid was converted into other non-volatile compounds. However, for formic acid used for ensilaging this is not the case, and this usage makes a substantial contribution to emissions in source category 3D. The calculated emissions from formic acid were 3 600 tonnes in 2005, 2 500 tonnes in 2006 and 3 600 tonnes in 2007. Removing these emissions from the solvent balance would bring us to a level similar to the emissions from the previous solvent balance. Emissions of formic acid used for ensilage was added to the previous model, based on production numbers and the relationship between emissions from new model and production numbers from production statistics.

In the previous model, emissions from production of chemicals and chemical products (NFR/CRF 3C) were considerable, while this source is insignificant in the new model. On the other hand, the emissions from CRF category 3D - Other, is much higher in the new than in the previous model. The allocation of biocides used in the chemical industry may account for much of this difference. In the present model, it is deemed that these products are not used in the production process itself, but as biocides for disinfecting the machinery etc.

6.2. Comparison to the results in other countries

The emissions in Norway, estimated in kilos per inhabitant, is somewhat higher than in countries for which the estimation method is comparable, namely Sweden and the United Kingdom. The SPIN database (Nordic Product Registers 2008) can be used to compare amounts declared to different industries in Sweden, Denmark, Finland and Norway. This database contains information about declared amounts of substances in the Nordic countries, and does not have information about NMVOC substances in particular. The total amount for a particular industrial sector can however give an indication as to the activity level within this industry in Sweden and Norway. Calculated NMVOC emissions per inhabitant for Norway, Sweden and the United Kingdom in 2005 are given in Table 6.1. For Norway, the estimates are based on emissions calculated in the new model, and for Sweden and the United Kingdom the emission estimates reported to the Centre on Emission

Inventories and and Projections (CEIP) are used (CEIP 2008). The population numbers are gathered from the United Nations demography Yearbook (United Nations 2008). Denmark and Finland uses different approaches than Norway for calculating emissions of NMVOC from solvent and other product use, and the Norwegian emissions are thus not compared to the emissions from these countries in the following.

Table 6.1. NMVOC emissions in Norway, Sweden, and United Kingdom by NFR/CRF source category, 2005. Kilos per inhabitant

NFR/CRF source category	Norway	Sweden	United Kingdom
TOTAL PER INHABITANT	11.220	7.762	6.729
3 A PAINT APPLICATION	2.471	1.846	1.948
3 B DEGREASING AND DRY CLEANING	0.125	0.014	0.512
3 C CHEMICAL PRODUCTS, MANUFACTURE AND PROCESSING	0.195	0.085	0.246
3 D OTHER including products containing HMs and POPs	8.429	5.817	4.024

6.2.1. Paint application (3A)

The emissions per inhabitant in this group are similar to the emissions per inhabitant in Sweden and the UK, though in the high end of the range. Approximately 2.5 kilos per inhabitant were emitted from this source in Norway in 2005. Renovation of private households is widespread in Norway, and this may account for the relatively high emissions from the use of paint and varnish.

6.2.2. Degreasing and dry cleaning (3B)

The Norwegian model includes degreasing as well as dry cleaning, while Sweden only includes dry cleaning, and this can account for the higher emissions in this NFR/CRF sector in Norway. The United Kingdom has higher estimates in this source than both Sweden and Norway. The reason for this discrepancy is not known.

6.2.3. Chemical products, manufacture and processing (3C)

The emissions from this sector were higher in Norway than in Sweden in 2005 and lower in Norway than in the UK in the same year. The emissions were quite low; approximately 0.1 kilos per inhabitant in Norway. The reason why emissions are higher per inhabitant in Norway than in Sweden may be due to more exclusions in this source in the Swedish than in the Norwegian inventory. The Norwegian Product Register used the NACE codes at a more detailed level than the Swedish Product Register. On the other hand, the Swedish Product Register does not have the downwards 100 kilo limit for declaration that the Norwegian Product Register has. The consumption of substances in manufacture of chemicals and chemical products (NACE 24) was, per inhabitant, in the same order of magnitude in Sweden and Norway in 2005, according to the SPIN database (Nordic Product Registers 2008).

6.2.4. Other (3D)

It is especially in this source category that the NMVOC emissions are estimated to be much higher for Norway than the other two countries in this comparison. One major reason for this is the use of formic acid.

The consumption of formic acid is far higher in Norway than in Denmark and Sweden, and at similar levels as in Finland. The declared amount of formic acid was 50 440 tonnes in Norway and 20 403 tonnes in Sweden in 2005, according to the SPIN database (Nordic Product Registers 2008). The high consumption of ensilage means in Norway is due to the partiality towards acidified grass as winter forage. In Norway, almost 100 per cent of grass preserved as winter forage is silage (acified grass), while this fodder type constitutes only one third of the winter forage in Denmark. The sugar content is considerably lower in the grass types used in Norway, which calls for a higher use of ensilage means, and at the same time the conditions for drying of forage are more unpredictable in Norway than in Sweden and Denmark (Selmer-Olsen 2006). In Sweden, wilting prior to ensiling is more

common than in Norway, and this reduces the necessary amount of silage additives. Thus, more ensilage means is required in order to preserve the grass properly in Norway. The consumption of concentrated cattle feed is also traditionally lower in Norway, and thus the demand for good ensilage has been higher. In addition to this, the wet and cold climate makes the season for outdoor grazing shorter, and the need for preserved food increases (Å. T. Randby, Norwegian University of Life Sciences, *pers. comm.* 2008).

6.3. Conclusions

The new calculation method for emissions of NMVOC from solvents and other product use covers a wide range of substances and a wide range of industrial sectors and product types, and it is possible to study the emissions at a much more detailed level than the previous solvent balance. This facilitates a possible assessment of where to focus the attention when efforts to reduce the emissions take place.

The coverage is deemed to be better for the new than for the previous model, and sufficient for reporting requirements. The emission factors have been evaluated and revised through a cooperation project between the Nordic countries. I addition, the new model makes no assumptions about solvent content in products, and is thus more accurate than the previous model.

7. Areas of methodological improvement

While the new model has included most of the improvements deemed necessary for producing sufficient emission estimates of NMVOC from solvent and other product use, some potential further improvements have been identified. Some of these improvements are of such a character that they may be performed continuously as small projects and as part of the yearly update of the model. Main areas of improvement are given in prioritised order below. The priority-setting is based on the current assessment of the importance of the improvements as well as the expected resource need for each task.

7.1. Solvent balance

7.1.1. New NACE standard

A new NACE standard (SIC2007) has been introduced (Statistics Norway 2007), and this new standard will entail revision of the emission factor matrix and the source allocation matrix. The new standard will need to be incorporated in this model when the model is updated with activity data for 2008 and onwards.

7.1.2. Emission factors

Further efforts to identify and adopt emission factors from sources other than the ones currently in use, are recommended. The assumptions of similarity between Swedish and Norwegian conditions as well as the assumptions of similarities among industries need to be investigated, and if they prove not to be acceptable, new factors values have to be estimated. Reports from the Norwegian Pollution Control Authority and the Technical Guidance Document on Risk Assessment (European Chemicals Bureau 2003) can provide valuable information.

In 2008, a joint project among the Nordic countries (Fauser *et al.* In prep) aimed at improving the emissions factors used in the calculations of emissions from solvent and other product use. Further cooperation between the Nordic countries in improving and assessing emission factors would be beneficial.

7.1.3. Activity data

At present, the statistics on NMVOC only cover the emission of such substances as generated by use of products declared to the Norwegian Product Register in accordance with the duty of declaration. The emission estimates would undoubtedly benefit from increased quality and completeness of the Product Register data. The quality of the Product Register data could be improved by reducing the use of quantity intervals.

7.1.4. Hold up and accumulated amounts

Some of the products declared to the Product Register a given year are probably stored and used (or exported) in subsequent years. The extent of this should be evaluated and possibly taken into account in the emission model, e.g. by using a moving average. Such an evaluation would entail contact with declarants, and would require involvement from the Product Register.

Furthermore, when a product containing NMVOCs is used over several years, e.g. construction materials, the emissions will probably take place during the whole lifetime of the product. Such product-specific delay in emissions can be included in the current model, but a considerable amount of additional information is required. Some of this additional information may be available in the Norwegian Pollution Control Authority's monitoring of dangerous substances in products (Norwegian Pollution Control Authority 2007).

7.1.5. Identifying raw materials

Currently, some substances declared to the Product Register as raw materials are assumed to not be used as raw materials, while other substances not reported as

such are assumed to be raw materials for other products (cf. section 3.2). To evaluate whether a substance is correctly identified as a raw material one could e.g. compare reported point sources to declared quantities of raw material used.

7.1.6. Treatment of hazardous waste

A fraction of the solvent-containing products is handled as hazardous waste. This can be specified as a part of the emission factor in the new model (see section 3.1). Currently, no such waste management factors have been included in the model. In 2007, the solvent-containing products received for approved treatment amounted to approximately 100 tonnes for halogen-containing solvents, 6 160 tonnes for solvents not containing halogens, ten tonnes for trichloroethylene (TRI), and 12 600 tonnes paint and varnish (including two-component paint, solvent- and water based paint) (Statistics Norway 2009b). These amounts may seem considerable, but the declared amounts are the total weight delivered, including non-NMVOC substances in the products and packaging. There may also be some evaporation of NMVOCs during handling and repackaging of the waste.

For waste handling to be included in our model, the industrial sector and product type of the amounts delivered for approved handling need to be recognized in order to identify where in the emission factor matrix the reduction factors should be incorporated.

7.1.7. Conversion to CO_2 emissions

Currently, an average carbon content of 82 per cent is used when converting the NMVOC emissions to CO_2 emissions (cf. section 3.7). This will not give an accurate figure of the amount of CO_2 being produced by the emissions of NMVOC, as the NMVOC substances reported here have varying carbon content. By using the carbon content in each individual chemical, the estimate of CO_2 emissions would be more accurate.

Not all NMVOC included in the current model are of fossil origin. The substances of non-fossil origin should ideally not be included in the conversion to CO_2 emissions, as the reporting according to the UNFCCC Reporting Guidelines should only include emissions of fossil origin. Thus, identifying substances of non-fossil origin and excluding these when converting to CO_2 emissions would improve the accuracy of the reporting under the Kyoto protocol.

7.2. Other aspects

7.2.1. Point source specification

The point sources referred to in this report (i.e. point sources reported to CRF/NFR 3C) are currently given as total NMVOC emissions, and are not given at the substance level (see section 4.7.1). These emissions can thus not be included in analyses on a refined level. The evaluation of the emissions from production of chemicals and chemical products (NFR/CRF category 3C) would benefit from more detailed information about the substances in question. Including point sources in a more refined conversion to CO_2 emissions (cf. section 3.7) would also require emissions on a substance level. Such a specification of point sources would need to be undertaken by the Norwegian Pollution Control Authority, as point sources are reported directly to this authority.

7.2.2. Photochemical ozone creation potential

Not all NMVOC have the same potential for ground level ozone production. The photochemical ozone creation potential (POCP) can be used to assess the potential ozone production as a result of emissions of NMVOCs, and is given as a value relative to the potential reference substance. Finding a POCP values for each VOC demands considerable effort, and the POCP values will depend on external factors as well as the chemical characteristics of the substance. However, much

information regarding POCP values relevant for European conditions have already been gathered (Altenstedt & Pleijel 1998).
Because the model estimates emissions at the substance level, we have the opportunity to assess the ozone formation potential of the NMVOC emissions using POCP values. This elaboration would not be a response to reporting requirements, but a means of evaluating more explicitly the risk of ground level ozone production as a result of emissions of NMVOC. By calculating the POCP, it would also be possible to evaluate effects of substituting one NMVOC with another.

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Appendix A

Substance- and code lists

A1: Substances included in this study

Substances included in this study, supplied with CAS-numbers. Years present in the activity data is indicated with X.

