

The Malé Declaration Air Pollutant Emissions Inventory Manual

Draft: September, 2003



Implementation of the Malé Declaration on Control and Prevention of
Air Pollution and its Likely Transboundary Effects

Aim and objective of the parallel activity on emissions inventories

Aim:

each Malé Declaration country to compile (during Phase III) air pollutant emission inventories which are compatible with each-other and with the Integrated Assessment Model (IAM)

Aim and objective of the parallel activity on emissions inventories

Aim:

each Malé Declaration country to compile (during Phase III) air pollutant emission inventories which are compatible with each-other and with the Integrated Assessment Model (IAM)

Objective:

to produce, in consultation with the NIAs and S. Asian experts, a manual and associated software (Excel-based workbook) for use by the Malé Declaration countries in compiling these emission inventories

Process for developing the manual and workbook

- At end of Phase I, development of an IAM (including an emission inventory) **identified by NIAs as a priority** - to be carried out in parallel to the monitoring efforts.

Process for developing the manual and workbook

- At end of Phase I, development of an IAM (including an emission inventory) **identified by NIAs as a priority** - to be carried out in parallel to the monitoring efforts.
- This activity **builds on earlier work** carried out during Phase I - especially the *Baseline Studies*

Process for developing the manual and workbook

- At end of Phase I, development of an IAM (including an emission inventory) **identified by NIAs as a priority** - to be carried out in parallel to the monitoring efforts.
- This activity **builds on earlier work** carried out during Phase I - especially the *Baseline Studies*
- The manual and workbook have been developed in **consultation with the NIAs** (questionnaire circulated last year) and regional experts

Process for developing the manual and workbook

- At end of Phase I, development of an IAM (including an emission inventory) **identified by NIAs as a priority** - to be carried out in parallel to the monitoring efforts.
- This activity **builds on earlier work** carried out during Phase I - especially the *Baseline Studies*.
- The manual and workbook has been developed in **consultation with the NIAs** (questionnaire circulated last year) and regional experts
- Malé Declaration countries will then use the manual to develop emission inventories and run scenario projections in Phase III

Pollutants included in manual

- Sulphur dioxide (SO_2)
- Nitrogen oxides (NO_x)
- Particulate matter (PM_{10} and Total Suspended Particulate (TSP))
- Ammonia (NH_3)

Summary of emission source categories used in the manual

Energy sources:

- 1 Combustion in the Energy Industries
- 2 Combustion in Manufacturing Industries and Construction
- 3 Transport
- 4 Combustion in Other Sectors

Summary of emission source categories used in the manual

Energy sources:

- 1 Combustion in the Energy Industries
- 2 Combustion in Manufacturing Industries and Construction
- 3 Transport
- 4 Combustion in Other Sectors

Other source sectors:

- 5 Fugitive emission from fuels
- 6 Industrial Processes
- 7 Agriculture
- 8 Vegetation Fires & Forestry
- 9 Waste
- 10 Natural sources

Breakdown of energy source sectors

Sector	Sub-sector	Sub-sub sector
1. Combustion in Energy industries	Public Electricity and Heat Production	
	Petroleum Refining	
	Manufacture of Solid Fuels and Other Energy:	Coke ovens
		Patent fuel, BKB
Gas works		
	Charcoal production	
2. Combustion in Manufacturing Industries and Construction	Iron and steel	
	Non-ferrous metals	
	Chemicals	
	Pulp, paper and print	
	Food, beverages and tobacco	
	Textiles and leather	
	Other	
3. Transport	Civil Aviation	
	Road transport	
	Railways	
	Navigation	
	Pipeline transport	
	Other	
4 Combustion in other sectors	Commercial/Institutional	
	Residential	
	Agriculture/Forestry/Fishing	

Fuel combustion sectors – *Fuel categories*

Coal	Gas	Oil	Combustible Renewables / wastes
Coking Coal	Gas Works Gas (GWG)	Crude Oil	Solid Biomass and Animal Products:
Other Bituminous Coal & Anthracite	Natural Gas	Natural Gas Liquids (NGL)	<i>Wood</i>
Sub-Bituminous Coal		Refinery Gas	<i>Vegetal materials and wastes</i>
Lignite		Liquefied Petroleum Gases (LPG)	<i>Other (e.g. Animal products/wastes)</i>
Patent Fuel		Motor Gasoline	Gas/Liquids from Biomass + wastes
Coke Oven Coke		Aviation Gasoline	Municipal Waste
Gas Coke		Gasoline type Jet Fuel	Industrial Waste
BKB (Brown coal briquettes)		Kerosene type Jet Fuel	Charcoal
Coke Oven Gas (COG)		Kerosene	
Blast Furnace Gas (BFG)		Gas/Diesel Oil	
		Residual Fuel Oil (RFO)	
		Petroleum Coke	
		Other Petroleum Products	

General approach for calculation of emissions

Unless measured directly, emissions are generally estimated using emission factors:

$$\text{Emission} = (\text{emission factor}) \times (\text{activity rate})$$

Emission Factors (EFs)

EFs are the rate of emission of a pollutant per unit of activity (e.g. kg NO_x per ktoe coal burnt; kg SO₂ per tonne copper smelted)

The manual and associated workbook contains suggested default EFs

Default EFs mostly derived from European or North American source documents (e.g. EMEP/Corinair; USEPA AP-42; IPCC Guidelines)

Emission Factors (EFs)

Where possible, EFs appropriate for the region have been used in the manual (and workbook) after consultation with NIAs, local experts and a literature search e.g. :

- Road vehicle EFs - mostly from Indian Central Pollution Control Board (CPCB), New Delhi.
- Biomass fuel and biomass residue burning – Centre for Environmental Science and Engineering, Mumbai, India.

