

Establishment of VOCs Emission Inventory in Thailand: A Report on Methodology and Early Results



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Rational of study

Establishment of VOCs emission inventory is crucially important as a foundation for further implementation, such as policy formulation and VOCs monitoring, which would eventually contribute to improvement of environmental quality.





Objectives

Phase I & Phase II

- To study relevant supporting data and information for the selected VOCs
- To identify significant emission source category for effective formulation of regulations and standards



Objectives (continued)

Phase III

- To provide data for integrated evaluation of VOCs emission and ambient monitoring resultd
- To identify existing management status of major emission sources



What are Emission Inventories?

Emission inventories are quantities of pollutants measured over time. Emission inventories can be compared with air pollutant levels in an area to determine if increased emissions decreases the air quality.



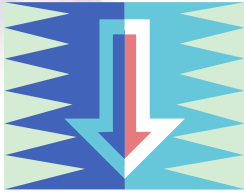
Emission Sources

- Point sources
- Mobile sources
- Biogenic sources include trees and vegetation, gas seeps, and microbial activity.
- Area sources consist of smaller stationary sources such as dry cleaners and degreasing operations.





Emissions Inventory Development Approaches



- Top-Down approach

- Bottom-Up approach



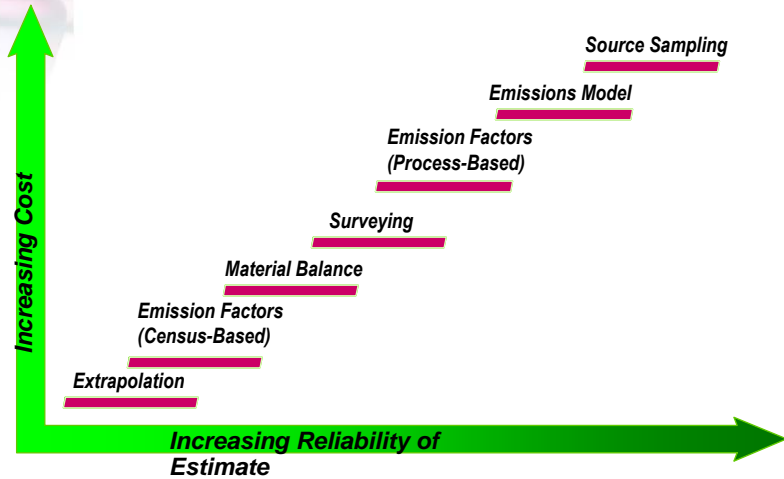
Estimate emissions of substances

In general, there are 4 types of emission estimation techniques available:

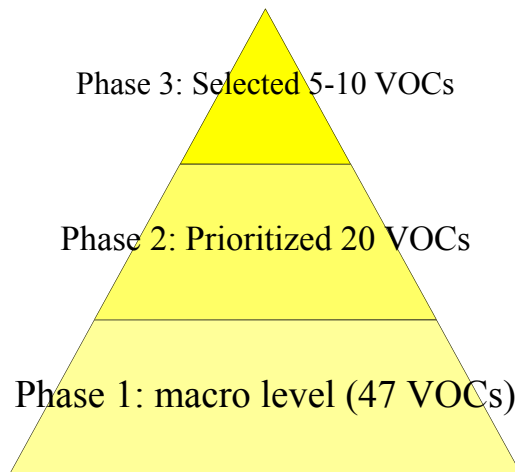
1. Sampling or direct measurement
2. Mass balance
3. Fuel analysis or other engineering calculations
4. Emission factors



Emission Estimation Techniques



Scope of the study





Phase 1 Study

- 44 VOCs compound, listed in US.EPA TO14
- 3 additional compounds
 - Formaldehyde
 - Acetaldehyde
 - Ethylene oxide



List of 44 VOCs compounds

Vinyl chloride	Freon12	Ethyl chloride	Stylene
Dichloroethylene	CCl ₄	Ethylbenzene	1,2-Dichloropropane
Freon113	Methyl chloride	Freon11	Acrylonitrile
Chloroform	Trichloroethylene	o-xylene	1,3-butadiene
Benzene	Freon114	Dicholomethane	3-Chloro-1-propane
1,2 Dichloroethane	Cis-1,3-dichloropropene	m-xylene	4-Ethyltoluene
Toluene	Methyl bromide	p-xylene	m-Dichlorobenzene
Methyl Chloroform	Trans-1,3-Dichloropopane	1,1-Dichloroethane	Benzyl chloride



