Outlines of

Guidelines for Developing Emission Inventory in East Asia

1. Background and Objectives of "Guidelines for Developing Emission Inventory in East Asia"

1) Background

East Asia region, whose economy has been rapidly growing, has seen the increase in emissions of air pollutants such as SO2 and NOx, which are also acidifying species, Volatile Organic Compound (VOC), and particulate matters, leading to rising concerns of their environmental impacts. Also, tropospheric ozone, partly generated through the chemical reaction process involving NOx and VOC, has attracted attention as regional air pollution, and there have been reports on the increase in its concentrations, and effects on plants. Fine particulate matter is another pollutant of concerns in many countries.

This serious condition of air pollution not only impedes the sustainable development in each country in the East Asia region, but may also affect the air quality of neighboring countries or the background level on a global scale. Large point sources of air pollutants are also large point sources of greenhouse gas.

In order to take science-based effective policy measures against these air pollutants, basic information necessary to assess reduction potentials and control measures and to establish reduction targets should be organized as a starting point. So far, a few sets of emission inventory, including global-scale one, which is one form of such basic information, have been developed in East Asia by respective governments and researchers. However, there were no agreed methodologies of developing emission inventory, which would improve the transparency and comparability of inventory. This guidelines (hereinafter "the Guidelines") are developed with the aim to establish the common methodologies of developing emission inventory.

2) Objectives

Effective management of atmospheric environment at regional level is becoming more urgent in East Asia, as shown, among other things, by the increase in tropospheric ozone concentrations. To handle long range transports of air pollutants, analyses based on emission inventory and simulation models are especially critical. Such analyses will be much more simplified and useful, once the methodologies can be standardized across the region. Also through cooperation in preparing emission inventory, national capacity could be developed for the measurement of emission and emission factor as well as application of inventory and models. These can result in contribution to both environmental protection in each country and reduced long range transports of air pollutants.

3) Framework of Guidelines

The Guidelines are constituted as follows.

Composition of Chapters	Constitution of Calculation Methods	Target Pollutants
The Guidelines consist of chapters corresponding to each sector (fuel combustion, fuel leakage, industrial process, solvent & product uses, agriculture, forest fires, waste disposal and natural sources).	Calculation methods of each sector are classified into a simple method and a detailed method. Each method is composed of estimation of emission, estimation of activity data, setting of emission factor and calculation of temporal change & spatial distribution.	SO_x, NO_x, CO, NMVOC, NH_3, TSP, PM_{10}, $PM_{2.5}$, BC(Black Carbon), OC(Organic Carbon), CO_2, CH_4, N_2O

2. What is Emission Inventory?

Emission Inventory is the inventory that shows the source and the volume of air pollutant's emissions within a specific period of time. It is an indispensable tool used for the design and implementation related to air pollution measures.

1) Quantitative understanding of actual emissions

The quantitative emissions estimates provided by inventory promote a better understanding of the actual emissions and help to raise the awareness of both policy makers and the general public. Through this process, the major emission sources can be identified, priorities for emission reduction can be defined and any data gaps requiring additional work are revealed.

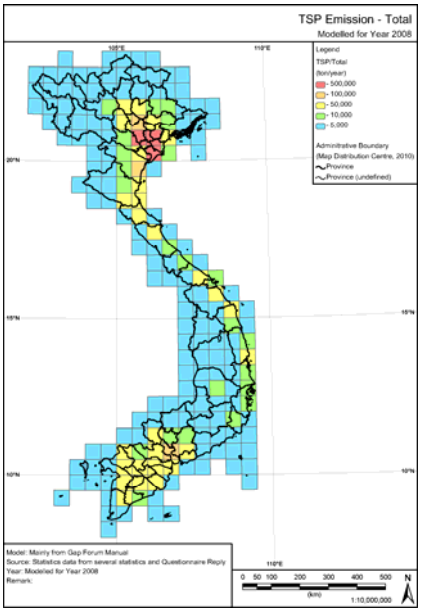


Fig Distribution map of TSP emission inventory in Vietnam

2) Use for modeling activity

Emission data allocated spatially and temporally can be used as input data for atmospheric transport and deposition models. The air concentration and deposition estimates obtained by model simulations, after verification with monitoring data on the ground, will be important information for air quality management decision-making. These results can be used to establish effective air pollution control measures to attain environmental quality standard, through comparison between the simulated results and the standard, or to assess the likely adverse impacts to humans, animals, crops and natural ecosystems.