Cas number	Substance name	2005	2006	2007
50-00-0	Formaldehyde	X	X	X
50-21-5	Propanoic acid, 2-hydroxy-	X	X	X
50-32-8	Benzo(a)pyrene	X	X	X
56-23-5	Carbon tetrachloride	X	X	X
56-81-5	Glycerol	X	X	X
57-13-6	Urea	X	X	X
57-55-6	1,2-Propanediol	X	X	X
60-29-7	Diethyl ether	X	X	X
62-53-3	Aniline	X	X	X
64-17-5	Ethanol	X	X	X
64-18-6	Formic acid	X	X	X
64-19-7	Acetic acid	X	X	X
64-67-5	Diethyl sulphate	X	X	X
66-25-1	1-hexanal	X	X	X
67-56-1	Methanol	X	X	X
67-63-0	2-propanol	X	X	X
67-64-1	2-propanone (acetone)	X	X	X
67-66-3	Chloroform	X	X	X
67-68-5	Methane, sulfinylbis-	X	X	X
68-12-2	N,N-Dimethylformamide	X	X	X
69-72-7	Salicylic acid	X	X	X
71-23-8	1-propanol	X	X	X
71-36-3	1-butanol	X	X	X
71-41-0	1-pentanol	X	X	X
71-43-2	Benzene	X	X	X
74-84-0	Ethane	X	X	X
74-85-1	Ethylene	X	X	X
74-86-2	Ethyne (acetylene)	X	X	X
74-89-5	Methylamine	X	X	X
74-98-6	Propane	X	X	X
74-99-7	Propyne	X	X	X
75-01-4	Vinyl chloride	X	X	X
75-05-8	Acetonitrile	X	X	X
75-07-0	Acetaldehyde	X	X	X
75-08-1	Ethanethiol			X
75-09-2	Dichloromethane	X	X	X
75-21-8	Ethylene oxide	X	X	X
75-28-5	Isobutane	X	X	X
75-35-4	1,1-dichloroethene			X
75-37-6	1,1-difluorothane	X	X	X
75-45-6	Chlorodifluoromethane	X	X	X
75-52-5	Nitromethane			X
75-56-9	Methyloxirane	X	X	X
75-64-9	Tert-butylamine	X	X	X
75-65-0	2-propanol, 2-methyl-	X	X	X
75-69-4	Trichlorofluoro-methane	X	X	X
75-71-8	Dichlorodifluoro-methane	X		
75-83-2	2,2-dimethylbutane	X	X	X
77-78-1	Dimethyl sulphate	X		
77-99-6	1,3-propanediol, 2-ethyl-2-(hydroxymethyl)-	X	X	X
78-00-2	Tetraethyllead	X	X	
78-59-1	2-cyclohexen-1-one, 3,5,5-trimethyl-	X	X	X
78-78-4	2-methylbutane	X	X	X
78-83-1	2-methyl-1-propanol	X	X	X

Cas number	Substance name	2005	2006	2007
78-87-5	1,2-dichloropropane	X	X	X
78-92-2	2-butanol	X	X	X
78-93-3	2-butanone	X	X	X
79-01-6	Trichloroethylene (TRI)	X	X	X
79-06-1	Acrylamide	X	X	X
79-09-4	Propanoic acid	X	X	X
79-10-7	Acrylic acid	X	X	X
79-20-9	Methyl acetate	X	X	X
79-29-8	2,3-dimethylbutane	X	X	X
79-33-4	Propanoic acid, 2-hydroxy-, (S)-	X	X	X
79-41-4	Methacrylic acid	X	X	X
80-43-3	Bis(alpha,alpha-dimethylbenzyl) peroxide	X	X	X
80-56-8	Bicyclo[3.1.1]hept-2-ene, 2,6,6-trimethyl-	X	X	X
80-62-6	Methyl methacrylate	X	X	X
84-66-2	1,2-benzenedicarboxylic acid, diethyl ester	X	X	X
85-44-9	Phthalic anhydride	X	X	X
87-69-4	Butanedioic acid, 2,3-dihydroxy- [R-(R*,R*)]-	X	X	X
90-12-0	Naphthalene, 1-methyl-			X
91-17-8	Naphthalene, decahydro-	X	X	X
91-20-3	Naphthalene	X	X	X
91-57-6	Naphthalene, 2-methyl-			X
91-66-7	N,N-diethylaniline	X	X	X
92-52-4	Biphenyl			X
94-36-0	Dibenzoyl peroxide	X	X	X
95-47-6	Benzene, 1,2-dimethyl-	X	X	X
95-48-7	o-cresol	X	X	X
95-50-1	1,2-dichlorobenzene	X	X	X
95-63-6	1,2,4-trimethylbenzene	X	X	X
96-14-0	3-methylpentane	X	X	X
96-29-7	2-butanone oxime	X	X	X
96-33-3	Methyl acrylate	X	X	X
96-48-0	2(3H)-furanone, dihydro-	X	X	X
96-49-1	1,3-dioxolan-2-one	X	X	X
97-64-3	Propanoic acid, 2-hydroxy-, ethyl ester	X	X	X
97-88-1	Butyl methacrylate	X	X	X
98-00-0	2-furanmethanol	X	X	X
98-01-1	2-furaldehyde	X	X	X
98-82-8	Cumene	X	X	X
98-83-9	2-phenylpropene	X	X	X
99-87-6	1-methyl-4-isopropylbenzene	X	X	X
100-37-8	Ethanol, 2-(diethylamino)-	X	X	X
100-41-4	Ethylbenzene	X	X	X
100-42-5	Benzene, ethenyl-	X	X	X
100-44-7	Alpha-chlorotoluene	X	X	X
100-51-6	Benzenemethanol	X	X	X
100-52-7	Benzaldehyde	X	X	X
100-74-3	4-ethyl morpholine	X	X	X
100-97-0	Methenamine	X	X	X
101-68-8	4,4'-methylenediphenyl diisocyanate	X	X	X
101-77-9	4,4'-methylenedianiline	X	X	X
101-84-8	Benzene, 1,1'-oxybis-	X	X	X
102-71-6	Triethanolamine	X	X	X
102-76-1	1,2,3-propanetriol, triacetate	X	X	X
103-11-7	2-ethylhexyl acrylate	X	X	X
103-76-4	1-piperazineethanol		X	X
103-82-2	Phenylacetic acid	X	X	X
103-83-3	Benzyldimethylamine	X	X	X
104-68-7	Ethanol, 2-(2-phenoxyethoxy)-	X	X	X
104-76-7	2-ethyl hexanol	X	X	X
105-37-3	Ethyl propionate			X
105-54-4	Ethyl butanoate	X	X	X
105-59-9	Ethanol, 2,2'-(methylimino)bis-	X	X	X
105-60-2	2H-azepin-2-one, hexahydro-	X	X	X

Cas number	Substance name	2005	2006	2007
106-42-3	Benzene, 1,1'-methylenebis [4-isocyanato-]	X	X	X
106-44-5	¤-kresol		X	X
106-46-7	1,4-dichlorobenzene	X	X	X
106-51-4	p-benzoquinone	X	X	X
106-65-0	Dimethyl succinate	X	X	X
106-89-8	1-chloro-2,3-epoxypropane	X	X	X
106-97-8	Butane	X	X	X
106-99-0	Buta-1,3-diene	X	X	X
107-06-2	1,2-dichloroethane	X	X	X
107-12-0	Propionitrile	X	X	X
107-13-1	Acrylonitrile	X	X	X
107-15-3	1,2-ethanediamine	X	X	X
107-18-6	2-propen-1-ol	X	X	X
107-21-1	Ethylene glycol	X	X	X
107-22-2	Glyoxal	X	X	X
107-41-5	2-methyl-2,4-pentanediol	X	X	X
107-46-0	Hexamethyldisiloxane	X	X	X
107-83-5	2-methylpentane	X	X	X
107-98-2	1-methoxy-2-propanol	X	X	X
108-01-0	Ethanol, 2-(dimethylamino)-	X	X	X
108-05-4	Acetic acid ethenyl ester	X	X	X
108-08-7	2,4-dimethylpentane	X	X	X
108-10-1	4-methyl-2-pentanone	X	X	X
108-11-2	4-methyl-2-pentanol	X	X	X
108-21-4	Acetic acid, 1-methylethyl ester	X	X	X
108-24-7	Acetic anhydride	X	X	X
108-31-6	Maleic anhydride	X	X	X
108-32-7	1,3-dioxolan-2-one, 4-methyl-	X	X	X
108-38-3	Benzene, 1,3-dimethyl-	X	X	X
108-39-4	Phenol, 3-methyl-		X	X
108-46-3	1,3-benzenediol	X	X	X
108-65-6	1-methoxy-2-propyl acetate	X	X	X
108-67-8	Mesitylene	X	X	X
108-78-1	1,3,5-triazine-2,4,6-triamine	X	X	X
108-83-8	4-heptanone, 2,6-dimethyl-	X	X	X
108-87-2	Methylcyclohexane	X	X	X
108-88-3	Toluene	X	X	X
108-90-7	Chlorobenzene	X	X	X
108-91-8	Cyclohexanamine	X	X	X
108-93-0	Cyclohexanol	X	X	X
108-94-1	Cyclohexanone	X	X	X
108-95-2	Phenol	X	X	X
109-52-4	Valeric acid			X
109-59-1	2-isopropoxyethanol	X	X	X
109-60-4	Propyl acetate	X	X	X
109-66-0	Pentane	X	X	X
109-83-1	Ethanol, 2-(methylamino)-	X	X	X
109-86-4	Ethanol, 2-methoxy-	X	X	X
109-87-5	Dimethoxymethane	X	X	X
109-99-9	Tetrahydrofuran	X	X	X
110-12-3	5-methyl-2-hexanone	X	X	X
110-15-6	Butanedioic acid	X	X	X
110-17-8	Fumaric acid	X	X	X
110-19-0	2-methylpropyl acetate	X	X	X
110-43-0	2-heptanone	X	X	X
110-54-3	N-hexane	X	X	X
110-63-4	1,4-butanediol	X	X	X
110-80-5	2-ethoxyethanol	X	X	X
110-82-7	Cyclohexane	X	X	X
110-85-0	Piperazine	X	X	X
110-86-1	Pyridine		X	X
110-91-8	Morpholine	X	X	X
110-94-1	Pentanedioic acid	X	X	X

