RAPIDC
Regional Air Pollution in Developing Countries

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Malé Declaration emissions inventory workshop

Delhi, India, November 2010

Session 3 – Compiling emissions by sector: The energy sources (Sectors 3 - 5)

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Malé Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia

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**
5 **Fugitive emissions from fuels**

Other source sectors:

6 Industrial Processes
7 Solvent and Other Product Use
8 Agriculture
9 Vegetation Fires & Forestry
10 Waste

Emissions for Energy sources – Sector 3: *Transport*

The Transport sector includes emissions from both the combustion (SO_2, NO_x, CO, NMVOC, NH_3 and PM_{10}) and evaporation (NMVOC) of fuel.

The activities included are:

- **civil aviation;**
- **road transport (includes road dust emissions);**
- **railways;**
- **navigation (except fishing boats);**
- **pipeline transportation; and**
- **non-specified transport (e.g. ground activities in airports and harbours)**

Specifically excluded are:

- **all *off*-road mobile activities; and**
- **evaporation of gasoline during refueling at service stations.**

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Emissions for Energy sources – *Transport*

Sector:		Transport					
Fuel type	Sub-sector:	Civil Aviation[6]	Road transport	Railways	Navigation[6]	Pipeline transport	Non-specified transport
Coal	Coking Coal						
	Other Bituminous Coal & Anthracite						
	Sub-Bituminous Coal						
	Lignite						
	Patent Fuel						
	Coke Oven Coke						
	Gas Coke						
	BKB (Brown coal briquettes)						
	Coke Oven Gas						
	Blast Furnace Gas						
Gas	Gas Works Gas						
	Natural Gas						
Oil	Crude Oil						
	Natural Gas Liquids						
	Refinery Gas						
	Liquefied Petroleum Gases						
	Motor Gasoline						
	Aviation Gasoline						
	Gasoline type Jet Fuel						
	Kerosene type Jet Fuel						
	Kerosene						
	Gas/Diesel Oil						
	Heavy Fuel Oil						
	Petroleum coke						
	Other Petroleum Products						
Combustible renewables/ wastes	Primary Solid Biomass:						
	Wood						
	Vegetal materials and wastes						
	Other (e.g. animal products/wastes)						
	Unspecified primary solid biomass						
	Gas/Liquids from Biomass + wastes						
	Municipal Waste						
	Industrial Waste						
	Charcoal						

Transport:

Simple method

- **Total fuel use**
- **Bulk emission factors**

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Emissions for Energy sources - *Civil Aviation (Detailed Method)*

For all pollutants emitted by domestic and international aircraft:

Included are:

- ***landing and take-off (LTO) cycle* emissions; and**
- ***cruise activity* emissions (domestic only)**

If detailed activity data are available, use separate emission factors for each type of aircraft.

Otherwise, default EFs are also given in the Workbook typical of "old fleet" or "average fleet" aircraft.

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Transport: Civil Aviation (Detailed Method)

Domestic flights: aircraft type (* =old fleet)	A Total number of LTOs per aircraft type per year	B Fuel consumption per LTO (kg/LTO)		C Fuel consumption for LTO activities (Tonnes)	D Total fuel sold for domestic aviation (TJ)	E Total fuel sold for domestic aviation (Tonnes)	F Fuel consumed for cruise activities (Tonnes)
			Default[b]	C = A x B/1000	(From Sheet 1.1.1)	E = 1000*D/(Net Calorific Value[f])	F = (E x (A/A_{Total}))-C
Airbus A310			1540.5	0			0.00
Airbus A320			802.3	0			0.00
Airbus A330			2231.5	0			0.00
Airbus A340			2019.9	0			0.00
BAe 111			681.6	0			0.00
BAe 146			569.5	0			0.00
Boeing 727*			1412.8	0			0.00
Boeing 737-100			919.7	0			0.00
Boeing 737-400			825.4	0			0.00
Boeing 747 100-300			3413.9	0			0.00
Boeing 747-400			3402.2	0			0.00
Boeing 757			1253	0			0.00
Boeing 767 300 ER			1617.1	0			0.00
Boeing 777			2562.8	0			0.00
McDonnel Douglas DC-8*			1839.4	0			0.00
McDonnel Douglas DC-9*			876.1	0			0.00
McDonnel Douglas DC-10			2381.2	0			0.00
McDonnel Douglas M81-88			1003.1	0			0.00
Fokker 28			666.1	0			0.00
Fokker 100			744.4	0			0.00
Type unknown (old fleet[h])			920	0			0.00
Type unknown (average fleet[g])			825	0			0.00
Other (Please specify)				0			0.00
Total	0			0	0	0	0