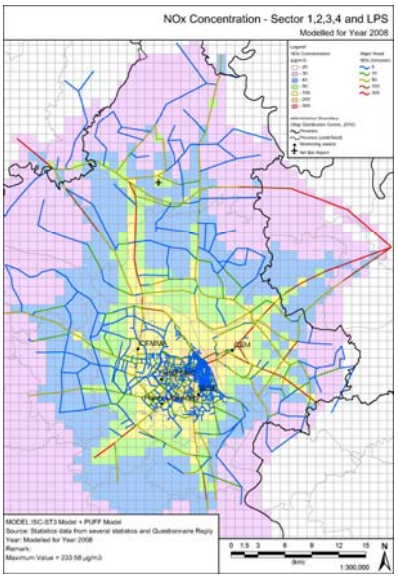


Fig NO_x simulation result in Hanoi

3) Future projection & air quality management measures

The inventory data is estimated from activity data from socio-economic statistics and emission factor. The future emission is estimated based on forecast of socio-economic indices (e.g. population growth, economic growth, changes in energy use per unit activity), and effects of ongoing and possible measures including reduction of emission factors and/or fuel switching. The estimated future emissions provide important information for setting air quality management plan.

4) Consideration of possible technologies

Emission inventory enables easier comparison of emissions before and after introduction of various technologies. Furthermore by evaluating and comparing the cost of various technologies and the effectiveness in reducing emissions, those technologies with higher cost effectiveness can be selected.

3. Emission Estimation Method

In general, emissions of air pollutants are estimated by the following basic formula for each source category, when it is difficult to measure them directly. Details of emission estimation method are explained in the Guidelines.

Emission = Emission Factor x Activity Data

Example

- SO_x emission per the amount of fuel burnt, calculated based on the sulfur content of fuel, the sulfur retained in the ash and the reduction achieved by emission control technology (fuel combustion)
- NO_x emission per unit distance of one vehicle travelled (exhaust gas emissions from vehicles)
- SO_x emission per the amount of copper smelted (copper smelting)

- The amount of fuel burnt (fuel combustion)
- The distance of vehicle travelled (exhaust gas emissions from vehicles)
- The production amount of the commodity (industrial process without combustion)

1) Emission Factor

Emission factors are the average rate of emission of a pollutant per unit of activity data for a given category. When there is no emission factor reflecting the actual local situation, default values in manuals can be used. However, if the default factor is considered to be inappropriate, it is preferable to obtain an emission factor that reflects the real situation by direct measurement etc.

The reduction level and the deployment rate of technical measures have to be reflected in the emission factor or the formula, as introduction of countermeasures reduces the emission.

In these Guidelines, the values from “GAP Forum Manual”, “EMEP/EEA Guidebook”, “USEPA AP-42”, “COPPERT” and so on, are cited for emission factors, such as the default values or the values specified by control technology, etc.

2) Activity Data

Activity data indicates the extent of activity causing emissions. Required data can be basically collected from statistics and surveys. Within these Guidelines, the statistics data of a targeted country have given first priority. If no data exists in the country, then use international statistical data in principle.

4. Sectors and Categories

The Guidelines are described corresponding to each sector shown below. Each sector (e.g. Industrial Process) comprises individual categories (e.g. Mineral Products) and sub-categories (e.g. Cement Industry). Final product of inventory would be built up from the sub-categories, because accurate estimates can only be made at this level and because this detail information makes inventory more useful to policymakers.

Sector	Category (corresponding page of the Guideline)	Main sub-categories
Fuel	Energy industry (page 3-3 ~)	Electricity & heat supply industry, Oil refinery etc.

combustion (Stationary source)	Manufacturing industry, Construction industry (page 3-3 ~)	Steel, non-ferrous metal, chemical industry, etc.
	Small scale facility (page 3-3 ~)	Residential houses, Commercial and public services, Agriculture/forestry, Fishery, etc
	Off-road (page 3-3 ~)	Off-road equipment in manufacturing, construction industry, off-road vehicles used in agricultural industry, etc.
Fuel combustion (Mobile source)	Cars (page 3-44 ~)	Passenger cars, trucks, buses, motorcycles, etc.
	Aircrafts (page 3-86 ~)	Civil passenger aircrafts, Civil freight aircrafts
	Navigation (page 3-94 ~)	Cargo vessels, container vessels, passenger ship,etc.
	Railways (page 3-108 ~)	Diesel, gas and steam locomotives
Fossil Fuel Leakage	Leakage from solid fuel, such as coal (page 4-4 ~)	Coal exploration & handling, Leakage from solid fuel
	Leakage from crude oil & natural gas (page 4-20 ~)	Oil exploration survey, production, loading, oil refining, storage, oil product distribution, Natural gas exploration, production, loading, refining, transportation
Industrial Process	Mineral products (page 5-5 ~)	Cement industry, Lime industry, Bricks industry, Construction & demonlition, etc.
	Chemical products (page 5-36 ~)	Ammonia manufacturing, Adipic acid manufacturing, Carbon black manufacturing, etc.
	Metal products (page 5-59 ~)	Steel industry, Copper manufacturing, Lead manufacturing, Storage, processing, transportation in metal manufacturing, etc.
	Other product manufacturing (page 5-103 ~)	Paper & pulp manufacturing, Food, drink manufacturing, Wood processing industry, etc.
Solvent use and Product use	Paint application (page 6-2 ~)	Manufacture of automobiles, Construction and building, Domestic use, Boat building, etc.
	Metal & other surface treatment (page 6-10 ~)	Metal degreasing, Electronic components manufacturing, other industrial cleaning
	Dry cleaning (page 6-13 ~)	Dry cleaning
	Chemical product manufacturing (page 6-16 ~)	Polyester processing, Polyvinylchloride processing, Polyurethane foam processing, Rubber products, etc.
	Printing (page 6-23 ~)	Printing
	Household solvent use (page 6-28 ~)	Household solvent use (except paints)
	Other product use (page 6-31 ~)	Glass wool coating, Fat, Edible and non-edible oil