List of 44 VOCs compounds (continued)

1,1,2,2-Tetrachloroethylene	Tetrachloroethelene	Hexachloro-1-3-butadiene
1,1,2-Trichloroethane	1,2,4-Trimethylbenzene	1,2,4-Trichlorobenzene
1,3,5- Trimethylbenzene	Monochlorobenzene	p-Dichlorobenzene
1,2-Dibromoethane	0-Dichlorobenzene	

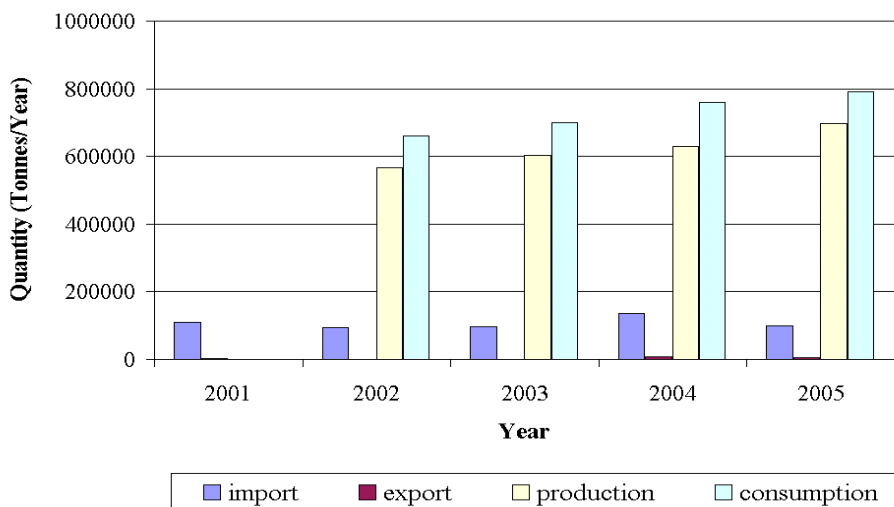


Analysis of VOCs usage quantity in Thailand

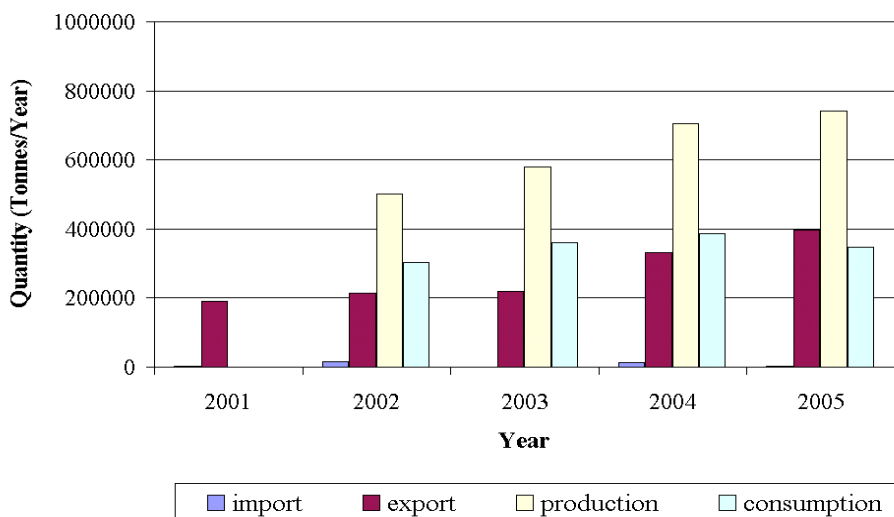
- Collection data
 - Production
 - Import/export quantity
 - Energy consumption
- Temporal analysis (2001-2005)
 - Data of 2005 are used as base year for emission inventory



