SNAP CODE: **060000**

SOURCE ACTIVITY TITLE: **SOLVENT AND OTHER PRODUCT USE**
Introduction

NOSE CODE: **107.various**

NFR CODE: **various**

1 ACTIVITIES INCLUDED

All activities in which organic solvents are used and are emitted, are included in this chapter. In this chapter a general method for estimating the overall solvent use in a country is described. For more detailed methods the chapters on source-specific solvent use (060100 - 0600409) should be consulted.

2 CONTRIBUTION TO TOTAL EMISSIONS

Solvent use is a major contributor to NMVOC emissions. On a European scale its contribution is roughly a quarter of the total anthropogenic NMVOC emission. Per country its contribution to anthropogenic NMVOC emissions varies between 15% and 30%.

Allegedly, solvent use contributes also to the emissions of some heavy metals (Cd, Cu, Pb and Zn), but no quantification can be given at this stage.

3 GENERAL

3.1 Description

Most solvents are part of a final product, e.g. paint, and will sooner or later evaporate. This evaporation of solvent is a major source of NMVOC emission in any country, thus inventorying of this source is of great importance.

A small fraction of the solvents will end up in waste or as emission to water and may finally also contribute to air pollution by evaporation from these compartments.

Estimating emissions from solvent use can be done in two ways: either by estimating the amount of (pure) solvents consumed or by estimating the amount of solvent containing products consumed (taking account of their solvent content).

For the first method you need to inventory all relevant solvents, at least those together representing more than 90% of the total NMVOC emission. The sum of all these solvents equals the NMVOC emission. This method is the detailed methodology of this chapter.

For the second method you need to inventory all relevant source categories, at least those together contributing more than 90% to the total NMVOC emission. To estimate these source

categories they have to be defined first. In the SNAP system this defining of categories has already been done (see chapters 060100 - 060409), but several countries have their own categorisation. To get data for each source category two ways are possible: either collecting all relevant consumption data or (only to be applied when no consumption data are available) using a per capita emission for each category. The first way is used in most 060… chapters, the other way is described in this chapter as the simpler methodology.

3.2 Definitions

Solvent content: percentage of a product that consists of organic solvent

Water-borne: the solvent in the product is water

Solvent-borne: the solvent in the product is an organic solvent

3.3 Techniques

Many different process and other techniques use solvent products. It is not within the remit of this chapter to describe these techniques in detail, but many are described in other chapters within SNAP Group 6.

3.4 Emissions

The use of solvents, like other products, has three stages in which emissions occur: during production, during the actual use and during the disposal. The methodology in this chapter only deals with stage two. Stage one is dealt with in the chapters on production processes and stage three is covered by chapters on waste treatment and disposal.

3.5 Controls

NMVOC emissions can be decreased by lowering the solvent content of a product or replace the solvent by another non-NMVOC substance (e.g. water-borne paint instead of solvent-borne paint). The harmfulness of a solvent containing product can be decreased by replacing the solvent by another solvent.

In industry the emission caused by the use of solvents can be decreased by using closed circuits with abatement technologies, e.g. activated carbon, instead of open application.

4 SIMPLER METHODOLOGY

The NMVOC emission from solvent use is calculated based on per capita data for several source categories. The categories most used for this purpose are:

- paint, all applications
- industrial degreasing
- dry cleaning
- glues & adhesives
- graphic arts (ink)
- chemical industry (e.g. pharmaceutics)

- household products (e.g. toiletries)
- rubber and plastics industry
- vegetable oil extraction
- leather industry
- pesticides
- other solvent use

To get the emission for a source category in your country for which you do not have any information, you only have to select a per capita factor, which resembles the situation in your country as close as possible, and multiply the factor by the inhabitants of your country.

To get the total emission due to solvent use in your country you can take the per capita factor for the total of all source categories from a country resembling yours and multiply it by the inhabitants from your country.