Transport: Civil Aviation (Detailed Method)

Domestic flights: aircraft type (* =old fleet)	A Total number of LTOs per aircraft type per year	G SO2 emission factor per LTO (kg/LTO)		H SO_2 emission factor for cruise activities (kg/Tonne)		I SO_2 emissions (Tonnes)	J NOx emission factor per LTO (kg/LTO)		K NOx emission factor for cruise activities (kg/Tonne)		L NOx emissions (Tonnes)
			Default[c]		Default[c]	I = (A x G/1000) + (F x H/1000)		Default[b]		Default[b]	L = (A x J/1000) + (F x K/1000)
Airbus A310			1.5		1	0.00		23.2		10.3	0.00
Airbus A320			0.8		1	0.00		10.8		10.3	0.00
Airbus A330			2.2		1	0.00		36.1		10.3	0.00
Airbus A340			2		1	0.00		35.4		10.3	0.00
BAe 111			0.7		1	0.00		4.9		10.3	0.00
BAe 146			0.6		1	0.00		4.2		10.3	0.00
Boeing 727*			1.4		1	0.00		12.6		9.4	0.00
Boeing 737-100			0.9		1	0.00		8		10.3	0.00
Boeing 737-400			0.8		1	0.00		8.3		10.3	0.00
Boeing 747 100-300			3.4		1	0.00		55.9		10.3	0.00
Boeing 747-400			3.4		1	0.00		56.6		10.3	0.00
Boeing 757			1.3		1	0.00		19.7		10.3	0.00
Boeing 767 300 ER			1.6		1	0.00		26		10.3	0.00
Boeing 777			2.6		1	0.00		53.6		10.3	0.00
McDonnel Douglas DC-8*			1.8		1	0.00		14.8		9.4	0.00
McDonnel Douglas DC-9*			0.9		1	0.00		7.3		9.4	0.00
McDonnel Douglas DC-10			2.4		1	0.00		41.7		10.3	0.00
McDonnel Douglas M81-88			1		1	0.00		12.3		10.3	0.00
Fokker 28			0.7		1	0.00		5.2		10.3	0.00
Fokker 100			0.7		1	0.00		5.8		10.3	0.00
Type unknown (old fleet[h])			1		1	0.00		8		10.3	0.00
Type unknown (average fleet[g])			0.85		1	0.00		8.3		10.3	0.00
Other (Please specify)					1	0.00				10.3	0.00
Total	0					0					0.00

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Road transport emissions – detailed or simple method?

- EFs usually depend on vehicle type, age, fuel, emission controls and so forth.
- If only national total fuel consumption data available - *simple method* using average 'bulk' emission factors allows a very rough estimate.
- If data are available on vehicle fleet composition (number of vehicles by class and age) and average distance travelled per year – then the *detailed method* is recommended.
- Workbook will permit either method.

Mobile emissions of (detailed) for on-road vehicles

Sheet 1.9.3 Mobile emissions (detailed) of NO_X, CO and PM for on-road vehicles.

Sector: Transport (Detailed method)

Sub-sector: Road transportation

BACK TO MENU

Fuel	Vehicle class	Year of manufacture	A Number of vehicles in use	B Average distance travelled per vehicle (km/yr)	C Total distance travelled (km/yr) C = A x B	D 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	
		2011-2015			0	
Gasoline	2-wheeler, 4-stroke	Pre 1986			0	
		1986-1990			0	
		1991-1995			0	
		1996-2000			0	
		2001-2005			0	
		2006-2010			0	
		2011-2015			0	
Gasoline	3-wheeler, 2-stroke	Pre 1986			0	

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

			E		F	G
			NO_x emission factor (g/km)		NO_x deterioration factor	NO_x emissions (Tonnes)
Fuel	**Vehicle class**	**Year of manufacture**		**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 particulate matter (PM_{10}) from road dust

Sheet 1.9.3 Mobile emissions (detailed) of NO_X, CO and PM for on-road vehicles.

