Australian Government

Department of Climate Change

AUSTRALIAN METHODOLOGY FOR THE ESTIMATION OF GREENHOUSE GAS EMISSIONS AND SINKS 2006

SOLVENTS AND OTHER PRODUCT USE

National Greenhouse Gas Inventory Committee

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http://www.climatechange.gov.au/inventory.

The Intergovernmental Panel on Climate Change *Guidelines for National Greenhouse Gas Inventories* are at:

http://www.ipcc-nggip.iges.or.jp.

Suggestions and comments would be appreciated. They should be addressed to the Manager, Australian National Greenhouse Gas Inventory, Emissions Analysis Team, Department of Climate Change or sent to ageis@climatechange.gov.au.

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FOREWORD

This inventory methodology workbook presents the Australian methodology to estimate greenhouse gas emissions and sinks from solvents sources. It is part of a series that includes:

Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Energy (Stationary Sources)

Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Energy (Transport)

Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Energy (Fugitive Fuel Emissions)

Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Industrial Processes

Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Agriculture

Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Land use, land use change and forestry

Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Waste

The methodology in this workbook was developed with input from researchers and other experts specialising in greenhouse gas emissions from the solvents sector. The methodologies presented here are largely based on the methodologies first presented in the *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks, Industrial Processes and Solvents and other Product Use*, Workbooks 7.0 (1994) and 7.1 (1998), Canberra. Contributors to the development of the original methodology are listed in those Workbooks.

The development of Australia's inventory methodologies and the compilation of Australia's national inventories are guided by the National Greenhouse Gas Inventory Committee, comprising representatives of the Australian, State and Territory governments.

ABBREVIATIONS

ABS	Australian Bureau of Statistics
ANZECC	Australia and New Zealand Environment and Conservation Council
APMF	Australian Paint Manufacturers Federation
BHP	The Broken Hill Proprietary Company Ltd
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
NA	Not Applicable
NAV	Not Available
NMVOC	Non Methane Volatile Organic Compounds
OECD	Organisation for Economic Co-operation and Development
UNFCCC	United Nations Framework Convention on Climate Change

UNITS

The units mainly used in this workbook are joules (J), grams (g), metres (m) and litres (l), together with their multiples. Standard metric prefixes used in this workbook are:

kilo (k) = 10^3 (thousand)
mega (M) = 10^6 (million)
giga (G) = 10^9 (billion)
tera (T) = 10^{12}
peta (P) = 10^{15}

One gigagram (Gg) equals one thousand tonnes, or one kilotonne (kt). One million tonnes or one megatonne (Mt) is equal to one thousand gigagrams. One kilogram per gigajoule (kg/GJ) is equal to one gigagram per petajoule (Gg/PJ).

ABBREVIATIONS FOR CHEMICAL COMPOUNDS

Al_2O_3	Alumina
CaO	Lime
CaO.MgO	Dolomitic lime
CF_4	Tetrafluoromethane (carbon tetrafluoride)
C_2F_6	Hexafluoroethane (carbon hexafluoride)
CH_4	Methane
CFC	Chlorofluorocarbons
CO	Carbon monoxide
CO_2	Carbon dioxide
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
N_2O	Nitrous oxide
NOx	Oxides of nitrogen
PFC	Perfluorocarbons
SF_6	Sulphur hexafluoride

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INTRODUCTION

Australia's national greenhouse gas inventory is prepared annually by the Department of Climate Change in accordance with both the IPCC *Revised 1996 Guidelines for National Greenhouse Gas Inventories* (IPCC 1997) and the *IPCC Good Practice Guidance* (IPCC 2000) while taking into account Australian conditions. Documenting the methods used in the estimation of emissions for the inventory enhances transparency and improves the comparability of estimates with those reported in the inventories produced by other countries.

The methods and emission factors used by Australia to estimate annual emissions of greenhouse gases from activities associated with *Solvents* are documented in this workbook. It covers the UN Framework Convention on Climate Change (UNFCCC) reporting categories:

- Paint application (3A),
- Degreasing and dry cleaning (3B),
- Chemical products manufacture and processing (3C),
- Other (3D).

The list of data sources underpinning the emissions estimates in the solvents and other product use sector is presented in table 1.

Table 1: Summary of data sources

Solvents and Other Product Use sector	Activity data
3.A. Paint application	Australian Paint Manufacturers' Federation (APMF)
3.B. Degreasing and drycleaning	Estimated from ABS population data (ABS 3101.0)
3.C. Chemical products manufacturing	Based on paint data from APMF
3.D. General solvent use	Estimated from ABS population data (ABS 3101.0)

The IPCC has identified solvent use as a major source category for NMVOC gas emission inventories. An important reason for this is that solvent use may account for up to 30% of total anthropogenic NMVOC emission in some countries.

In Australia, emissions from solvent use primarily involve the evaporation of organic or petroleum based compounds from paint application (surface coatings and thinners), degreasing and dry cleaning, chemical products manufacture and processing, general household and commercial cleaning solvents and aerosol sprays, cutback bitumen and printing (graphic arts).