Cas number	Substance name	2005	2006	2007
110-98-5	2-propanol, 1,1'-oxybis-	X	X	X
111-15-9	2-ethoxyethyl acetate	X	X	X
111-27-3	1-hexanol	X	X	X
111-30-8	Glutaral	X	X	X
111-40-0	2,2'-iminodi(ethylamine)	X	X	X
111-41-1	2-(2-aminoethylamino)ethanol	X	X	X
111-42-2	Ethanol, 2,2'-iminobis-	X	X	X
111-46-6	Ethanol, 2,2'-oxybis-	X	X	X
111-65-9	Octane	X	X	X
111-66-0	1-octene	X	X	X
111-76-2	2-butoxyethanol	X	X	X
111-77-3	2-(2-methoxyethoxy)-ethanol	X	X	X
111-87-5	1-octanol	X	X	X
111-90-0	2-(2-ethoxyethoxy)ethanol	X	X	X
111-96-6	Bis(2-methoxyethyl) ether	X	X	X
112-05-0	Nonanoic acid	X	X	X
112-07-2	2-butoxyethyl acetate	X	X	X
112-15-2	2-(2-ethoxyethoxy)ethyl acetate	X	X	X
112-24-3	Trientine	X	X	X
112-27-6	Ethanol, 2,2'-[1,2-ethanediylbis(oxy)]bis-	X	X	X
112-34-5	2-(2-butoxyethoxy)ethanol	X	X	X
112-35-6	Ethanol, 2-[2-(2-methoxyethoxy)ethoxy]-		X	X
115-07-1	Propylene	X	X	X
115-10-6	Dimethyl ether	X	X	X
115-11-7	2-metylpropen	X	X	X
115-77-5	1,3-propanediol, 2,2-bis(hydroxymethyl)-	X	X	X
116-14-3	Tetrafluoroethylene	X	X	X
119-61-9	Benzophenone	X	X	X
119-64-2	1,2,3,4-tetrahydronaphthalene	X	X	X
120-12-7	Anthracene			X
120-82-1	1,2,4-trichlorobenzene	X		X
121-44-8	Triethylamine	X	X	X
121-69-7	N,N-dimethylaniline	X	X	X
121-75-5	Malathion	X		X
123-31-9	Hydroquinone	X	X	X
123-35-3	Myrcene	X	X	X
123-42-2	4-methyl-4-hydroxy-2-pentanone	X	X	X
123-51-3	3-methylbutanol	X	X	X
123-54-6	2,4-pentanedione	X	X	X
123-72-8	1-butanal	X	X	X
123-86-4	Butyl acetate	X	X	X
123-91-1	1,4-dioxane	X	X	X
124-09-4	Hexamethylenediamine	X	X	
124-17-4	2-(2-butoxyethoxy)ethyl acetate	X	X	X
124-40-3	Dimethylamine	X	X	X
124-68-5	2-amino-2-methylpropanol	X	X	X
126-30-7	1,3-propanediol, 2,2-dimethyl-	X	X	X
127-09-3	Sodium acetate	X	X	X
127-18-4	Tetrachloroethene (PER)	X	X	X
127-19-5	N,N-dimethylacetamide	X	X	X
127-91-3	Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-	X	X	X
135-98-8	Sec-butylbenzene	X	X	X
137-32-6	1-butanol, 2-methyl-	X	X	X
138-86-3	Dipentene	X	X	X
140-31-8	2-piperazin-1-ylethylamine	X	X	X
140-88-5	Ethyl acrylate	X	X	X
141-32-2	Butyl acrylate	X	X	X
141-43-5	2-aminoethanol	X	X	X
141-78-6	Ethyl acetate	X	X	X
142-82-5	Heptane	X	X	X
149-57-5	2-ethylhexanoic acid	X	X	X
280-57-9	1,4-diazabicyclo[2.2.2]octane	X	X	X
287-92-3	Cyclopentane	X	X	X

Cas number	Substance name	2005	2006	2007
298-12-4	Acetic acid, oxo-	X	X	X
333-41-5	Diazinon	X	X	X
354-33-6	Ethane, pentafluoro-	X	X	X
463-82-1	Neopentane	X	X	X
526-73-8	1,2,3-trimethylbenzene	X	X	X
540-84-1	2,2,4-trimethylpentane	X	X	X
541-05-9	Hexamethylcyclotrisiloxane		X	X
552-30-7	1,2,4-tricarboxylic acid 1,2-anhydride benzene	X		
556-67-2	Octamethylcyclotetrasiloxane (D4)	X	X	X
584-84-9	4-methyl-m-phenylene diisocyanate	X	X	X
592-41-6	1-hexene	X	X	
622-96-8	4-ethyltoluene	X	X	X
623-84-7	1,2-propanediol, diacetate	X	X	X
624-92-0	Dimethyl disulphide	X	X	X
627-93-0	Hexanedioic acid, dimethyl ester	X	X	X
646-06-0	1,3-dioxolane	X	X	X
682-11-1	1,3-propanediol, 2-ethyl-2-[(2-propenyloxy)methyl]-			X
687-47-8	Etyl-(S)-2-hydroksypropionat	X	X	X
763-69-9	Propanoic acid, 3-ethoxy-, ethyl ester	X	X	X
770-35-4	2-propanol, 1-phenoxy-	X	X	X
811-97-2	Ethane, 1,1,1,2-tetrafluo	X	X	X
872-50-4	N-methyl pyrrolidone	X	X	X
919-30-2	Aminopropyltrietoxysilan	X	X	X
924-42-5	N-(hydroxymethyl) acrylamide		X	X
1119-40-0	Pentanedioic acid, dimethyl ester	X	X	X
1120-21-4	Undecane	X	X	X
1120-36-1	Tetradecane		X	
1300-71-6	Xylenol	X	X	X
1319-77-3	Phenol, methyl-	X	X	X
1320-67-8	Propanol, methoxy-	X	X	X
1330-20-7	Ethyldimethylbenzene	X	X	X
1338-23-4	2-butanone, peroxide	X	X	X
1569-01-3	2-propanol, 1-propoxy-	X	X	X
1569-02-4	1-ethoxy-2-propanol	X	X	X
1589-47-5	2-methoxypropanol	X	X	X
1634-04-4	2-methoxy-2-methylpropane	X	X	X
1965-29-3	Ethanol, 2-[[2-[(2-aminoethyl)amino]ethyl]amino]-	X	X	X
2768-02-7	Trimethoxyvinylsilane	X	X	X
2807-30-9	Ethanol, 2-propoxy-	X	X	X
2855-13-2	3-aminomethyl-3,5,5-trimethylcyclohexylamine	X	X	X
3006-82-4	Hexaneperoxoic acid, 2-ethyl-, 1,1-dimethylethyl ester	X	X	X
4767-03-7	2,2-bis(hydroxymethyl)propionic acid	X	X	X
5131-66-8	2-propanol, 1-butoxy-	X	X	X
5187-23-5	1,3-dioxane-5-methanol, 5-ethyl-	X	X	X
5625-90-1	Morpholine, 4,4'-methylenebis-	X	X	X
5989-27-5	(R)-p-mentha-1,8-diene	X	X	X
5989-54-8	(S)-p-mentha-1,8-diene	X	X	X
6876-12-6	Trans-1-methyl-4-(1-methylvinyl)cyclohexene	X	X	X
7376-31-0	Bis[tris(hydroxyethyl)ammonium] sulphate	X	X	X
7397-62-8	Acetic acid, hydroxy-, butyl ester	X	X	X
7473-98-5	1-propanone, 2-hydroxy-2-methyl-1-phenyl-	X	X	X
7705-14-8	(±)-1-methyl-4-(1-methylvinyl)cyclohexene	X		
8006-64-2	Turpentine, oil	X	X	X
8008-20-6	Kerosine	X	X	X
9002-86-2	Polyvinyl chloride	X	X	X
9004-70-0	Cellulose, nitrate	X	X	X
9005-90-7	Turpentine	X	X	X
13466-78-9	Bicyclo[4.1.0]hept-3-ene, 3,7,7-trimethyl-	X	X	X
13475-82-6	2,2,4,6,6-pentamethylheptane	X	X	X
15821-83-7	1-propanol, 2-butoxy-	X		
19089-47-5	1-propanol, 2-ethoxy-	X	X	X
19766-89-3	Sodium 2-ethylhexanoate	X	X	X
25155-25-3	Peroxide, [phenylenebis(1-methylethylidene)]bis[(1,1-	X	X	X

Cas number	Substance name	2005	2006	2007
	dimethylethyl)]			
25167-67-3	Butene	X	X	X
25265-71-8	Propanol, oxybis-	X	X	X
25265-77-4	2,2,4-trimethyl-1,3-pentanediol monoisobutyrate	X	X	X
25339-17-7	Isodecanol	X	X	X
25340-17-4	Diethylbenzene	X	X	X
25498-49-1	Propanol, [2-(2-methoxymethylethoxy)methylethoxy]-	X	X	X
26447-40-5	Methylenediphenyl diisocyanate	X	X	X
26471-62-5	M-tolylidene diisocyanate	X	X	X
29387-86-8	Propanol, butoxy-	X	X	X
29911-27-1	2-propanol, 1-(1-methyl-2-propoxyethoxy)-	X	X	X
29911-28-2	2-propanol, 1-(2-butoxy-1-methylethoxy)-	X	X	X
30525-89-4	Paraformaldehyde	X	X	X
34590-94-8	Methoxy-2-propoxy-2-propanol	X	X	X
37187-22-7	2,4-pentanedione, peroxide	X	X	X
51200-87-4	Oxazolidine, 4,4-dimethyl-	X	X	X
51774-11-9	Isoheptanol	X	X	X
52645-53-1	M-phenoxybenzyl 3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate	X	X	X
54839-24-6	1-ethoxy-2-propyl acetate	X	X	X
55934-93-5	Propanol, [(butoxymethylethoxy)methylethoxy]-	X	X	X
57350-24-0	1-propanol, 2-ethoxy-, acetate	X	X	X
63231-51-6	Aromatic hydrocarbons	X	X	X
64741-44-2	Distillates (petroleum), straight-run middle	X	X	X
64742-47-8	Distillates (petroleum), hydrotreated light	X	X	X
64742-48-9	Naphtha (petroleum), hydrotreated heavy	X	X	X
64742-49-0	Naphtha (petroleum), hydrotreated light	X	X	X
64742-81-0	Kerosine (petroleum), hydrodesulfurized	X	X	X
64742-82-1	Naphtha (petroleum), hydrodesulfurized heavy	X	X	X
64742-88-7	Solvent naphtha (petroleum), medium aliph.	X	X	X
64742-89-8	Solvent naphtha (petroleum), light aliph.	X	X	X
64742-94-5	Solvent naphtha (petroleum), heavy arom.	X	X	X
64742-95-6	Solvent naphtha (petroleum), light arom.	X	X	X
64742-96-7	Solvent naphtha (petroleum), heavy aliph.	X	X	X
64771-72-8	Paraffins (petroleum), normal C5-2-0	X	X	X
67762-38-3	Fatty acids, C16-18 and C18-unsatd., Me esters	X	X	X
68334-30-5	Fuels, diesel		X	X
68478-07-9	Naphtha (petroleum), light steam-cracked arom., piperylene conc., polymd.	X	X	X
68511-50-2	1-propene, 2-methyl-, sulfurized	X	X	X
68551-07-5	Alcohols, C8-18		X	X
70657-70-4	2-methoxypropyl acetate	X	X	X
84540-57-8	Propanol, methoxy-, acetat	X	X	X
85586-25-0	Fatty acids, rape-oil, Me esters	X	X	X
90622-56-3	Alkanes, C7-10-iso-	X	X	X
90622-57-4	Alkanes, C9-12-iso-	X	X	X
90622-58-5	Alkanes, C11-15-iso-	X	X	X
90669-79-7	Paraffins (petroleum), normal C5-20, acid- and clay-treated		X	X
91722-33-7	Tar, wood	X	X	X
91770-15-9	Kerosine (petroleum), sweetened	X	X	X
92045-36-8	Kerosine (petroleum), solvent-refined sweetened	X	X	X
111109-77-4	Propane, oxybis[methoxy]-	X	X	X

A2: Standard Industrial Classification (SIC2002/NACE)

The standard for industrial classification (NACE) used in this model (Statistics Norway 2002b).