Vinyl Chloride

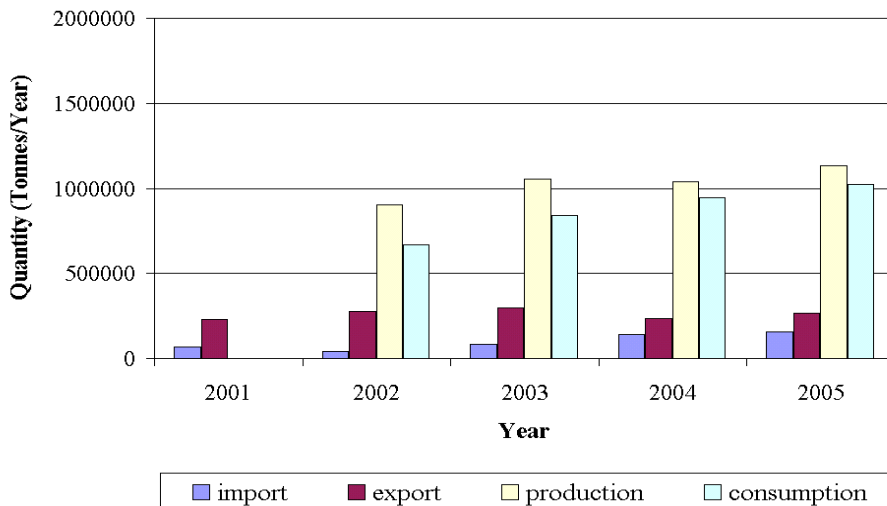


Benzene



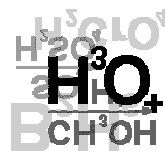


p-Xylene



Concept of Selecting Criteria of prospective priority VOCs

- Toxicity
- Possibility of Exposure
 - High Toxicity
 - Low Toxicity but large quantity or present in high concentration in environment





Selecting criteria on toxicity

Carcinogenicity

	IARC	US.EPA	ACGIH	JSOH
Criteria	1,2A	A, B	A1, A2	1,2A



Selecting criteria on inhalation chronic toxicity

Organization	Status	Criteria
WHO	Environmental standards guideline values	< 0.1 mg/m ³
IRIS: Integrated Risk Information System, (US.EPA)	RfC (Reference Concentration) Concentration or quantity that may not cause adverse effect even if the substance is inhaled or taken into one's body in his/her whole lifetime.	unit: mg/m ³ Smaller the value, higher the inhalation chronic toxicity



Screening of prospective priority VOCs

Ist Target VOCs	selection	Detected in existing monitoring results	Import and Export in 2005 (ton/year)			Production in 2005 (ton/year)	Exposure (Import+production)	Inhalation chronic toxicity(mg/m ³)		Carcinogenicity					
			Export Quantity	Import Quantity	Net			WHO	IRIS	IARC	EPA	ACGIH	JSOH		
								*1	*2	*5	*6	*7	*8		
1 Vinyl Chloride	○	○	5,677.8	98,626.0	92,948.2	697,000	795,626.0	0.01	0.0011	1	A	A1	1		
2 Vinylidene Chloride			0.0	57.0	57.0		57.0		0.2						
3 Freon 114		○	0.0	0.0	0.0		0.0								
4 Chloroform	○	○	24.2	141.7	117.5		141.7	0.024	0.00043	2B	B	A3	2B		
5 1,2-Dichloroethane	○	○	0.0	336,125.9	336,125.9		336,125.9	0.061	0.00038	2B	B	A3	2A		
6 Benzene	○	○	398,019.0	3,150.1	-394,868.9	742,000	745,150.1	0.0017	0.0013	1	A	A1	1		
7 Toluene	○	○	32,896.0	27,407.3	-5,488.7	179,000.0	206,407.3			3		A4			
8 Methyl Chloroform		○	0.0	0.0	0.0		0.0			3		A4			
9 Freon 12			17.5	1,157.4	1,139.9		1,157.4								
10 Carbon Tetrachlorid	○	○	0.0	0.0	0.0		0.0		0.00067	2B	B	A2	2B		
11 Methyl Chloride		○	0.0	0.0	0.0		0.0			3		A4			
12 Trichloroethylene	○	○	35.1	5,831.6	5,796.5		5,831.6	0.023		2A	B	A5	2B		