		extraction, Application of glues and adhesives, etc.
Agriculture	Livestock (page 7-3 ~)	Livestock excreta, Livestock housing, Fermentation indigestive tract
	Agricultural soils (page 7-19 ~)	Fertilizer use in agricultural soils, etc.
	Open burning of savanna (page 7-24 ~)	Open burning of savanna
	Open burning of crop residues (page 7-30 ~)	Open burning of crop residues
Forest fires	Forest fires (page 8-1 ~)	Vegetation
Waste Disposal	Solid waste disposal (page 9-3 ~)	Landfill site
	Biological treatment (page 9-3 ~)	Compost, Sludge
	Incineration (page 9-4 ~)	Incinerators, Open burning, Small incinerators and others
	Waste water treatment (page 9-32 ~)	Waste water treatment
	Others (page 9-33 ~)	Anthropogenic source, wild animal
Natural Source	Vegetation (page 10-1 ~)	Land-use of each vegetation classification
	Volcanoes (page 10-9 ~)	Volcanoes
	Soils (page10-10 ~)	Land-use of each soil classification

5. Outlines of Sectors and their Potential Data Sources

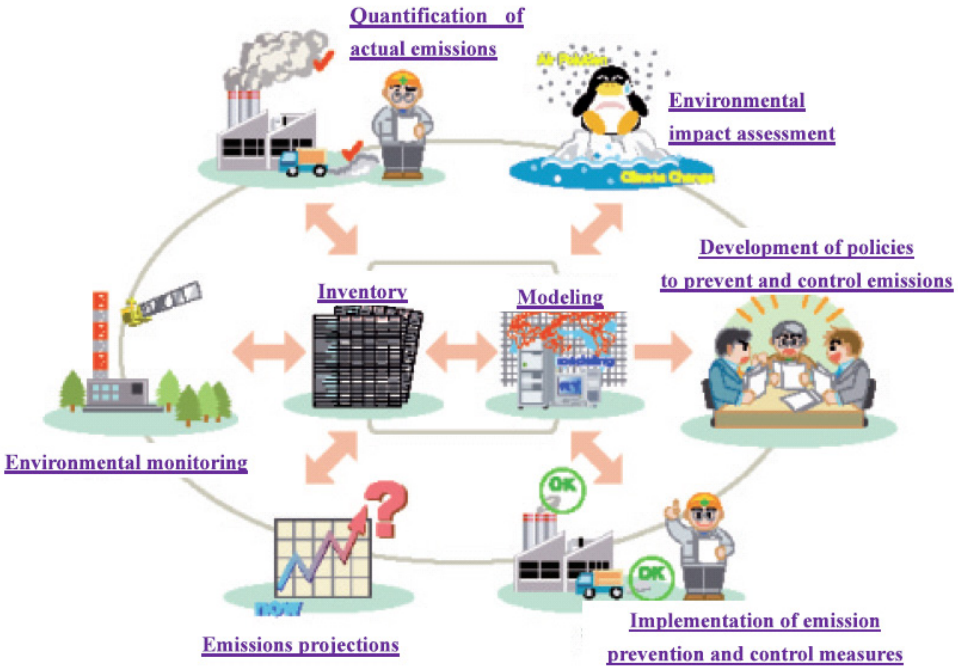
Examples of main activity and sources of activity data are as follows;