NACE	Title
1	Agriculture, hunting and related service activities
2	Forestry, logging and related service activities
5	Fishing, fish farming and related service activities
10	Mining of coal and lignite, extraction of peat
11	Extraction of crude petroleum and natural gas, service activities incidental to oil and gas extraction excluding surveying
12	Mining of uranium and thorium ores
13	Mining of metal ores
14	Other mining and quarrying
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel, dressing and dyeing of fur
19	Tanning and dressing of leather, manufacture of luggage, handbags, saddlery, harness and footwear
20	Manufacture of wood and of products of wood and cork, except furniture, manufacture of articles of straw and plaiting materials
21	Manufacture of pulp, paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Manufacture of coke, refined petroleum products and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastic products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
30	Manufacture of office machinery and computers
31	Manufacture of electrical machinery and apparatus n.e.c.
32	Manufacture of radio, television and communication equipment and apparatus
33	Manufacture of medical, precision and optical instruments, watches and clocks
34	Manufacture of motor vehicles, trailers and semi-trailers
35	Manufacture of other transport equipment
36	Manufacture of furniture, manufacturing n.e.c.
37	Recycling
40	Electricity, gas, steam and hot water supply
41	Collection, purification and distribution of water
45	Construction
50	Sale, maintenance and repair of motor vehicles and motorcycles, retail sale of automotive fuel
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52	Retail trade, except of motor vehicles and motorcycles. Repair of personal and household goods
55	Hotels and restaurants
60	Land transport. transport via pipelines
61	Water transport
62	Air transport
63	Supporting and auxiliary transport activities, activities of travel agencies
64	Post and telecommunications
65	Financial intermediation, except insurance and pension funding
66	Insurance and pension funding, except compulsory social security
67	Activities auxiliary to financial intermediation
70	Real estate activities

NACE	Title
71	Renting of machinery and equipment without operator and of personal and household goods
72	Computers and related activities
73	Research and development
74	Other business activities
75	Public administration and defence, compulsory social security
80	Education
85	Health and social work
90	Sewage and refuse disposal, sanitation and similar activities
91	Activities of membership organizations n.e.c.
92	Recreational, cultural and sporting activities
93	Other service activities
95	Activities of households with employed persons
99	Extra-territorial organizations and bodies

A3: Use Code Nordic (UCN)

UCN are product types developed by the Nordic Product Register Group – a subgroup under the Nordic Chemical Group – Nordic Council of Ministers (Product Register 2007)

Product code	Product type
A05100	Filtration materials
A05200	Filtration media
A05250	Ion exchanger
A05300	Air cleaners and anti-odour agents (not filters)
A05400	Other absorbents and adsorbents
A20100	Anti-scaling agents
A25100	Anti-set-off agents
A40100	De-icing agents
A40200	Cooling agents
A40300	Other anti-freezing agents
A45100	Anti-clotting agents
A50100	Anti-tack agents
A55100	Anti-static agents
A60100	Dressing agents (glazing agents, polishing agents)
B15110	Human hygiene biocidal products (PT1)
B15120	Private area and public health area disinfectants and other biocidal products (PT2)
B15130	Veterinary hygiene biocidal products (PT3)
B15140	Food and feed area disinfectants (PT4)
B15142	Sanitation agents for toilets
B15150	Drinking water disinfectants (PT5)
B15310	In-can preservatives (PT6)
B15315	Wood preservatives (PT8)
B15320	Film preservatives (PT7)
B15330	Fibre, leather, rubber and polymerised materials preservatives (PT9)
B15340	Masonry preservatives (PT10)
B15350	Preservatives for liquid-cooling and processing systems (PT11)
B15360	Slimicides (PT12)
B15370	Metalworking-fluid preservatives (PT13)
B15510	Rodenticides (PT14)
B15520	Avicides (PT15)
B15530	Molluscicides (PT16)
B15540	Piscicides (PT17)
B15550	Insecticides, acaricides and products to control other arthropods (PT18)
B15560	Repellents and attractants (PT19)
B15710	Preservatives for food or feedstock (PT20)
B15720	Antifouling (PT21)
B15730	Embalming and taxidermist fluids (PT22)
B15740	Control of other vertebrates (PT23)
B16110	Insecticides
B16120	Fungicides
B16130	Herbicides (weed killers)
B16140	Growth inhibitors
B16150	Soil disinfection agents
B16190	Other plant protection products
B18100	Car care products
B20100	Binding agents for paints, adhesives etc
B20200	Binding agents for moulding sand
B20300	Other binding agents
B25200	Bleaching agents for textiles
B25300	Other bleaching agents
B30100	Blasting agents (sandblasting agents)
B35100	Softeners for plastic, rubber, paint and adhesive
B35200	Softeners - Softeners not included in B35100
B45100	Flame retardants
B50100	Fire extinguishing agents
B55100	Motor fuels
B55150	Ignition gas
B55200	Heating fuels
B55300	Other fuels
B60100	Anti-knocking agents
B60200	Other fuel additives
B65100	Deposit inhibitors
D05100	Denaturing agents
D15100	Propellants
D20100	Industry perfumes - (odorants)

Product code	Product type
D20200	Deodorants - Chemicals and products that not are cosmetic products
D20300	Other odour agents
D25100	Dental products
E03100	Expanding products
E05100	Extraction agents
E07100	Semiconductors
E07200	Commutators and materials for commutators
E07300	Conductive materials
E07400	Dielectrics
E07500	Transformers and materials for transformers
E07900	Other electric and electromechanical components
E10100	Electrolytes
E15100	Emulsion-inhibiting agents
E20100	EP-additives
F05100	Pigments to glazing materials, enamels and glass
F05110	Pigments to paint and printing inks
F05250	Pigment pastes
F05400	Regenerator to colours
F05990	Other colouring agents
F10100	Fixatives
F10300	Fixing agents for photocopies
F10400	Fixing agents for offset plates
F10700	Other fixing agents
F12100	Coating agents
F15100	Flotation agents
F20100	Flux agents (casting)
F32100	Bleachers for photographic film
F32150	Toners to photographic paper
F32200	Fixatives for photographic film
F32300	Developers for photographic film
F32400	Film hardeners
F32600	Photographic emulsions
F32800	Stopping bath
F32900	Retouch chemicals
F32990	Other photographic chemicals
F35200	Developers for photocopies
F35300	Offset developers
F35400	Other developers
F40100	Friction agents
F45100	Reinforcing fillers
F45200	Extenders
F45300	Other fillers
F50100	Flocculating chemicals
F50150	Slag initiators
F50200	Poly-electrolytes
F50300	Other flocculating agents
G05100	Salts for galvanic baths
G05200	Glazing additives
G05300	Flux agents for hot electroplating
G05400	Other galvano-technical agents
G10100	Hair remover
G10200	Tannin
G10300	Pyring remedies
G10400	Thouging products
G10990	Other tanning agents
G12300	Calendring agents
G12900	Other glossing agents
G15100	Enamels
G15200	Glazing materials
G15300	Other related coatings
G30100	Joint-less floors
G30200	Other flooring materials
G35100	Rubberising materials
G40100	Fertilizers
H10100	Hydraulic oils
H10200	Brake Fluids
H10990	Hydraulic fluids, by general
H15100	Concrete hardeners

Product code	Product type
H15400	Plastic hardeners
H15500	Other hardeners
I05100	Leather impregnation agents
I05200	Paper impregnation agents
I05300	Textile impregnation agents
I05400	Wood impregnation agents , wood preserving agents
I05450	Closing net proofing
I05500	Other impregnation agents
I15100	Fire prevention materials
I15200	Other thermic insulating materials
I15300	Electric current insulation materials
I15400	Sound insulating materials
I15500	Light insulating materials
I15600	Other insulation materials
K15100	Coagulating agents
K20100	Sequestering agents
K25100	Anti-mist agents
K25200	Condensation removers
K25300	Other anti-condensation agents
K35100	Cement/concrete/mortar
K35120	Fireproof cement
K35200	Plastic construction materials
K35300	Steel construction materials
K35500	Road construction materials
K35900	Other construction materials
K40100	Contactors (electrical)
K45100	Correction lacquers (offices)
K45200	Correction lacquers (printing plates)
K45400	Erasing fluid
K45500	Eraser (rubber)
K45600	Other correction materials
K52110	Shaving foams
K52120	Shaving creams and lotions
K52190	Other shaving products
K52210	Body lotions
K52220	Face creams
K52230	Eye creams
K52240	Hands creams
K52250	Leg creams
K52260	Foot creams
K52270	Exfoliating creme
K52280	Depilatories
K52290	Sunbathing creams
K52300	After sun preparations
K52310	Skin cleaning products and soap (toilet soaps, deodorant soaps, bath foams, shower gels)
K52320	Eye make-up removers
K52330	Make-up removers
K52350	Skin tonic
K52360	Bath salts and oils
K52370	Skin protection preparations
K52380	Face masks
K52390	Face steam bath
K52400	Anti-wrinkle products
K52410	Massage oils
K52420	Body powders
K52430	Products for external intimate hygiene
K52440	Skin-whitening products
K52450	Corn remedies
K52460	Deodorants
K52470	Antiperspirants
K52480	Skin care preparations for babies
K52490	Other skin care preparations
K52510	Hair bleaches
K52520	Hair dye permanent
K52530	Hair dye, semi-permanent
K52540	Hair dye, temporary
K52550	Hair cosmetics
K52560	Hair cleansing products (shampoos, powders etc)

Product code	Product type	
K52570	Lotions for straighten out hair	
K52580	Water undulation lotions	
K52590	Permanent remedies	
K52600	Hair balsam	
K52610	Hair lotion	
K52620	Hair mousse	
K52630	Hair wax	
K52640	Hair spray (hair lacquer)	
K52650	Other hair setting products	
K52660	Hair treatment	
K52690	Other hair dressing products	
K52710	Eye shadow	
K52720	Mascara	
K52730	Liner (kajal)	
K52740	Other Eye make-up	
K52750	Rouge	
K52760	Powder (face)	
K52770	Lipstick and Lip salve	
K52780	Lip liner	
K52790	Other face make-up	
K52800	Nail varnish	
K52810	Nail varnish remover	
K52820	Nail hardner	
K52830	Cuticle remover	
K52840	Other products for nail care and make-up	
K52850	Face paints	
K52860	Artist make-up and effects	
K52870	Body paints	
K52880	Products for tanning without sun	
K52890	Perfumes, toilet waters and eau de Cologne	
K52900	Other cosmetic products	
K52910	Toothpaste for children	
K52920	Toothpaste and other tooth-cleaning products	
K52930	Tooth bleaching	
K52940	Dental plate remedy	
K52950	Tooth rinsing remedies	
K52960	Chewing gum	
K52980	Other tooth and mouth care products	
K55100	Cooling agents	
K60100	Drilling oils	
K60140	Threading oils	
K60150	Honing oils	
K60160	Lubricants for broaching	
K60200	Cooling agents for grinding	
K60250	Other fluids for removing metal	
K60300	Milling oils	
K60350	Other fluids for modelling metal	
K60400	Punching oils	
K60450	Other fluids for cutting metal	
K60500	Other cutting fluids	
L05100	Reagents	
L05200	Indicators (pH-Indicators)	
L05250	Nutritive medium - Chemicals and products that for growing of micro-organisms	
L05300	Other laboratory chemicals	
L10…	Adhesives	
…	10 water based	1 Industrial use
…	20 based on organic thinners	2 Consumer use
…	30 No thinner	
…	40 Powder	
…	50 Cyanoacrylate	
	60 Hardner for adhesive	
L15100	Flux agents for soldering	
L15200	Soldering metals	
L15990	Other soldering agents	
L20050	Veterinary pharmaceuticals	
L20080	Anaesthesia	
L20100	Pharmaceuticals for organs of digestion and metabolism	
L20200	Pharmaceuticals for blood and blood-generating organs	