5 DETAILED METHODOLOGY

This method is based on a mass balance per solvent. The sum of all solvent mass balances equals the NMVOC emission due to solvent use. In formula the solvent mass balance is:

consumption = production + import - export - destruction/disposal - hold-up (1)

Note that solvent used as feedstock is not included in the consumption. Destruction and disposal of solvents is a way of lowering one's emissions due to solvent use. The amount of solvents disposed is small, but increasing in most countries. Hold-up is the difference in the amount in stock in the beginning and at the end of the year of inventory.

For each solvent the NMVOC emission can be calculated by multiplying the consumption by the fraction emitted; in formula:

NMVOC component emission = consumption * fraction emitted (2)

When no other information is available the fraction emitted in formula (2) can be set to 1.0. Veldt [20] estimated that this assumption will lead to an error of less than 10%. Formula (3) shows how the total NMVOC emission due to solvent use can be calculated.

Total NMVOC emission = sum of all individual NMVOC component emissions (3)

In making a solvent mass balance you have to be very careful not to double count certain NMVOC components. A lot of solvents consist of a mixture of NMVOC components, e.g. white spirit consists of several alkanes (paraffins), alkenes (olefins) and aromatics representing dozens of individual compounds. Before setting up a mass balance you have to decide whether you will inventory groups of NMVOC components, e.g. alkanes, chlorinated hydrocarbons, cellosolves, etc. or individual compounds, e.g. methylbenzene (toluene), 1,1,1-trichloroethane, etc.

6 RELEVANT ACTIVITY STATISTICS

6.1 Simpler methodology

- Data on population per country
- Data on per capita emission factors (see Tables 8.1.1 and 8.1.2)

6.2 Detailed methodology

- A list of the most important solvents, covering at least 90% of all solvent emissions
- Per solvent: data on import, export, disposal and destruction, feedstock, hold-up and production of the solvent and the solvent containing products
- Data on solvent content of products

7 POINT SOURCE CRITERIA

As a default approach solvent use can be considered as an area source. If information is available, large plants in some industrial branches can be distinguished as point sources (see also 060… chapters).

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Simpler methodology

Table 8.1.1 lists the per capita NMVOC emission factors per source category reported by several industrialised countries. The table was originally made by Veldt [20] and has been updated and expanded.

Table 8.1.1: Reported NMVOC emissions for some source categories[1] (in kg/cap./year).

Country	year	paint	industrial degreasing	graphic arts	glues & adhesives	household products	total	lit.
Australia	1990	3.7	1.6[2]	0.80		1.3	11.0	21
Australia	1990	5.0	1.6[2]				9.9	27
Austria	1987	5.3		0.60	1.45			13
Austria	1990						17.1	32
Canada	1985	4.8					12.7	20
Canada	1985	4.8					17.1	28
Canada	1990	6.5					22.8	28
Czech Rep.	1995						14.6	31
Finland	1988	5.55		1.8		0.7	9.6	20
Finland	1991	3.7	2.7[3]	0.4	0.17	0.27	12.3	23
France	1985	4.8	0.84	0.47	0.26	1.1	10.4	17
W. Germany	1986	6.8	2.0	1.5	1.1	±2	18.8	10
Italy	'84-'86	4.5	0.75	0.60	1.0	0.8	12.9	16
Japan	1983	6.4	0.74	1.15	0.29		10.4	20
Netherlands	1981	6.6	0.85	1.2	0.20	1.6	15.3	18
Netherlands	1989	5.05						22
Netherlands	1990	4.5	0.40	0.76		1.5	10.0	20
Netherlands	1992	4.6	0.73	0.99	0.05	1.75	11.3	18
Norway	1976						15.1	1-4
Norway	1992	4.5		0.36			7.5	20
Norway	'88-'92	2.5 - 5.0					10.1	1-4
Poland	1989	4.45						20
Slovak Rep.	1990	6.2[5]	1.3[3]			1.6	9.0	30
Slovak Rep.	1993	3.6[5]	0.64[3]			1.6	5.8	30
Sweden	1988	4.7	1.4	0.82		2.6	12.1	15
Switzerland	1990						22.1	29
UK	1988?	4.8	0.81	0.68	1.02	3.3	13.7	9
UK	'91-'92						11.4[4]	26
USA	1985						17.5	20
USA	1989	8.6	2.8	1.3	1.3	1.5	21.3	24
USA	1990	9.5	2.7	2.5			22.9	25
USA	1990	7.6	2.7	1.3	2.7	3.9	21.6	28
W. Europe	1988						15.2	20
W. Europe	1990	5.3	1.0	0.86	0.84	1.1	14.4	19
Europe[6]	*>1990*	*4.5±0.4*	*0.85±0.3*	*0.65±0.25*	*0.6±0.45*	*1.8±0.45*	*12±3.4*	