Sector: Transport (Detailed method)

Sub-sector: Road transportation

BACK TO MENU

			P		Q	T		U	V
			Paved road dust (PM_{10}) emission factor (g/km)		Paved road dust (PM_{10}) emissions (Tonnes)	Unpaved road dust (PM_{10}) emission factor in dry weather (g/km)		Percent dry days (< 0.25 mm precipitation) in a year (%)	Unpaved road dust (PM_{10}) emissions (Tonnes)
Fuel	Vehicle class	Year of manufacture		Default [i]	Q = C x (100-D)/100 x P/1000000		Default [k]		V = U/100 x C x (D/100) x T/1000000
Gasoline	2-wheeler, 2-stroke	Pre 1986		0.02	0		36		0
		1986-1990		0.02	0		36		0
		1991-1995		0.02	0		36		0
		1996-2000		0.02	0		36		0
		2001-2005		0.02	0		36		0
		2006-2010		0.02	0		36		0
		2011-2015			0		36		0
Gasoline	2-wheeler, 4-stroke	Pre 1986		0.02	0		36		0
		1986-1990		0.02	0		36		0
		1991-1995		0.02	0		36		0
		1996-2000		0.02	0		36		0
		2001-2005		0.02	0		36		0
		2006-2010		0.02	0		36		0
		2011-2015			0		36		0
Gasoline	3-wheeler, 2-stroke	Pre 1986		0.04	0		90		0

Mobile emissions (detailed) for on-road vehicles: details of user-entered emission factors

Details of user-entered emission factors

Fuel	Vehicle class and year of manufacture	Pollutant	Emission factor	Units	Reference source	Notes/Comments

Mobile emissions (detailed) for on-road vehicles: reference sources for activity data

Reference source for activity rate(s)			
Fuel	**Vehicle class**	**Reference source(s) for activity data**	**Notes/Comments**

More detailed models commonly used for estimating mobile emissions.

- **MOBILE**
  US EPA Emission factor model for on-road vehicles

- **MOVES**
  EPA next-generation emissions inventory model that will replace MOBILE

- **COPERT 4**
  European Environment Agency emissions inventory model for on-road Vehicles

- **IVEM**
  International Vehicle Emissions Model by University of California (Designed for use in developing countries)

Emissions for Energy sources – Sector 4: Combustion in *"Other sectors"*

This category includes emissions from fuel combustion in:

- ***"Commercial and Institutional"*** **buildings (Offices, Hotels, Schools, Hospitals etc.)**
- ***"Residential";*** **and**
- ***"Agriculture, Forestry and Fishing"*****.**

It includes mobile emissions from off-road activities in agriculture and forestry and from fishing vessels engaged in domestic inland, coastal or deep-sea fishing.

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Emissions for Energy sources – *Other sectors*

Sheet: 1.1.1b Fuel consumption in thousands of tonnes oil equivalent per year (ktoe/yea

BACK TO MENU

	Sector:	Combustion in Other Sectors		
	Sub-sector:	Commercial/ Institutional	Residential	Agriculture/ Forestry/Fishing
Fuel type				
Coal	Coking Coal			
	Other Bituminous Coal & Anthracite			
	Sub-Bituminous Coal			
	Lignite			
	Patent Fuel			
	Coke Oven Coke			
	Gas Coke			
	BKB (Brown coal briquettes)			
	Coke Oven Gas			
	Blast Furnace Gas			
Gas	Gas Works Gas			
	Natural Gas			
Oil	Crude Oil			
	Natural Gas Liquids			
	Refinery Gas			
	Liquefied Petroleum Gases			
	Motor Gasoline			
	Aviation Gasoline			
	Gasoline type Jet Fuel			
	Kerosene type Jet Fuel			
	Kerosene			
	Gas/Diesel Oil			
	Heavy Fuel Oil			
	Petroleum coke			
	Other Petroleum Products			
Combustible renewables/ wastes	Primary Solid Biomass:			
	Wood			
	Vegetal materials and wastes			
	Other (e.g. animal products/wastes)			
	Unspecified primary solid biomass			
	Gas/Liquids from Biomass + wastes			
	Municipal Waste			

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Compilation of emissions for Energy sources -

Practical session Transport (simple method) and combustion in other sectors:

1. Filling in workbook with dummy data *(see Exercise 5a notes)*

Practical session Transport (detailed method):

2. Filling in workbook with dummy data *(see Exercise 5b notes)*
3. Plenary session – *sharing problems encountered etc.*

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