Product code	Product type		
L20250	Pharmaceuticals for heart- and circulation		
L20300	Pharmaceuticals for skin treatment (dermatological agents)		
L20400	Pharmaceuticals for the urinary system (not sexual hormones)		
L20430	Sexual hormones (incl contraceptive (P-) pills)		
L20450	Hormones for systemic use		
L20500	Pharmaceuticals for infectious diseases, systemic preparations		
L20600	Pharmaceuticals for muscles, joints and bones		
L20700	Pharmaceuticals for the central nervous system		
L20800	Pharmaceuticals for respiration organs		
L20850	Pharmaceuticals for sense organs		
L20910	AI preparations		
L20920	Cytostatica and immune-suppressive preparations		
L20930	Other therapeutic preparations		
L20940	Diagnostic preparations		
L20960	Diet preparations		
L20990	Other pharmaceuticals		
M05…	Paint and varnish		
…	1 Water based	1 Active biolgical/biocide function (not antifouling)	1 Interior
…	2 Volatile organic thinner	2 Fire prevention	2 Exterior
…	3 Non volatile organic thinner eg Linseed oil	3 Active corrosion inhibitor	3 Industrial use
…	4 No thinner	4 Decorative/protection	4 Base colour for boats and ships
…	5 Powder based	9 Other (including road-, art-, furniture-, autopaint)	5 Powder based
…	6 Hardeners to paint and varnish		
M08100	Additives for paint and varnishes not mentioned elsewhere in the table Pigments is not to be classified in this code		
M10100	Remover for printing ink		
M10200	Graffiti removers		
M10300	Paint and varnish removers		
M15100	Metal staining agents		
M15200	Non-galvanic metal surface coatings (chromatisising agents)		
M15300	Hardening agents (metal, tarnishing agents)		
M15400	Rust removers		
M15500	Other surface treatment of metal		
O15100	Solvents		
O25100	Moisturizers		
O25200	Dispersion agents (carriers)		
O25300	Emulsifiers		
O25400	Anti foaming agents, foamreducing agents		
O25500	Other surface active agents		
O27100	Surface treatment for paper and cardboard		
O27200	Corroding agent for electronics		
O27300	Corroding agent for glass		
O27900	Other surface treatment for other non-metals		
O30100	Stove black polish		
O40100	Burnishing (bronzing) agents		
O40200	Other oxidation agents		
P01200	Bearing linings		
P01300	Gaskets, unspecified		
P01400	Gaskets for fuel engines		
P01600	Gaskets for pumps,machines, boilers etc		
P01900	Other gaskets		
P05100	PH-regulating agents		
P10050	Polishing agents for rubber materials		
P10100	Polishing agents for lacquers (car wax)		
P10150	Polishing agents for leather (incl shoe polish)		
P10200	Polishing agents for metal		
P10400	Polishing agents for furniture		
P10450	Polishing agents for plastic materials		
P10500	Wax and other polishing preparations for floors		
P10990	Other polishing agents		
P15100	Accelerators		
P15200	Activators		
P15300	Retarders		
P15400	Other inhibitors		

Product code	Product type
P15500	Catalysts
P15900	Process regulators
R03100	Radioactive materials
R05100	Reduction agents
R10100	Degreasers (cold degreasing, de-waxing, de-polishing)
R10130	Drain cleaners
R10150	General cleaning/washing agents (floor wash, basic cleaning)
R10160	Auto shampoo
R10250	Glass- and window cleaner (window polish)
R10330	High pressure cleaning/washing agents
R10340	Anti-incrustators
R10350	Lime deposit (calcium) remover
R10370	Cleaning/washing agents for washing machines
R10400	Cleaning/washing agents for dish washing (machines)
R10450	Stove- and grill cleaning agents
R10500	Spot (stain) removers
R10600	Foam cleaning/washing agents
R10700	Windscreen washing agents
R10800	Carpet detergents
R10970	Washing agents for textile (detergents)
R10980	Optical whiteners
R10990	Other cleaning/washing agents
R15100	Cracking indicators
R20100	Underseal materials, incl cavity seals
R20200	Corrosion inhibitors
R20900	Other anti-corrosion materials
R30100	Raw materials for synthesis and intermediate products
R30200	Raw materials for production of glass and ceramics
R30300	Raw materials for production of rubber products
R30400	Raw materials for production of semi-conductors
R30500	Raw materials for production of cosmetics etc
R30600	Raw materials for production of medicament/medicine
R30700	Raw materials for production of metals
R30800	Raw materials for production of plastics
R30900	Raw materials for production of paper
R30990	Other raw materials
S05150	Oil sanitation agents
S05200	Other sanitation agents
S07100	Sensitisers for photocopies
S07200	Sensitisers for serigraphy
S07900	Other sensitisers
S10100	Writing ink
S10200	Ribbons
S10300	Carbon paper
S10400	Self-copying paper
S10500	Spirit markers
S10600	Other writing materials
S15100	Foaming agents for solid materials, plastic, rubber etc
S15200	Foaming agents for liquids
S25100	Rinsing agents (for dish washing machines)
S25500	Rinsing agents (textiles)
S25990	Other rinsing agents
S30100	Sludge treatment preparations
S35100	Abrasives
S40100	Oils and waxes for laths and shutters
S40200	Casting slips for plastic etc
S40300	Slip agents for modelling metal
S40400	Slip agents for sand moulding
S40500	Other anti-setoff agents
S42100	Aroma boosters
S42200	Ensilage means
S42300	Nutrient - (included vitamins)
S42500	Sweetening agents
S42600	Food colours
S42900	Other food and fodder additives
S45110	Base Oils
S45120	Brake grease
S45150	Gear oils

Product code	Product type		
S45170	Stiff (cup) grease		
S45180	Motor oils		
S45200	Friction-reducing additives		
S45250	Additive to lubricating agents		
S45300	Other lubricants		
S50100	Gunpowder		
S50200	Pyrotechnical products		
S50900	Other explosives		
S60100	Antioxidants (anti-ozonants)		
S60150	Anti-siccatives		
S60200	Other stabilizers		
S65100	Moulding compounds		
S70100	Dust laying agents		
S75100	Flux agents for welding		
S75200	Electrodes (welding)		
S75400	Other welding auxiliaries		
S80100	Stimulating agents		
T10200	Toners for photocopies and laserprinters		
T10900	Other toners		
T15…	Printing ink		
…	1 Water base	1 Letterpress printing	2 Metal
…	2 Based on organic thinner	2 Rotogravure	3 Plastic
…	3 No thinner	3 Flexocolour (aniline dye)	4 Fabric
…	4 Powder	4 Offset printing	5 Other
…	5 Hardener to printing inks	5 Serigraphic printing	2 Metal
…	6 Additive to printing inks	6 Fabric printing	
		7 Other	
T20100	Drying agents		
U05100	Padding (filling) materials		
U05200	Stopping material		
U05300	Tightening materials (putty)		
U05340	Sealing agents for rock		
U05350	Curing agents for padding		
U05400	Other filling materials		
V05100	Water softeners		
V10100	Heat transmission agents		
V15100	Thickening agents		
V15200	Gelatinising agents		
V15400	Thixotropic additives		
V15500	Other viscosity-changing agents		
V20100	Vulcanizers		
X05984-Y99999	Dummy codes		

A4: Raw materials (Intermediates)

List of substances assumed to be raw material (intermediates) when associated with a product type code for raw material (R30). The selection is based on Fischer et al. (2005).

CAS number	Substance name
50-00-0	Formaldehyde
50-32-8	Benzo(a)pyrene
75-01-4	Vinyl chloride
75-07-0	Acetaldehyde
75-21-8	Ethylene oxide
77-73-6	4,7-methano-1H-indene, 3a,4,7,7a-tetrahydro-
85-44-9	Phthalic anhydride
106-99-0	Buta-1,3-diene
107-06-2	1,2-dichloroethane
107-13-1	Acrylonitrile
108-95-2	Phenol
127-18-4	Tetrachloroethene (PER)
584-84-9	4-methyl-m-phenylene diisocyanate

A5: CRF and NFR codes in which emissions of NMVOC are reported

CRF codes under which indirect CO_2 emissions from NMVOC were reported to the UN as part of the obligations under the Kyoto protocol, and NFR codes under which NMVOC emissions were reported to the LRTAP under the obligations under the Gothemburg protocol (2008 reporting format). Extentions are given for NFR codes relevant for the emissions referred to in this report.

CRF and NFR code	Description	NFR extention
1	**1 TOTAL ENERGY**	
1A	**A Fuel Combustion Activities**	
1B	**B Fugitive Emissions from Fuels**	
2	**2 TOTAL INDUSTRIAL PROCESSES**	
2A	**A Mineral Products**	
2B	**B Chemical Industry**	
2C	**C Metal Production**	
2D	**D Other production**	
2G	**G Other (mines)**	
3	**3 TOTAL SOLVENT AND OTHER PRODUCT USE**	
3A	**A Paint Application**	**3 A Paint Application** 3 A i Decorative paint application 3 A ii Industrial paint application 3 A iii Other paint application
3B	**B Degreasing and Dry Cleaning**	**3 B Degreasing and Dry Cleaning** 3 B i Degreasing 3 B ii Dry cleaning 3 B iii Other
3C	**C Chemical Products, Manufacture and Processing**	**3 C Chemical Products, Manufacture and Processing**
3D	**D Other**	**3 D Other (including products containing HMs and POPs)** 3 D i Printing 3 D ii Preservation of wood 3 D iii Domestic solvent use 3 D iv Other including products containing HMs and POPs
4	**4 TOTAL AGRICULTURE**	
4F	**F Field Burning of Agricultural Residues**	
4G	**G Other**	
5	**5 TOTAL LAND-USE CHANGE AND FORESTRY**	
5B	**B Forest and grassland conversion**	
6	**6 TOTAL WASTE**	
6A	**A Solid Waste Disposal on Land**	
6B	**B Wastewater Handling**	
6C	**C Waste Incineration**	
6D	**D Other**	
7	**7 OTHER**	

A6: NFR source allocation

Source allocation of CAS number, product type and NACE, based on the NFR sources with extentions. The product type codes (from and to) refer to Appendix A3 (chronologically) and the NACE codes (from and to) refer to Appendix A2 (chronologically). The CRF categories include the first number and letter in the NFR codes.

CAS number	Product type (from)	Product type (to)	NACE (from)	NACE (to)	NFR with extentions
All	M05000	M08100	Private households	Public use	3A i
All	M05000	M08100	45.000	45.999	3A i
All	M05000	M08100	51.000	52.999	3A i
All	M05000	M08100	34.000	34.999	3A ii
All	M05000	M08100	50.000	50.999	3A ii
All	M05000	M08100	01.000	24.299	3A ii
All	M05000	M08100	24.400	33.999	3A ii
All	M05000	M08100	35.000	37.999	3A ii
All	M05000	M08100	40.000	44.999	3A iii
All	M05000	M08100	46.000	49.999	3A iii
All	M05000	M08100	53.000	99.998	3A iii
All	M05000	M08100	Ureg	Ureg	3A iii
All	R10100	R10100	27.000	35.999	3B i
All	R10100	R10100	37.100	37.100	3B i
All	A55100	A60100	93.000	93.019	3B ii
All	B15120	B15120	93.000	93.019	3B ii
All	B15140	B15140	93.000	93.019	3B ii
All	B15330	B15330	93.000	93.019	3B ii
All	B25200	B25200	93.000	93.019	3B ii
All	B35200	B35200	93.000	93.019	3B ii
All	D20300	D20300	93.000	93.019	3B ii
All	F05990	F05990	93.000	93.019	3B ii
All	G10400	G10400	93.000	93.019	3B ii
All	I05100	I05100	93.000	93.019	3B ii
All	I05300	I05300	93.000	93.019	3B ii
All	I05500	I05500	93.000	93.019	3B ii
All	K20100	K20100	93.000	93.019	3B ii
All	M10300	M10300	93.000	93.019	3B ii
All	O15100	O15100	93.000	93.019	3B ii
All	O25100	O25500	93.000	93.019	3B ii
All	P05100	P05100	93.000	93.019	3B ii
All	R10100	R10100	93.000	93.019	3B ii
All	R10150	R10150	93.000	93.019	3B ii
All	R10350	R10350	93.000	93.019	3B ii
All	R10400	R10400	93.000	93.019	3B ii
All	R10500	R10600	93.000	93.019	3B ii
All	R10800	R10990	93.000	93.019	3B ii
All	R20200	R20200	93.000	93.019	3B ii
All	R30000	R30999	93.000	93.019	3B ii
All	S25100	S25500	93.000	93.019	3B ii
All	R10000	R10999	01.000	26.999	3B iii
All	R10000	R10999	36.000	37.000	3B iii
All	R10000	R10999	37.200	37.999	3B iii
All	R10110	R10999	27.000	35.999	3B iii
All	A40200	A40300	24.000	25.999	3C
All	B20300	B20300	24.000	24.099	3C
All	B20300	B20300	24.200	25.999	3C
All	B25300	B25300	24.000	25.999	3C
All	E03100	E03100	24.000	25.999	3C
All	H15400	H15400	24.000	25.999	3C
All	K35200	K35200	24.000	24.099	3C
All	K35200	K35200	24.200	25.999	3C
All	M05000	M08100	24.300	24.399	3C
All	O15100	O15100	24.000	24.099	3C
All	O15100	O15100	24.200	25.999	3C
100-42-5	O15100	O15100	Public use	Public use	3C
All	P15900	P15900	24.000	25.999	3C