Estimates of emissions from solvent use are derived from a consumption based methodology. This process involves the compilation of solvent data according to end use (for example, surface coatings, degreasing, household cleaning products) followed by the establishment of emission factors for each end use category. From a consideration of activity level data (according to end use category) and emission factors, emissions may be estimated. In the case of paint application (surface coatings and thinners) the activity data used is production data, and it is assumed that these products are used immediately after being purchased. For degreasing and dry cleaning, and general solvent use and

consumer cleaning, the inventory is based on default per capita emission factors. It is assumed that these products are used soon after they are purchased. The primary solvent use categories reported in Australia are listed in Table 2.

Table 2: Solvent use categories

Source category	Subcategories	Description
Paint Application (Surface Coatings and Thinners)	Architectural/Decorative Industrial Thinners	Application of paint primers and finishing coats for decorative, protective or architectural purposes to buildings, household goods, furniture, metal and other miscellaneous surfaces. Use of thinning solvents for paint or cleaning purposes.
Degreasing and Dry Cleaning	Degreasing Cleaning Products Dry Cleaning	Use of solvents for cleaning and degreasing metal and other surfaces. Dry cleaning of clothing, carpets and other goods.
Chemical Products Manufacture and Processing	Paint Manufacture Printing Ink Production	Loss of solvents in the manufacture of a variety of products.
General Solvent Use/ Consumer Cleaning Products	Aerosol Sprays Consumer Products Caulking/Sealants	Use of gases to propel organic and other solvents in grooming, general household and other products. Use of miscellaneous domestic/commercial solvent based products.
Printing (Graphic Arts)	Gravure Flexography Lithography/Other	Use of solvents in the manufacture/ application/ thinning of printing inks and for equipment cleaning purposes.

An overview of the major IPCC solvents categories together with greenhouse gases, which may be emitted from each activity within the sector are presented in table 3.

Table 3: Emissions from production processes [a]

	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	HFC	PFC
3. Solvent and Other Product Use								
3.A. Paint Application						**x**		
3.B. Degreasing and Dry Cleaning						**x**		
3.C. Chemical Products Manufacture and Processing						**x**		
3.D. Other			**x**			**x**		

x Source of gas emission/Produced in Australia.

3.A: Paint Application

Surface coating operations involve the application of paint, varnish, lacquer or paint primer for decorative or protective purposes. Thinning solvents are normally used to dilute surface coating formulations or for cleaning purposes. Collectively, surface coatings and thinners represent the most significant solvent use category.

Surface coatings and thinners are evaluated for a number of categories, including architectural/decorative (used primarily by home owners and contract painters for coating interior/exterior house and building parts), industrial automotive (used by motor vehicle manufacturers and panel beaters) and other industrial (used by manufacturers of white goods, wood products, ship building/repair and other miscellaneous uses).

Surface coatings have differing solvent content (see Table 4). In order to establish a methodology for accurately estimating solvent loss from surface coatings and thinners, the average solvent content of formulations and associated activity level data has been accounted for.

Table 4: Properties of surface coatings and thinners[a]

Category	Average De nsity (kg/l)	EF kg NMVOC / kg Product
Architectural/Decorative	1.33	0.11
Industrial	1.24	0.44
Thinners	0.77	1.00

a. Australian Paint Manufacturers Federation (1995).

NMVOC emissions from the use of surface coatings and thinners may be estimated according to equation (3.A.1):

$$E_{SC} = \sum (A \cdot D \cdot EF \cdot 10^{-6}) \qquad (3.A.1)$$

Where *Esc* is the total NMVOC emission (Gg/yr) from use of all surface coatings and thinners,
A is activity level (l/yr),
D is density of product (kg/ l),
EF is emission factor of product (kg NMVOC/kg product).

The inventory is calculated by multiplying production in kilolitres by the typical density of the product shown in Table 4. The result is then multiplied by the relevant emission factor and expressed in gigagrams (Gg).

3.B: Degreasing and Dry Cleaning

Surface cleaning or degreasing operations involve the removal of materials such as oils, grease, waxes and moisture from surfaces. In the commercial/industrial sectors, surface cleaning/degreasing is normally conducted in preparation for other treatment such as painting and electroplating.

There are three basic types of surface cleaning operations, which are used by commerce and industry. These operations are referred to as cold cleaning, vapour cleaning and in-line or conveyorised cleaning.

Cold cleaning is a batch process in which solvents are applied at or near room temperature. Parts are normally immersed, sprayed or wiped with a solvent such as mineral spirits. Mineral spirits (also known as white spirits) typically consists of 70-75% non methane hydrocarbons and 25-30% aromatics (i.e. 100% NMVOC). The primary cold cleaning application is cleaning of tools or metal parts at service and automotive repair stations and manufacturing facilities.

Vapour cleaning is a process in which solvent vapour is condensed on the surface to be cleaned. The process involves the heating of solvents, which traditionally have consisted of chlorinated compounds. Vapour cleaning is normally used in metalworking operations and manufacturing facilities.

In-line cleaning involves the use of automated load systems, typically conveyors, to maintain a continuous feed to the cleaning unit. These units employ both cold and vapour cleaning methods, with the majority traditionally being halogenated solvent vapour cleaning systems. In-line cleaning systems are used for large-scale operations such as the cleaning of printed circuit boards for the electronic and electrical components industries.