1) the definition of the categories varies per country and per report, especially for the category household products

2) the sum of the US EPA emission factors for cold cleaning in manufacturing and automobile repair

3) includes industrial and dry cleaning

4) in the report the NMVOC emission from solvent use is constant for 1970-1994; the per capita NMVOC emission from solvent use decreases due to the increase in inhabitants in the UK (1970: 11.8; 1980: 11.7; 1990: 11.5 kg/capita/year)

5) including (application of) glues

6) default European per-capita factors (average of country data)

Table 8.1.2 lists the percentages of source categories as are found in several European countries. With Table 8.1.2 you can estimate which percentage of the total NMVOC emission due to solvent use is covered by your known source categories, so that you can estimate which percentage for the unknown source categories should be added to get the total NMVOC emission.

Table 8.1.2. Reported source category subdivisions in country studies (wt.% of total NMVOC emissions).

Source category	France	West Germany	Italy	Country the Netherlands	Sweden	the UK	Western Europe	Europe[3]
Paint	46.1	39.6	35.2	40.4	36.1	35.6	36.7	40±4
Household prod.	10.6	9.2	3.5	15.5	18.5	21.6	8.2	15±5
Chem. industry	14.0	10.8	13.7	12.4	4.7	5.5	11.8	
Industr. degreasing	8.1	10.8	5.8	6.4	10.5	5.8	6.9	8±2.5
Graphic arts	4.5	8.2	8.0	8.8	6.3	5.6	5.9	7±1.7
Glues & Adhesives	2.5	5.8	8.0	0.4	[1]	7.9	5.8	
Rubber & plastics	7.5	3.5	2.3	3.5	4.3	0.9[2]	[1]	
Dry cleaning	3.1	2.0	4.7	0.9	1.5	1.5	2.1	
Pesticides	2.7	0.5	2.1	[1]	1.4	5.3	[1]	
Veg. oil extraction	0.5	1.4	2.0	[1]	[1]	1.4	2.2	
Leather	[1]	[1]	[1]	0.2	0.5	0.3	[1]	
Other solvent use	0.5	8.2	14.8	11.7	16.3	8.7	20.5	
Year	1985	1986	'84-'86	1990	1988	1988?	1990	
Reference	17	10	16	18	15	9	19	

[1)] included in other solvent use
[2)] rubber industry only
[3)] default European percentages

8.2 Detailed methodology

The following information is needed:

- a list with the most important compounds or groups, e.g. those groups used in Table 9.1
- a list with solvent content per source category (see chapters 060100-060408)
- a list with solvent composition per product or source category (see Table 9.1)
- production, import, export and waste disposal statistics from the national statistics office

9 SPECIES PROFILES

9.1 Simpler methodology

Table 9.1.1 gives an idea of the NMVOC profile for solvent use. All profiles are overall profiles for solvent use as a whole (category 060000), for profiles per source category see the relevant (060...) chapters.

This table was just as Table 8.1.1 originally made by Veldt [20] and has been updated and expanded.

Table 9.1.1: Reported NMVOC composition per country (wt.% of total NMVOC emissions).