CAS number	Product type (from)	Product type (to)	NACE (from)	NACE (to)	NFR with extentions
All	R30000	R30999	17.000	19.999	3C
All	R30000	R30999	24.000	24.099	3C
All	R30000	R30999	24.200	25.999	3C
All	S42200	S42200	24.000	24.099	3C
All	S42200	S42200	24.200	25.999	3C
All	X99998	X99998	24.000	25.999	3C
All	A05000	B54999	22.000	22.999	3D i
All	B61000	L09000	22.000	22.999	3D i
All	L11000	M04999	22.000	22.999	3D i
All	M10000	O04999	22.000	22.999	3D i
All	O05020	R09000	22.000	22.999	3D i
All	R11000	Y99999	22.000	22.999	3D i
All	B15000	B16999	20.000	20.999	3D ii
All	I05000	I05999	20.000	20.999	3D ii
All	R30000	R30999	20.000	20.999	3D ii
All	V15400	V15499	20.000	20.999	3D ii
All	A05000	B54999	Private households	Public use	3D iii
All	A05000	B54999	52.000	52.999	3D iii
All	A05000	B54999	50.500	50.599	3D iii
All	A05000	B54999	92.600	92.799	3D iii
All	A05000	B54999	93.020	93.029	3D iii
All	A05000	B54999	93.050	93.059	3D iii
64771-72-8[9]	B55300	B55300	Private households	Public use	3D iii
64771-72-8[9]	B55300	B55300	52.000	52.999	3D iii
64771-72-8[9]	B55300	B55300	50.500	50.599	3D iii
64742-47-8[9]	B55300	B55300	Private households	Public use	3D iii
64742-47-8[9]	B55300	B55300	52.000	52.999	3D iii
64742-47-8[9]	B55300	B55300	50.500	50.599	3D iii
64742-48-9[9]	B55300	B55300	Private households	Public use	3D iii
64742-48-9[9]	B55300	B55300	52.000	52.999	3D iii
64742-48-9[9]	B55300	B55300	50.500	50.599	3D iii
64-17-5[9]	B55300	B55300	Private households	Public use	3D iii
64-17-5[9]	B55300	B55300	52.000	52.999	3D iii
64-17-5[9]	B55300	B55300	50.500	50.599	3D iii
78-93-3[9]	B55300	B55300	Private households	Public use	3D iii
78-93-3[9]	B55300	B55300	52.000	52.999	3D iii
78-93-3[9]	B55300	B55300	50.500	50.599	3D iii
108-10-1[9]	B55300	B55300	Private households	Public use	3D iii
108-10-1[9]	B55300	B55300	52.000	52.999	3D iii
108-10-1[9]	B55300	B55300	50.500	50.599	3D iii
141-78-6[9]	B55300	B55300	Private households	Public use	3D iii
141-78-6[9]	B55300	B55300	52.000	52.999	3D iii
141-78-6[9]	B55300	B55300	50.500	50.599	3D iii
67-63-0[9]	B55300	B55300	Private households	Public use	3D iii
67-63-0[9]	B55300	B55300	52.000	52.999	3D iii
67-63-0[9]	B55300	B55300	50.500	50.599	3D iii
67-64-1[9]	B55300	B55300	Private households	Public use	3D iii
67-64-1[9]	B55300	B55300	52.000	52.999	3D iii
67-64-1[9]	B55300	B55300	50.500	50.599	3D iii
All	B61000	L19000	Private households	Public use	3D iii
All	B61000	L19000	52.000	52.999	3D iii
All	B61000	L19000	50.500	50.599	3D iii
All	B61000	L19000	92.600	92.799	3D iii
All	B61000	L19000	93.020	93.029	3D iii
All	B61000	L19000	93.050	93.059	3D iii
All	M10000	O04999	Private households	Public use	3D iii
All	M10000	O04999	52.000	52.999	3D iii
All	M10000	O04999	50.500	50.599	3D iii
All	M10000	O04999	92.600	92.799	3D iii
All	M10000	O04999	93.020	93.029	3D iii

[9] Typical component in lighter fuel

CAS number	Product type (from)	Product type (to)	NACE (from)	NACE (to)	NFR with extentions
All	M10000	O04999	93.050	93.059	3D iii
All	O05020	Y99999	Private households	Public use	3D iii
All	O05020	Y99999	52.000	52.999	3D iii
All	O05020	R10000	50.500	50.599	3D iii
All	O05020	Y99999	92.600	92.799	3D iii
All	O05020	Y99999	93.020	93.029	3D iii
All	O05020	Y99999	93.050	93.059	3D iii
All	R10130	R19000	50.500	50.599	3D iii
All	R21000	Y99999	50.500	50.599	3D iii
All	A05000	B54999	01.000	19.999	3D iv
All	A05000	B14999	20.000	20.999	3D iv
All	A05000	B54999	21.000	21.999	3D iv
All	A05000	B54999	23.000	23.999	3D iv
All	A05000	B54999	26.000	37.999	3D iv
All	A05000	A40199	24.000	25.999	3D iv
All	A05000	L20999	Ureg	Ureg	3D iv
All	A05000	B54999	38.000	49.999	3D iv
All	A05000	B54999	50.000	50.499	3D iv
All	A05000	B54999	53.000	92.599	3D iv
All	A05000	A55000	93.000	93.019	3D iv
All	A05000	B54999	94.000	99.998	3D iv
All	A05000	A55000	93.030	93.049	3D iv
All	A05000	B54999	51.000	51.999	3D iv
All	A05000	M04999	45.320	45.320	3D iv
All	A40400	B20299	24.000	25.999	3D iv
All	A60200	B15110	93.000	93.019	3D iv
All	A60200	B15110	93.030	93.049	3D iv
All	B15130	B15130	93.000	93.019	3D iv
All	B15130	B15130	93.030	93.049	3D iv
All	B15142	B15320	93.000	93.019	3D iv
All	B15150	B15320	93.030	93.049	3D iv
All	B15340	B25100	93.000	93.019	3D iv
All	B15340	B25100	93.030	93.049	3D iv
All	B17000	B54999	20.000	20.999	3D iv
All	B20400	B25299	24.000	25.999	3D iv
All	B25300	B35100	93.000	93.019	3D iv
All	B25300	B35100	93.030	93.049	3D iv
All	B25400	B54999	24.000	25.999	3D iv
All	B35300	B54999	93.000	93.019	3D iv
All	B35300	B54999	93.030	93.049	3D iv
All	B61000	L09000	01.000	14.999	3D iv
All	B61000	E05000	15.400	15.499	3D iv
All	B61000	L09000	17.000	19.999	3D iv
All	B61000	I04999	20.000	20.999	3D iv
All	B61000	L09000	21.000	21.999	3D iv
All	B61000	L09000	23.000	23.999	3D iv
All	B61000	L09000	26.000	37.999	3D iv
All	B61000	E03099	24.000	25.999	3D iv
All	B61000	M04999	38.000	49.999	3D iv
All	B61000	M04999	50.000	50.499	3D iv
All	B61000	L20050	53.000	92.599	3D iv
All	B61000	D20200	93.000	93.019	3D iv
All	B61000	M04999	94.000	99.998	3D iv
All	B61000	D20200	93.030	93.049	3D iv
All	B61000	M04999	51.000	51.999	3D iv
All	B61000	L09000	15.000	15.399	3D iv
All	B61000	L09000	15.500	16.999	3D iv
All	D20400	F05400	93.000	93.019	3D iv
All	D20400	F05400	93.030	93.049	3D iv
All	E03200	H15399	24.000	25.999	3D iv
All	E05100	E05100	15.400	15.499	3D iv
All	E06000	L09000	15.400	15.499	3D iv

CAS number	Product type (from)	Product type (to)	NACE (from)	NACE (to)	NFR with extentions
All	F10100	G10300	93.000	93.019	3D iv
All	F10100	G10300	93.030	93.049	3D iv
All	G10500	I05000	93.000	93.019	3D iv
All	G10500	I05000	93.030	93.049	3D iv
All	H15500	K35199	24.000	25.999	3D iv
All	I05200	I05200	93.000	93.019	3D iv
All	I05200	I05200	93.030	93.049	3D iv
All	I05400	I05450	93.000	93.019	3D iv
All	I05400	I05450	93.030	93.049	3D iv
All	I05600	K20000	93.000	93.019	3D iv
All	I05600	K20000	93.030	93.049	3D iv
All	I06000	L09000	20.000	20.999	3D iv
All	K20200	L20050	93.000	93.019	3D iv
All	K20200	L20050	93.030	93.049	3D iv
All	K35300	L09000	24.000	25.999	3D iv
All	L10000	L10999	01.000	37.999	3D iv
All	L11000	M04999	01.000	21.999	3D iv
All	L11000	M04999	23.000	23.999	3D iv
All	L11000	M04999	26.000	37.999	3D iv
All	L15000	L20999	24.000	25.999	3D iv
All	L20000	L20999	Private households	Public use	3D iv
All	L20000	L20999	50.000	50.999	3D iv
All	L20000	L20999	52.000	52.999	3D iv
All	L20080	L20080	53.000	84.999	3D iv
All	L20080	L20080	86.000	92.599	3D iv
All	L20080	L20080	85.000	85.999	3D iv
All	L20100	M04999	53.000	92.599	3D iv
All	L20100	M04999	93.000	93.019	3D iv
All	L20100	M04999	93.030	93.049	3D iv
All	M10000	O04999	01.000	10.999	3D iv
All	M10000	O04999	11.000	11.999	3D iv
All	M10000	O04999	12.000	21.999	3D iv
All	M10000	O04999	23.000	23.999	3D iv
All	M10000	O04999	26.000	37.999	3D iv
All	M10000	O04999	24.000	25.999	3D iv
All	M10000	Y99999	Ureg	Ureg	3D iv
All	M10000	O04999	38.000	49.999	3D iv
All	M10000	O04999	50.000	50.499	3D iv
All	M10000	O04999	53.000	92.599	3D iv
All	M10000	M10200	93.000	93.019	3D iv
All	M10000	O04999	94.000	99.998	3D iv
All	M10000	M10200	93.030	93.049	3D iv
All	M10000	O04999	51.000	51.999	3D iv
All	M10000	Y99999	45.320	45.320	3D iv
All	M10990	O04999	93.000	93.019	3D iv
All	M10990	O04999	93.030	93.049	3D iv
All	O05020	R09000	01.000	10.999	3D iv
All	O05020	R09000	11.000	11.999	3D iv
All	O05020	R09000	12.000	21.999	3D iv
All	O05020	R09000	23.000	23.999	3D iv
All	O05020	R09000	26.000	37.999	3D iv
All	O05020	O15099	24.000	25.999	3D iv
All	O05020	R29999	38.000	49.999	3D iv
All	O05020	R10000	50.000	50.499	3D iv
All	O05020	Y99999	53.000	92.599	3D iv
All	O05020	O15000	93.000	93.019	3D iv
All	O05020	Y99999	94.000	99.998	3D iv
All	O05020	O15000	93.030	93.049	3D iv
All	O05020	Y99999	51.000	51.999	3D iv
All	O15200	P15899	24.000	25.999	3D iv
All	O15200	O25000	93.000	93.019	3D iv
All	O15200	O25000	93.030	93.049	3D iv