NMVOC emission from surface cleaning/degreasing and dry cleaning may be estimated according to:

$$E_{cd} = \sum_i (P \cdot EF_i \cdot 10^{-6}) \qquad (3.B.1)$$

Where E_{cd} is the NMVOC emission (Gg/yr) from surface cleaning/degreasing and dry cleaning,
P is population for a given year and region,
EF_i is emission factor (kg NMVOC/capita/yr) for product category *i*.

Emission factors for surface cleaning/degreasing and dry cleaning are presented in Table 5.

Table 5: Surface cleaning/degreasing and dry cleaning emission factors

i	Category	Emission factor kg NMVOC/capita/yr
1	Cold Cleaning, Automobile Repair	1.14[a]
2	Cold Cleaning, Manufacturing	0.50[a]
3	Dry Cleaning	0.17[b]
	Total	1.81

a. US EPA (1991)
b. ICI (1994).

NMVOC emission from surface cleaning/degreasing and dry cleaning are estimated using equation (3.B.1). The emission factors are those shown in Table 5. Population figures are mean populations for the relevant financial year.

3.C: Chemical Products Manufacture and Processing

Chemical products manufacture and processing covers paint and ink manufacturing. Emissions associated with the refining and storage of petroleum products are not accounted in this workbook (see *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Energy (Fugitive Fuel Emissions))*.

NMVOC emissions from chemical products manufacture and processing may be estimated according to:

$$E_{cm} = \sum_i (A_i \cdot EF_i \cdot 10^{-6}) \qquad (3.C.1)$$

Where E_{cm} is the emission of NMVOC (Gg/yr) from chemical products manufacture and processing,
$_{Ai}$ is manufactured quantity of product i (tonnes/yr),
i is source category ($i = 1, 2$),
EF_i is emission factor for product i (kg NMVOC/tonne product).

Emission factors for chemical products manufacture and processing are presented in Table 6.

Table 6: Emission factors for chemical products manufacture and processing

i	Category	EF_i kg NMVOC/tonne Product
1	Paint Manufacturing	3[a]
2	Printing Ink Production	9[b]

a Dulux (1995).
b Mid-range value reported for USA facilities, Buonicore and Davis (1992).

3.D: OTHER

General solvent use and consumer cleaning by the domestic and commercial sectors covers a large range of products. These products include aerosol spray products such as insect sprays, hairsprays and household carpet cleaners, and non-aerosol spray products such as adhesives, waxes and general household solvents. Also included in this source category is the use of N_2O in aerosol products and for medical use.

N_2O emissions from Aerosol Products and Anesthesia

Emissions of N2O from aerosol products and anesthesia are based on production data provided by the industrial gas manufacturers (BOC and Air Liquide). These data and the resultant emissions estimates are confidential and are included in the 2.G.Other source category of the Industrial Processes Sector as confidential emissions reported as CO_2e.

NMVOC Emissions from General Solvent use and Consumer Cleaning

Because of the difficulty in obtaining region specific usage data on such a wide range of products, US EPA (1989) recommend that literature emission factors be employed on a per capita basis. Per-capita emission factors provided by the Aerosol Association of Australia (AAA, 1994) have been used for Domestic/Commercial Aerosol Products and US data for aerosol spray products and miscellaneous non-aerosol spray products (USEPA 1997) have been adopted for estimating NMVOC emissions from Other Domestic/Commercial products and Consumer Cleaning Products.

NMVOC emission from general solvent use and consumer cleaning products may be estimated according to:

$$E_g = \sum_i (P \cdot EF_{gi} \cdot 10^{-6}) \qquad (3.D.1)$$

Where E_g is the NMVOC emission (Gg/yr) for general solvent use/consumer cleaning products,
P is population for a given year and region,
EF_{gi} is emission factor (kg NMVOC/capita/yr) for product category i (i=1,20).

Emission factors for general solvent use and consumer cleaning products are presented in Table 7.

Table 7: Emission factors for general solvent use and consumer cleaning products

i	Product	Emission factor kg NMVOC/capita/yr
	Domestic/Commercial Aerosol Products [a]	
1	Insect/Garden Sprays	0.33
2	Hair Sprays	0.26
3	Personal Deodorants	0.17
4	Air Fresheners	0.14
5	Miscellaneous Automotive/Industrial	0.17
6	General Household	0.13
7	Other	0.10
	Subtotal	1.30
	Other Domestic/Commercial Products [b]	
7	Adhesives and Sealants	0.21
8	Coatings and Related Products	0.35
	Subtotal	0.56
	Consumer Cleaning Products [b]	
9	Automotive Products	0.51
10	Miscellaneous Products	0.03
	Subtotal	0.54
	Total	**2.40**

a. Aerosol Association of Australia (1994)
b. USEPA (1997)

NMVOC emissions from general solvent use and consumer cleaning products are estimated from equation (3.D.1). The mean population for the financial year is multiplied by the emission factor and the result is expressed in gigagrams (Gg). Emission factors are expressed in terms of per capita use per year.

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