Activity rates

Examples:

- For ***fuel combustion***, the “activity rate” is the annual rate of consumption of a fuel (e.g. kilotonnes oil equivalent (ktoe) burnt per year)
- For ***industrial process emissions*** the “activity rate” is the annual rate of production of the commodity (e.g. tonnes copper per year)

Activity rates

Sources of activity data:

- National statistical yearbooks

Activity rates

Sources of activity data:

- National statistical yearbooks
- International sources:

International Energy Agency (IEA) Energy Statistics and Balances of non-OECD Countries (on CD ROM)

United Nations, Industrial Commodity Statistics Yearbooks

*UN Food and Agricultural Organization's on-line database
FAOSTAT*

Top-down or bottom up approach?

- Depends on data availability – flexibility crucial

Top-down or bottom up approach?

- Depends on data availability – flexibility crucial
- If national data only – then top-down

Top-down or bottom up approach?

- Depends on data availability – flexibility crucial
- If national data only – then top-down
- If large point source (LPS) data – bottom-up

Top-down or bottom up approach?

- Depends on data availability – flexibility crucial
- If national data only – then top-down
- If large point source (LPS) data – bottom-up
- National and LPS sources can be inventoried together – the workbook will automatically adjust national activity data to avoid ‘double-counting’.












The emission inventory Excel workbook: main menu

User must enter inventory details here:

Inventory year:	2000
Region:	S. Asia
Country:	Someland
Province:	SomeCounty

The emission inventory Excel workbook: main menu

MENU OVERVIEW

	Menu1	Sectors 1. to 4. Fuel combustion activities
	Menu2	Sector 5. Fugitive emissions (non-combustion) for fuels
	Menu3	Sector 3. Fuel combustion activities. Sub-sector: Transport (Detailed method)
	Menu4	Sector 6. Industrial processes (non-combustion) emissions
	Menu5	Sector 7. Agriculture
	Menu6	Sector 8. Vegetation fires and Forestry.
	Menu7	Sector 9. Waste
	Menu8	Sector 10. Natural sources
	Menu9	Sector 11. Large Point sources
	Sheet 8	Summary sheet - Annual emissions of each pollutant by source sector
	References	

The emission inventory Excel workbook: Menu 3

Sector 3. Fuel combustion activities. Sub-sector: Transport (Detailed method)

GO

Sheet 1.7.1 Emissions for LTO^a and cruise activities of domestic aircraft.

GO

Sheet 1.7.2 Emissions for LTO^a and cruise activities of international aviation.

GO

Sheet 1.7.3 Mobile emissions of NO_x and PM (detailed) for on-road vehicles.

GO

Sheet 1.7.4 Age of vehicle deterioration factors for exhaust emissions.

*Back to
Main Menu*

Road transport emissions – detailed or simple method?

- Emission Factors usually depend on vehicle type, age, fuel type, emission controls and so forth.

Road transport emissions – detailed or simple method?

- Emission Factors usually depend on vehicle type, age, fuel type, emission controls and so forth.
- If only national total fuel consumption data available - *simple method* using average ‘bulk’ emission factors allows rough estimate.

Road transport emissions – detailed or simple method?

- Emission Factors usually depend on vehicle type, age, fuel type, emission controls and so forth.
- If only national total fuel consumption data available - *simple method* using average ‘bulk’ emission factors allows rough estimate.
- If data on fleet composition and average distance travelled per vehicle class per year are available – *detailed method* recommended.

Road transport emissions – detailed or simple method?

- Emission Factors usually depend on vehicle type, age, fuel type, emission controls and so forth.
- If only national total fuel consumption data available - *simple method* using average ‘bulk’ emission factors allows rough estimate.
- If data on fleet composition and average distance travelled per vehicle class per year are available – *detailed method* recommended.
- Workbook will permit either method.

Mobile emissions of (detailed) for on-road vehicles

Sheet 1.7.3 Mobile emissions of NOx, PM10 and TSP (detailed) for on-road vehicles.