CAS number	Product type (from)	Product type (to)	NACE (from)	NACE (to)	NFR with extentions
All	O25600	P05000	93.000	93.019	3D iv
All	O25600	P05000	93.030	93.049	3D iv
All	P05200	R10000	93.000	93.019	3D iv
All	P05200	R10000	93.030	93.049	3D iv
All	P16000	R10000	24.000	25.999	3D iv
All	R10100	R10100	50.000	50.999	3D iv
All	R10130	R19000	50.000	50.499	3D iv
All	R10130	R10130	93.000	93.019	3D iv
All	R10130	R10130	93.030	93.049	3D iv
All	R10160	R10340	93.000	93.019	3D iv
All	R10160	R10340	93.030	93.049	3D iv
All	R10360	R10370	93.000	93.019	3D iv
All	R10360	R10370	93.030	93.049	3D iv
All	R10450	R10450	93.000	93.019	3D iv
All	R10450	R10450	93.030	93.049	3D iv
All	R10700	R10700	93.000	93.019	3D iv
All	R10700	R10700	93.030	93.049	3D iv
All	R11000	Y99999	01.000	10.999	3D iv
All	R11000	R29999	11.000	11.999	3D iv
All	R11000	R29999	12.000	19.999	3D iv
All	R11000	R29999	20.000	20.999	3D iv
All	R11000	Y99999	21.000	21.999	3D iv
All	R11000	R29999	23.000	23.999	3D iv
All	R11000	Y99999	26.000	37.999	3D iv
All	R11000	R29999	24.000	25.999	3D iv
All	R11000	R20100	93.000	93.019	3D iv
All	R11000	R20100	93.030	93.049	3D iv
All	R20000	R20999	50.000	50.999	3D iv
All	R20300	R29999	93.000	93.019	3D iv
All	R20300	R29999	93.030	93.049	3D iv
All	R21000	Y99999	50.000	50.499	3D iv
All	R30000	R30999	12.000	16.999	3D iv
All	R30000	R30999	40.300	49.999	3D iv
All	R30000	R30999	38.000	40.199	3D iv
All	R31000	Y99999	11.000	11.999	3D iv
All	R31000	Y99999	12.000	19.999	3D iv
All	R31000	V15399	20.000	20.999	3D iv
All	R31000	X99997	23.000	23.999	3D iv
All	R31000	S42199	24.000	25.999	3D iv
All	R31000	Y99999	38.000	49.999	3D iv
All	R31000	S25000	93.000	93.019	3D iv
All	R31000	S25000	93.030	93.049	3D iv
All	S25600	Y99999	93.000	93.019	3D iv
All	S25600	Y99999	93.030	93.049	3D iv
All	S42300	X99997	24.000	25.999	3D iv
All	V15500	Y99999	20.000	20.999	3D iv
All	X99999	Y99999	23.000	23.999	3D iv
All	X99999	Y99999	24.000	25.999	3D iv

A7: Exclusions

Combinations of CAS numbers, product types and industrial sectors excluded from the model because they are reported elsewhere. The product type codes (from and to) refer to Appendix A3 (chronologically) and the NACE codes (from and to) refer to Appendix A2 (chronologically).

CAS number	Product type (from)	Product type (to)	NACE (from)	NACE (to)	Reason for exclusion
75-10-5	R10100	R10100	61.000	61.999	Export of degreasing
75-37-6	A05000	Z99999	00.000	99.999	HFC gases
75-46-7	A05000	Z99999	00.000	99.999	HFC gases
127-18-4	A05000	Z99999	00.000	99.999	HFC gases
354-33-6	A05000	Z99999	00.000	99.999	HFC gases
811-97-2	A05000	Z99999	00.000	99.999	HFC gases
All	O05000	O05010	00.001	99.998	Oil and gas industry
All	R30000	R30999	11.000	11.999	Oil and gas industry
All	R30000	R30999	23.000	23.999	Oil and gas industry
All	R30000	R30999	40.200	40.299	Oil and gas industry
All	X99998	X99998	23.000	23.999	Oil and gas industry
All	B55100	B55299	00.001	99.998	Oil and gas industry
All	B55300	B55300	00.001	99.999	Oil and gas industry
All	B60000	B60999	00.001	99.998	Oil and gas industry
All	B20300	B20300	24.100	24.199	Raw materials in NACE 24.1
All	K35200	K35200	24.100	24.199	Raw materials in NACE 24.1
All	O15100	O15100	24.100	24.199	Raw materials in NACE 24.1
All	R30100	R30999	24.100	24.199	Raw materials in NACE 24.1
All	S42200	S42200	24.100	24.199	Raw materials in NACE 24.1

A8: Emission factors

List of emission factors, given for combinations of specific substances (CAS), groups of substances, product types, industrial sectors and whether the substances are considered to be used as raw materials or not. The product type codes refer to Appendix A3 (chronologically) and the NACE codes refer to Appendix A2 (chronologically).

CAS number	Group	Raw material	Product code			NACE			Emission factor
Not specified	VOC	No	A05000	-	Z99999	Private, 01	-	99	1
Not specified	VOC	No	A05000	-	A40199	24	-	24	0.0025
Not specified	VOC	No	A05000	-	B14999	20	-	20	0.25
Not specified	VOC	No	A05000	-	B15700	15	-	16	0.25
Not specified	VOC	No	A05000	-	B15700	11	-	11	0.0025
Not specified	VOC	No	A05000	-	B15710	35	-	36	0.25
Not specified	VOC	No	A05000	-	B15710	34	-	34	0.2
Not specified	VOC	No	A05000	-	B15710	26	-	33	0.25
Not specified	VOC	No	A05000	-	B15710	25	-	25	0.25
Not specified	VOC	No	A05000	-	B15710	23	-	23	0.0025
Not specified	VOC	No	A05000	-	B15710	22	-	22	0.55
Not specified	VOC	No	A05000	-	B15710	21	-	21	0.25
Not specified	VOC	No	A05000	-	B15710	18	-	19	0.1
Not specified	VOC	No	A05000	-	B15710	17	-	17	0.1
Not specified	VOC	No	A40000	-	A40999	60	-	62	0.1
Not specified	VOC	No	A40200	-	A40300	24	-	24	0.001
Not specified	VOC	No	A40400	-	B15710	24	-	24	0.0025
Not specified	VOC	No	A55100	-	A60100	93	-	93	0.57
Not specified	VOC	No	B15000	-	B15999	20	-	20	0.15
Not specified	VOC	No	B15120	-	B15120	93	-	93	0.57
Not specified	VOC	No	B15140	-	B15140	93	-	93	0.57
Not specified	VOC	No	B15330	-	B15330	93	-	93	0.57
Not specified	VOC	No	B15710	-	B15710	Private, 01	-	16	0.1
Not specified	VOC	No	B15720	-	B15720	21	-	37	0.3
Not specified	VOC	No	B15720	-	B15720	15	-	19	0.3
Not specified	VOC	No	B15720	-	B15720	11	-	11	0.3
Not specified	VOC	No	B15730	-	B20299	25	-	25	0.25
Not specified	VOC	No	B15730	-	B20299	24	-	24	0.0025
Not specified	VOC	No	B15730	-	B54999	35	-	36	0.25
Not specified	VOC	No	B15730	-	B54999	34	-	34	0.2
Not specified	VOC	No	B15730	-	B54999	26	-	33	0.25
Not specified	VOC	No	B15730	-	B54999	23	-	23	0.0025
Not specified	VOC	No	B15730	-	B54999	22	-	22	0.55
Not specified	VOC	No	B15730	-	B54999	21	-	21	0.25
Not specified	VOC	No	B15730	-	B54999	18	-	19	0.1
Not specified	VOC	No	B15730	-	B54999	17	-	17	0.1
Not specified	VOC	No	B15730	-	B54999	15	-	16	0.25
Not specified	VOC	No	B15730	-	B54999	11	-	11	0.0025
Not specified	VOC	No	B16000	-	B16999	20	-	20	0.15
Not specified	VOC	No	B17000	-	B54999	20	-	20	0.25
Not specified	VOC	No	B20300	-	B20300	24	-	25	0.001
Not specified	VOC	No	B20400	-	B25299	25	-	25	0.25
Not specified	VOC	No	B20400	-	B25299	24	-	24	0.0025
Not specified	VOC	No	B25200	-	B25200	93	-	93	0.57
Not specified	VOC	No	B25300	-	B25300	24	-	25	0.001
Not specified	VOC	No	B25400	-	B54999	25	-	25	0.25
Not specified	VOC	No	B25400	-	B54999	24	-	24	0.0025
Not specified	VOC	No	B35200	-	B35200	93	-	93	0.57
Not specified	VOC	No	B55100	-	B55100	Private, 01	-	99	0.0025
Not specified	VOC	No	B55200	-	B55200	Private, 01	-	99	0.000005
Not specified	VOC	No	B55300	-	B55300	Private, 01	-	99	0.00125
Not specified	VOC	No	B60100	-	B60299	Private, 01	-	22	0.0025
Not specified	VOC	No	B60100	-	B60299	24	-	99	0.0025
Not specified	VOC	No	B60100	-	B60299	23	-	23	0.00005
Not specified	VOC	No	B61000	-	E03099	25	-	25	0.25
Not specified	VOC	No	B61000	-	E03099	24	-	24	0.0025
Not specified	VOC	No	B61000	-	H19999	20	-	20	0.25
Not specified	VOC	No	B61000	-	L20999	35	-	36	0.25
Not specified	VOC	No	B61000	-	L20999	34	-	34	0.2
Not specified	VOC	No	B61000	-	L20999	26	-	33	0.25
Not specified	VOC	No	B61000	-	L20999	23	-	23	0.0025
Not specified	VOC	No	B61000	-	L20999	22	-	22	0.55
Not specified	VOC	No	B61000	-	L20999	21	-	21	0.25

CAS number	Group	Raw material	Product code			NACE			Emission factor
Not specified	VOC	No	B61000	-	L20999	18	-	19	0.1
Not specified	VOC	No	B61000	-	L20999	17	-	17	0.1
Not specified	VOC	No	B61000	-	L20999	15	-	16	0.25
Not specified	VOC	No	B61000	-	L20999	11	-	11	0.0025
Not specified	VOC	No	D20300	-	D20300	93	-	93	0.57
Not specified	VOC	No	E03100	-	E03100	24	-	25	0.001
Not specified	VOC	No	E03200	-	H15399	25	-	25	0.25
Not specified	VOC	No	E03200	-	H15399	24	-	24	0.0025
Not specified	VOC	No	E20000	-	E20999	Private, 01	-	99	0
Not specified	VOC	No	F05990	-	F05990	93	-	93	0.57
Not specified	VOC	No	G10400	-	G10400	93	-	93	0.57
Not specified	VOC	No	H15400	-	H15400	24	-	25	0.001
Not specified	VOC	No	H15500	-	K35199	25	-	25	0.25
Not specified	VOC	No	H15500	-	K35199	24	-	24	0.0025
Not specified	VOC	No	I05000	-	I05999	20	-	20	0.15
Not specified	VOC	No	I05100	-	I05100	93	-	93	0.57
Not specified	VOC	No	I05300	-	I05300	93	-	93	0.57
Not specified	VOC	No	I05500	-	I05500	93	-	93	0.57
Not specified	VOC	No	I06000	-	L20999	20	-	20	0.25
Not specified	VOC	No	K20100	-	K20100	93	-	93	0.57
Not specified	VOC	No	K35200	-	K35200	24	-	25	0.001
Not specified	VOC	No	K35300	-	L20999	25	-	25	0.25
Not specified	VOC	No	K35300	-	L20999	24	-	24	0.0025
Not specified	VOC	No	L15000	-	L15999	Private, 01	-	99	0
Not specified	VOC	No	M05000	-	M05999	25	-	37	0.3
Not specified	VOC	No	M05000	-	M05999	24.4	-	24.7	0.3
Not specified	VOC	No	M05000	-	M05999	24.3	-	24.3	0.001
Not specified	VOC	No	M05000	-	M05999	24	-	24.2	0.3
Not specified	VOC	No	M05000	-	M05999	15	-	23	0.3
Not specified	VOC	No	M05000	-	M05999	11	-	11	0.3
Not specified	VOC	No	M08000	-	O04999	35	-	36	0.25
Not specified	VOC	No	M08000	-	O04999	34	-	34	0.2
Not specified	VOC	No	M08000	-	O04999	26	-	33	0.25
Not specified	VOC	No	M08000	-	O04999	25	-	25	0.25
Not specified	VOC	No	M08000	-	O04999	24	-	24	0.0025
Not specified	VOC	No	M08000	-	O04999	23	-	23	0.0025
Not specified	VOC	No	M08000	-	O04999	22	-	22	0.55
Not specified	VOC	No	M08000	-	O04999	21	-	21	0.25
Not specified	VOC	No	M08000	-	O04999	20	-	20	0.25
Not specified	VOC	No	M08000	-	O04999	18	-	19	0.1
Not specified	VOC	No	M08000	-	O04999	17	-	17	0.1
Not specified	VOC	No	M08000	-	O04999	15	-	16	0.25
Not specified	VOC	No	M08000	-	O04999	11	-	11	0.0025
Not specified	VOC	No	M10300	-	M10300	93	-	93	0.57
Not specified	VOC	No	O05010	-	O05010	Private, 01	-	10	1
Not specified	VOC	No	O05010	-	O05010	24	-	99	1
Not specified	VOC	No	O05010	-	O05010	23	-	23	0.001
Not specified	VOC	No	O05010	-	O05010	12	-	22	1
Not specified	VOC	No	O05010	-	O05010	11	-	11	0.001
Not specified	VOC	No	O05020	-	O15099	25	-	25	0.25
Not specified	VOC	No	O05020	-	O15099	24	-	24	0.0025
Not specified	VOC	No	O05020	-	R29999	20	-	20	0.25
Not specified	VOC	No	O05020	-	S42100	15	-	16	0.25
Not specified	VOC	No	O05020	-	S42100	11	-	11	0.0025
Not specified	VOC	No	O05020	-	Y99999	35	-	36	0.25
Not specified	VOC	No	O05020	-	Y99999	34	-	34	0.2
Not specified	VOC	No	O05020	-	Y99999	26	-	33	0.25
Not specified	VOC	No	O05020	-	Y99999	23	-	23	0.0025
Not specified	VOC	No	O05020	-	Y99999	22	-	22	0.55
Not specified	VOC	No	O05020	-	Y99999	21	-	21	0.25
Not specified	VOC	No	O05020	-	Y99999	18	-	19	0.1
Not specified	VOC	No	O05020	-	Y99999	17	-	17	0.1
Not specified	VOC	No	O15100	-	O15100	93	-	93	0.57
Not specified	VOC	No	O15100	-	O15100	24		25	0.001
Not specified	VOC	No	O15100	-	O15100	35.3	-	35.3	0.001
Not specified	VOC	No	O15200	-	P15899	25	-	25	0.25
Not specified	VOC	No	O15200	-	P15899	24	-	24	0.0025
Not specified	VOC	No	O25100	-	O25500	93	-	93	0.57
Not specified	VOC	No	P05100	-	P05100	93	-	93	0.57