Country	year	alkanes	aromatics	alcohols	esters	cello-solves[7]	ketones	ClHCs	other	lit.
Australia	1990	36.5	27.9	10.4	4.9	5.6	3.7	8.6	2.4	21
Austria	1987	29.5	11.3[1]	18.8	8.1	4.4	16.7[2]	10.7	0.5[3]	13
Finland	1991	26.1	18.0	34.4	7.4	4.4	6.5	3.3	0.0	23
France	1985	26.1	14.6	27.5	5.6[5]	-	9.8	14.5	1.9	17
W.Germany	1986	20[4]	20[4]	15.7	9.6	4.2	8.9	15.6	6.0[3]	10
Italy	'84-'86	15.1	24.0	14.8	9.9	4.3	13.8	15.4	2.7	16
Sweden	1988	12.4	13.7	29.8	8.8	4.8	2.6	9.6	18.3[6]	15
W. Europe	1990	27.3	18.7	16.3	10.2	5.3	11.8	10.1	0.3	19
UK	1988?	30.5	18.9	14.2	4.1	1.9	5.9	8.9	15.6[6]	9
USA	1989	30.9	8.7	17.9	14.7[5]	-	11.1	12.8	3.8	24
Europe8		23±7	18±4	22±8	8±2.5	4±1	8±4	11±4.5		

[1)] methylbenzene (toluene) and dimethylbenzenes (xylenes)
[2)] propanone (acetone)
[3)] includes chlorofluorocarbons (CFCs)
[4)] corrected for aromatics in alkanes
[5)] includes cellosolves
[6)] including unknowns (67% of 'other' is unknowns in Sweden and 98% in the UK)
[7)] cellosolves are glycol ethers and glycol ethanoates (acetates)
[8)] default European percentages

10 UNCERTAINTY ESTIMATES

10.1 Simpler methodology

The uncertainty of the resulting overall (per capita) emission for a country will be a factor 1.25 to 2.

The more the activity in a source category of your country resembles that of the country, which per capita factor is chosen, the lower the uncertainty.

10.2 Detailed methodology

The uncertainty differs per solvent. In the more products a solvent is present the higher the uncertainty. Compounds like methylbenzene (toluene) or butanone (methylethylketon; MEK) are difficult to inventory, others like most chlorinated hydrocarbons are easier.

The overall uncertainty is estimated to be 1.25 to 2, depending on completeness of mass balance data and quality of the production, import, export, disposal, destruction and hold-up data.

11 WEAKEST ASPECTS/PRIORITY AREA FOR IMPROVEMENT IN CURRENT METHODOLOGY

11.1 Simpler methodology

- more data on southern and eastern European countries would improve the estimates for those countries
- background data on source category activities of countries for the selection of per capita factors (with the information on the size of activities you can select the country resembling your country's situation for a certain source category the best)
- more data for small(er) source categories, e.g. leather industry

11.2 Detailed methodology

- a representative list with all important solvents (representing at least 90% of all emissions)
- (per country) data on solvent content of products
- consistent national statistics on import, export, production and waste disposal
- definition of compounds or compound groups to be inventoried

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Depending on source category: population density or certain industries can be used to distribute the emissions spatially. The default distribution method is using population density.

13 TEMPORAL DISAGGREGATION CRITERIA

Temporal variation does occur, but data to make a temporal disaggregation profile is not available. A complicating factor is that the temporal disaggregation differs per source category.

14 ADDITIONAL COMMENTS

The methods described in this chapter are "default" methods. The use of one of them should be limited to cases where it is not possible to set up an emission database on solvent use according to the methodologies in the chapters 060101 - 060409.

15 SUPPLEMENTARY DOCUMENTS

For the detailed method national trade statistics; for the simple method none.

16 VERIFICATION PROCEDURES

The simpler and detailed methodologies can be used to verify one another.

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18 BIBLIOGRAPHY

For application of solvents:

- Kirk-Othmer

For information per source category:

- All sorts of weekly and monthly magazines, like Farbe und Lack, EuroCoat, Rubber Statistical Bulletin, Chemical and Engineering News, European Chemical News, etc.

19 RELEASE VERSION, DATE AND SOURCE

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20 POINT OF ENQUIRY

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