Phase II Study

- 20 VOCs compounds were selected.
- Selected compounds are

✓ Vinyl chloride	✓ Chloroform	✓ 1,2-Dichloroethane	✓ Benzene
✓ Ethylbenzene	✓ Benzyl chloride	✓ Carbon tetrachloride	✓ Toluene
✓ Dichloromethane	✓ Acrylonitrile	✓ Trichloroethylene	✓ p-Xylene
✓ Perchloroethylene	✓ 1,3 butadiene	✓ 1-2 Ethylene dibromide	✓ Styrene
✓ p-Dichlorobenzene	✓ Acetaldehyde	✓ Ethylene oxide	✓ Formaldehyde



Methodology

- Activity data will be collected and will be multiplied with emission factor (FIRE emission database: EPA 454/C-05-001 version 12). Criteria of selection of emission factor were as follows;
 - ✚ Data availability
 - ✚ Locating and estimating (L&E) report series, US.EPA
 - ✚ Japanese PRTR

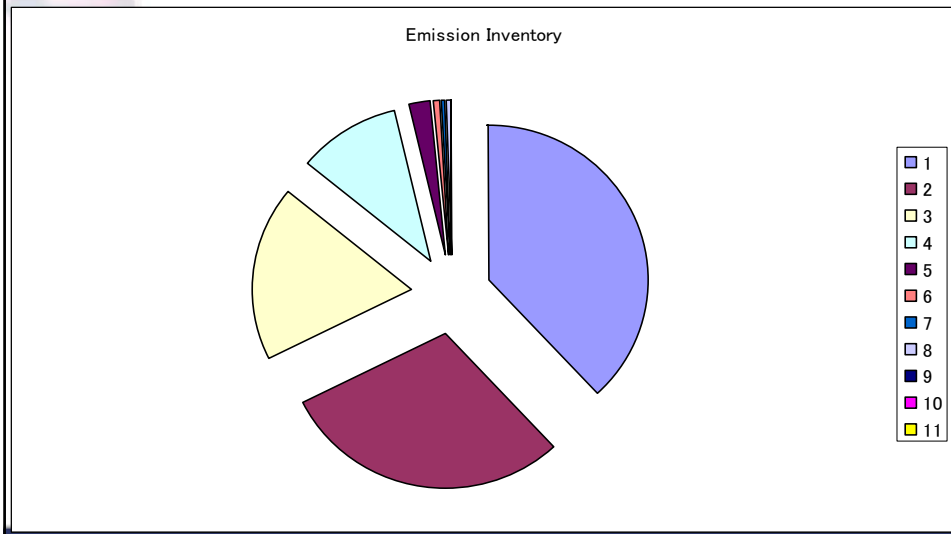


1,3-Butadiene

Data availability	SCC	CONTROL1	FACTOR	POLL_UNIT	MEASURE	MATERIAL	ACTION
1	50100701	UNCONTROLLED	1.70E+03	Lb	Tons	Butadiene	Processed
1	50300203	UNCONTROLLED	2.78E+02	Lb	1000 Tons	Tires	Burned
1	50300203	UNCONTROLLED	2.34E+02	Lb	1000 Tons	Tires	Burned
3	30101891	UNCONTROLLED	1.42E+01	Lb	Tons	Plastic	Produced
3	30115301	UNCONTROLLED	1.11E+01	Lb	Tons	Butadiene	Produced
3	30115301	UNCONTROLLED	6.85E+00	Lb	Tons	ABS Polymer	Produced
1	40600301	UNCONTROLLED	3.94E+00	Lb	1000 Gallons	Gasoline	Transferred



Expected result of phase II



Summary of VOCs inventory study

	Number of VOCs species to be studied	Number of VOCs species to be selected	Level of the data
1 st phase 2006.6 – 2006.8	Approx. 45	Approx. 20	National and macro level data
2 nd phase 2006.8 – 2007.1	Approx. 20	Approx. 5-10	Industry and source specific. (Geographic distribution)
3 rd phase 2007. 5 – 2007.7	Approx. 5-10	Not yet decided	Door to door survey for individual source (Source testing data)



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- Pollution Control Department



**VOCs emission inventory
working group**

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