CAS number	Group	Raw material	Product code			NACE			Emission factor
Not specified	VOC	No	P15900	-	P15900	24	-	25	0.001
Not specified	VOC	No	P16000	-	R29999	25	-	25	0.25
Not specified	VOC	No	P16000	-	R29999	24	-	24	0.0025
Not specified	VOC	No	R10100	-	R10100	93	-	93	0.57
Not specified	VOC	No	R10150	-	R10150	93	-	93	0.57
Not specified	VOC	No	R10350	-	R10350	93	-	93	0.57
Not specified	VOC	No	R10400	-	R10400	93	-	93	0.57
Not specified	VOC	No	R10500	-	R10600	93	-	93	0.57
Not specified	VOC	No	R10800	-	R10990	93	-	93	0.57
Not specified	VOC	No	R20200	-	R20200	93	-	93	0.57
Not specified	VOC	No	R30000	-	R30999	93	-	93	0.57
Not specified	VOC	Yes	R30000	-	R30999	26	-	28	0.001
Not specified	VOC	No	R30000	-	R30999	24	-	25	0.001
Not specified	VOC	Yes	R30000	-	R30999	21	-	23	0.001
Not specified	VOC	No	R30000	-	R30999	20	-	20	0.15
Not specified	VOC	Yes	R30000	-	R30999	15	-	19	0.1
Not specified	VOC	Yes	R30000	-	R30999	11	-	11	0.001
Not specified	VOC	No	R31000	-	S42199	25	-	25	0.25
Not specified	VOC	No	R31000	-	S42199	24	-	24	0.0025
Not specified	VOC	No	R31000	-	V14999	20	-	20	0.25
Not specified	VOC	No	S25100	-	S25500	93	-	93	0.57
Not specified	VOC	No	S42200	-	S42200	Private, 01	-	16	0.1
Not specified	VOC	No	S42200	-	S42200	24	-	25	0.001
Not specified	VOC	No	S42300	-	X99997	25	-	25	0.25
Not specified	VOC	No	S42300	-	X99997	24	-	24	0.0025
Not specified	VOC	No	S42300	-	Y99999	15	-	16	0.25
Not specified	VOC	No	S42300	-	Y99999	11	-	11	0.0025
Not specified	VOC	No	S50000	-	S50999	Private, 01	-	99	0
Not specified	VOC	No	S75000	-	S75999	Private, 01	-	99	0
Not specified	VOC	No	V15400	-	V15400	20	-	20	0.15
Not specified	VOC	No	V16000	-	Y99999	20	-	20	0.25
Not specified	VOC	No	X99998	-	X99998	24	-	25	0.001
Not specified	VOC	No	Y00000	-	Y99999	25	-	25	0.25
Not specified	VOC	No	Y00000	-	Y99999	24	-	24	0.0025

Result attachments

B1: Time series of emissions of NMVOC from solvent and other product use, 1989-2007

NFR source category	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Total	48 208	51 883	45 611	46 937	47 078	50 599	49 264	52 020	50 199	50 448	49 465	47 335	48 211	49 127	50 014	51 096	51 868	46 683	48 570
Decorative paint application (3A i)																	8 375	7 075	5 059
Industrial paint application (3A ii)																	2 957	1 637	1 898
Other paint application (3A iii)	12 867	13 003	11 002	10 934	10 921	12609	9 551	9 953	9797	8 190	9348	8 579	9143	9 713	10 283	10 853	91	33	39
Degreasing (3B i)																	94	9	7
Dry cleaning (3B ii)																	247	651	158
Other (industrial cleaning) (3B iii)	2 551	2 756	2 324	1 884	358	278	207	344	310	372	368	411	442	476	511	545	240	226	227
Chemical products, manufact. & proc. (3C)	2 880	2 802	4 139	4 146	7 655	6731	8 414	7 682	6469	6 529	6274	5 664	4668	3 711	2 726	1 936	900	540	510
Printing (3D i)																	726	447	551
Wood preservation (3D ii)																	232	240	254
Domestic solvent use (3D iii)																	10 521	9 063	9 973
Other (3D iv)	29 911	33 322	28 145	29 972	28 145	30 981	31 092	34041	33623	35 357	33475	32 682	33959	35 227	36 494	37 761	27 486	26 762	29 895

B2: Substances with the highest NMVOC emissions in 2007

Cas number	Substance name	Emissions (tonnes)
64-17-5	Ethanol	11663
64742-82-1	Naphtha (petroleum), hydrodesulfurized heavy	4708
107-21-1	Ethylene glycol	3752
64-18-6	Formic acid	3596
100-42-5	Benzene, ethenyl-	2441
67-63-0	2-propanol	2274
64742-48-9	Naphtha (petroleum), hydrotreated heavy	1666
1330-20-7	Ethyldimethylbenzene	1537
64742-47-8	Distillates (petroleum), hydrotreated light	1532
50-00-0	Formaldehyde	836
57-13-6	Urea	763
123-86-4	Butyl acetate	632
127-18-4	Tetrachloroethene (PER)	525
64742-95-6	Solvent naphtha (petroleum), light arom.	460
98-00-0	2-furan methanol	451
111-30-8	Glutaral	385
101-68-8	4,4'-methylenediphenyl diisocyanate	376
64-19-7	Acetic acid	339
108-88-3	Toluene	333
57-55-6	1,2-propanediol	293
64742-88-7	Solvent naphtha (petroleum), medium aliph.	293
67-56-1	Methanol	270
85-44-9	Phthalic anhydride	269
109-66-0	Pentane	268
584-84-9	4-methyl-m-phenylene diisocyanate	257
67-64-1	2-propanone (acetone)	256
100-51-6	Benzene methanol	255
64742-49-0	Naphtha (petroleum), hydrotreated light	250
71-36-3	1-butanol	226
111-42-2	2,2'-iminobis-ethanol	211
64742-81-0	Kerosine (petroleum), hydrodesulfurized	197
108-10-1	4-methyl-2-pentanone	176
115-77-5	1,3-propanediol, 2,2-bis(hydroxymethyl)-	163
141-43-5	2-aminoethanol	162
78-93-3	2-butanone	142
108-65-6	1-methoxy-2-propyl acetate	137
108-31-6	Maleic anhydride	129
112-34-5	2-(2-butoxyethoxy)ethanol	128
2855-13-2	3-aminomethyl-3,5,5-trimethylcyclohexylamine	118
74-98-6	Propane	118
141-78-6	Ethyl acetate	116
80-62-6	Methyl methacrylate	109
109-60-4	Propyl acetate	107
106-97-8	Butane	104
64771-72-8	Paraffins (petroleum), normal C5-2-0	103
107-98-2	1-methoxy-2-propanol	102
107-22-2	Glyoxal	102
30525-89-4	Paraformaldehyde	100
60-29-7	Diethyl ether	99
64742-94-5	Solvent naphtha (petroleum), heavy arom.	89
26471-62-5	M-tolylidene diisocyanate	89
34590-94-8	Methoxy-2-propoxy-2-propanol	86
74-86-2	Ethyne (acetylene)	86
78-83-1	2-methyl-1-propanol	86
142-82-5	Heptane	78
64742-46-7	Distillates (petroleum), hydrotreated medium; gas oil uspecified	75
90622-58-5	Alkanes, C11-15-iso-	72

B3: Product type groups with the highest NMVOC emissions in 2007

Product type group	Name	Emissions (tonnes)
B15	Biocides	9526
R10	Cleaning agents	8103
M05	Paint and varnish	6988
O15	Solvents	5221
A40	Anti freeze agents	4243
S42	Food and fodder additives	2405
K52[1]	Cosmetics[1]	1800
B20	Binding agents	1719
R30	Raw materials and intermediates	733
K35	Construction materials	700
I15	Isolation materials	521
L10	Adhesives	466
P10	Polishing agents	440
V10	Heat transmission agents	402
P05	PH-regulating agents	358
F05	Pigments	344
U05	Filling materials	330
P15	Process regulators	311
G30	Flooring materials	247
M15	Metal surface treatment agents	246
G15	Enamel and glazing materials	243
S45	Lubricants	233
H15	Hardeners	232
K55	Cooling agents	231

[1] From cosmetics side model

B4: Industrial sectors with the highest NMVOC emissions in 2007

NACE	Name	Emissions (tonnes)
45	Construction	6943
No NACE	Private and public use	6571
50	Sale, maintenance and repair of motor vehicles and motor cycles, retail sale of automotive fuel	6340
24	Manufacture of chemicals and chemical products	4425
35	Manufacture of other transport equipment	3293
36	Manufacture of furniture, manufacturing n.e.c.	2807
15	Manufacture of food products and beverages	2243
1	Agriculture, hunting and related service activities	2156
52	Retail trade, except of motor vehicles and motor cycles. Repair of personal and household goods	2051
11	Extraction of crude petroleum and natural gas, service activities incidental to oil and gas extraction excluding surveying	1009
28	Manufacture of fabricated metal products, except machinery and equipment	695
25	Manufacture of rubber and plastic products	659
93	Other service activities	659
22	Publishing, printing and reproduction of recorded media	650
27	Manufacture of basic metals	611
61	Water transport	609
20	Manufacture of wood and products of wood and cork	608
60	Land transport, transport via pipelines	580
85	Health and social work	405
40	Electricity, gas, steam and hot water supply	395
26	Manufacture of other non-metallic mineral products	360
51	Wholesale trade and commision trade, except for motor vehicles and motorcycles	311

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