Sector Name	Main Activity / Example of Sources of Activity Data (Sources)
Fuel combustion	This sector's emission sources are various activities of the fuel combustion; Stationary sources are classified as Energy Industry, Manufacturing construction industry, Others (commerce facility, public, residential, agriculture, forestry, fishery). Mobile sources are classified as Cars, Aircrafts, Ships and Railways.
	Sources: energy statistics of each country, energy statistics of IEA, etc.
Fossil fuel leakage	This sector's emission sources are the non-combustion activities such as extractions, processing, storage, transportation and use of fossil fuels.
	Sources: statistics data of each country, etc.
Industrial process	This sector's emission sources are the various industrial process activities without the fuel combustion. The main emission sources are the processes of converting raw material into products chemically or physically. Industrial processes are often intricately interrelated to the fuel combustion.
	Sources: statistics data of each country, Industrial Commodity Statistics Yearbook, etc.
Solvent & other products use	This sector's emission sources are NMVOC which are evaporated from solvent use and other product use. The NMVOC emission by manufacturing the solvent itself is

	calculated in the Industrial Process Sector.
	Sources: statistics data of each country, Industrial Commodity Statistics Yearbook, etc.
Agricultural activities	This sector's emission sources are livestock, field burning of savanna, field burning of crop residues and fertilizer use, etc.
	Sources: statistics data of each country, Food and Agriculture Organization (FAO) data, etc.
Forest fire	This sector's emission sources are forest fires, grassland fires, etc.
	Sources: statistics data of each country, etc.
Waste treatment	This sector's emission sources are the incineration of Municipal waste, Industrial waste and Toxic industrial waste, and open burning.
	Sources: statistics data of each country, etc.
Natural sources	This sector's emission sources are NMVOC emissions from vegetation, SO_x emissions from volcanoes, NO_x and NH_3 emissions from soils.
	Source: Data of "Global Land Cover by National Mapping Organizations (GLCNMO)", "Smithsonian Global Volcanic Network"

6. Example of Application and Utilization of Emission Inventory

Emission inventory is now regarded as an indispensable tool for air quality management and other environmental measures such as chemical management. The emission inventory is utilized for "confirmation of actual emissions situation" and "emissions projections". Furthermore, it is utilized for "environmental impact assessment", "implementation of emission control measures" and "development of policies to control emissions" by combining with a simulation model.



Source

Fig. Roles of emission inventory for air quality management

7. Future Tasks

There are not sufficient datasets of well-examined emission factors in the East Asia region. In many sectors, the emission factors measured in Western countries (Europe and North America) are being used as alternatives. Therefore, it is important to establish East Asian specific emission factors to better reflect the region's situation. When selecting sectors and pollutants for emission factor estimation, the sectors and pollutants with large emission in the East Asia region should be chosen.

In order to refine emission inventory, not only the development of emission factors but also the improvement in assessment accuracy of activity data is required. The status of organization of statistical data and its accuracy depends on each East Asian country. However, it is important to actually develop emission inventory in order to improve the accuracy of emission inventory. The practice to develop emission inventory will help identify the challenges, and improve emission calculation methods.

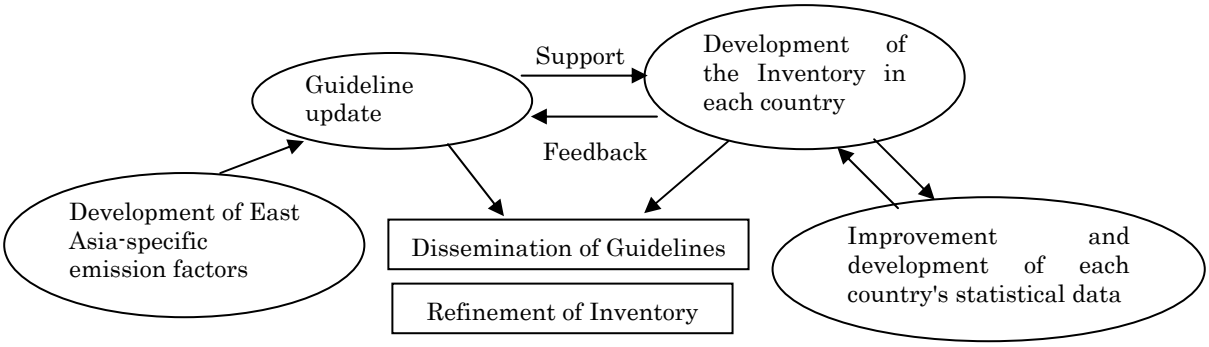


Fig. Relationship between "dissemination of the Guidelines" and "refinement of emission inventory"

By sharing the experience with other East Asian countries and in vice versa, and receiving feedback from other East Asian countries, the capacity to develop emission inventory in the whole East Asia region will be developed. For this purpose, the followings would be necessary in the future; development and distribution of the spreadsheet of emission inventory format, development of the check-tree for main emission sources, comprehension of the contribution rate of each pollutant/ each sector, quantification of uncertainties, establishment of inventory development cycle, and so forth.

- Ministry of the Environment of Japan
- Cooperation: JAPAN ENVIRONMENTAL SANITATION CENTER
  Asia Center for Air Pollution Research (ACAP)
  SUURI-KEIKAKU CO., LTD.
- Acknowledgement: The outcome of a bilateral project between Japan and Vietnam is reflected, as appropriate, in drafting the first version of the Guidelines.