Sector: Transport (Detailed method)

Sub-sector: Road transportation

[BACK TO MENU](#)

Fuel	Vehicle class	Year of manufacture	A	B	C	D
			Number of vehicles in use	Average distance travelled per vehicle (km/yr)	Total distance travelled (km/yr) C = A x B	Distance travelled on unpaved roads as a percent of total (%)
Gasoline	2-wheeler, 2-stroke	Pre 1986			0	
		1986-1990			0	
		1991-1995			0	
		1996-2000			0	
		2001-2005			0	
		2006-2010			0	
Gasoline	2-wheeler, 4-stroke	Pre 1986			0	
		1986-1990			0	
		1991-1995			0	
		1996-2000			0	
		2001-2005			0	
		2006-2010			0	
Gasoline	3-wheeler, 2-stroke	Pre 1986			0	

Mobile emissions of NO_x (detailed) for on-road vehicles

Fuel	Vehicle class	Year of manufacture	E		F	G
			NO _x emission factor (g/km)		NO _x deterioration factor	NO _x emissions (Tonnes)
				Default ^b		G = C x F x E/1000000
Gasoline	2-wheeler, 2-stroke	Pre 1986		0.03	1.4	0
		1986-1990		0.03	1.4	0
		1991-1995		0.03	1.3	0
		1996-2000		0.06	1.2	0
		2001-2005		0.07	Newer than year 2000!	#VALUE!
		2006-2010		0.08	Newer than year 2000!	#VALUE!
Gasoline	2-wheeler, 4-stroke	Pre 1986		0.31	1.4	0
		1986-1990		0.31	1.4	0
		1991-1995		0.31	1.3	0
		1996-2000		0.3	1.2	0
		2001-2005		0.3	Newer than year 2000!	#VALUE!
		2006-2010		0.3	Newer than year 2000!	#VALUE!
Gasoline	3-wheeler, 2-stroke	Pre 1986		0.05	1.7	0

Mobile emissions of PM₁₀ (detailed) for on-road vehicles

Year of manufacture	H		I	J	M		N	Q		R
	Exhaust PM10 emission factor (g/km) (Assume = TSP emission factors)		PM deterioration factor	Exhaust PM ₁₀ emissions (Tonnes)	Paved road resuspended dust (PM ₁₀) emission factor (g/km)		Paved road resuspended dust (PM ₁₀) emissions (Tonnes)	Unpaved road resuspended dust (PM ₁₀) emission factor (g/km)		Unpaved road resuspended dust (PM ₁₀) emissions (Tonnes)
		Default		$J = I \times C \times G / 1000000$		Default ⁱ	$N = C \times (100 - D) / 100 \times M / 1000000$		Default ⁱ	$R = C \times (D/100) \times Q / 1000000$
Pre 1986		0.23	1.4	0		0.02	0		64	0
1986-1990		0.23	1.4	0		0.02	0		64	0
1991-1995		0.23	1.3	0		0.02	0		64	0
1996-2000		0.1	1.2	0		0.02	0		64	0
2001-2005		0.05				0.02	0		64	0
2006-2010		0.05				0.02	0		64	0
Pre 1986		0.07	1.4	0		0.02	0		64	0
1986-1990		0.07	1.4	0		0.02	0		64	0
1991-1995		0.07	1.3	0		0.02	0		64	0
1996-2000		0.06	1.2	0		0.02	0		64	0
2001-2005		0.05				0.02	0		64	0
2006-2010		0.05				0.02	0		64	0
Pre 1986		0.35	1.7	0		0.04	0		128	0
1986-1990		0.35	1.7	0		0.04	0		128	0

Step-by-step guide to using workbook

Sheet 1.7.3 Mobile emissions of NO_x, PM₁₀ and TSP (detailed) for on-road vehicles.

- Step 1 Enter in column A the average number of vehicles in use, for each vehicle class, during the inventory year.
- Step 2 Enter in column B the average distance travelled (kilometres per year) for each vehicle class .
- Step 3 Enter in column D the % of total distance which was travelled on unpaved roads.
- Step 4 Enter in column E the NO_x emission factor (grammes NO_x per kilometre) for each vehicle class .
- Step 5 Enter in column H the PM₁₀ exhaust emission factor (grammes per kilometre) for each vehicle class.
- Step 6 Enter in column K the TSP exhaust emission factor (grammes per kilometre) for each vehicle class.
- Step 7 Enter in column M the paved road emission factors (grammes per kilometre) for resuspended dust (PM₁₀)
- Step 8 Enter in column O the paved road emission factors (grammes per kilometre) for resuspended dust (TSP)
- Step 9 Enter in column Q the unpaved road emission factors (grammes per kilometre) for resuspended dust (PM₁₀)
- Step 10 Enter in column S the unpaved road emission factors (grammes per kilometre) for resuspended dust (TSP)
- Output: Worksheet 1.7.3 calculates NO_x emissions (in column G), exhaust emissions of PM₁₀ and TSP (in columns J and L), paved road emissions of PM₁₀ and TSP (in columns N and P) and unpaved road emissions of PM₁₀ and TSP (in columns R and T) . Totals then carried forward to summary sheet (Worksheet 8).

The Malé Declaration Air Pollutant Emissions Inventory Manual

Draft: September, 2003



Implementation of the Malé Declaration on Control and Prevention of
Air Pollution and its Likely Transboundary Effects