Annex B

Methodology for Estimating Emissions of CH_4, N_2O, and Criteria Pollutants from Stationary Sources

Estimates of CH_4 and N_2O Emissions from Stationary Combustion

Methane (CH_4) and nitrous oxide (N_2O) emissions from stationary source fossil fuel combustion were estimated using IPCC emission factors and methods. Estimates were obtained by multiplying emission factors (by sector and fuel type) by fossil fuel and wood consumption data. This "top-down" methodology is characterized by two basic steps, described below. Data are presented in Table B-1 through Table B-9. Changes in the methodology for this source are outlined at the end of this discussion.

Step 1: Determine Energy Consumption by Sector and Fuel Type

Greenhouse gas emissions from stationary combustion activities were grouped into four sectors: industrial, commercial/institutional, residential, and electric utilities. For CH_4 and N_2O, estimates were based upon consumption of coal, gas, oil, and wood. Energy consumption data were obtained from EIA's Monthly Energy Review (1997), and adjusted to lower heating values assuming a 10 percent reduction for natural gas and a 5 percent reduction for coal and petroleum fuels. Table B-1 provides annual energy consumption data for the years 1990 through 1996.

Step 2: Determine the Amount of CH_4 and N O Emitted

Activity data for each sector and fuel type were multiplied by emission factors to obtain emissions estimates. Emission factors were taken from the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997). Table B-2 provides emission factors used for each sector and fuel type.

Estimates of NO , CO, and NMVOC Emissions from Stationary Combustion

For criteria pollutants, the major source categories included were those identified in EPA (1997): coal, fuel oil, natural gas, wood, other fuels (including bagasse, liquefied petroleum gases, coke, coke oven gas, and others), and stationary internal combustion (which includes emissions from internal combustion engines not used in transportation). EPA (1997) periodically estimates emissions of NO_x, CO, and NMVOCs by sector and fuel type using a "bottom-up" estimating procedure. In other words, the emissions were calculated either for individual sources (e.g., industrial boilers) or for many sources combined, using basic activity data (e.g., fuel consumption or deliveries, etc.) as indicators of emissions. EPA (1997) projected emissions for years subsequent to their bottom-up estimates. The national activity data used to calculate the individual categories were obtained from various sources. Depending upon the category, these activity data may include fuel consumption or deliveries of fuel, tons of refuse burned, raw material processed, etc. Activity data were used in conjunction with emission factors that relate the quantity of emissions to the activity. Table B-3 through Table B-9 present criteria pollutant emission estimates for 1990 through 1996.

The basic calculation procedure for most source categories presented in EPA (1997) is represented by the following equation:

$$E_{p,s} = A_s \times Ef_{p,s} \times (1 - C_{p,s}/100)$$

where,

E = emissions

p = pollutant

s = source category

A = activity level

EF = emission factor

C = percent control efficiency

The EPA currently derives the overall emission control efficiency of a category from a variety of sources, including published reports, the 1985 National Acid Precipitation and Assessment Program (NAPAP) emissions inventory, and other EPA databases. The U.S. approach for estimating emissions of NO_x, CO, and NMVOCs from stationary combustion as described above is similar to the methodology recommended by the IPCC (IPCC/UNEP/OECD/IEA 1997).

Differences with Previous Years' Inventories

In previous editions of the Inventory, methane emissions from stationary sources were calculated using a different methodology. Rather than using activity data and emission factors, CH_4 emissions were calculated as a ratio of NMVOC emissions. The accuracy of stationary source methane emissions have been improved in this year's inventory with the use of fuel type and end-use specific emission factors in place of the previous NMVOC ratio.

Table B-1: Fuel Consumption by Stationary Sources for Calculating CH_4 and N_2O Emissions (TBtu)

Fuel/End-Use Sector	1990	1991	1992	1993	1994	1995	1996
Coal	18,935.3	18,698.6	18,802.1	19,428.0	19,497.8	19,555.4	20,559.8
Residential	61.9	56.3	56.7	56.6	55.5	53.7	53.7
Commercial/Institutional	92.9	84.5	85.7	85.5	83.5	81.0	81.0
Industry	2,692.7	2,545.4	2,467.7	2,444.8	2,463.7	2,441.9	2,338.7
Utilities	16,087.8	16,012.4	16,192.0	16,841.1	16,895.2	16,978.9	18,086.4
Petroleum	11,741.5	11,389.6	11,696.4	11,641.5	11,928.7	11,465.9	12,132.3
Residential	1,266.3	1,293.3	1,312.4	1,387.0	1,340.4	1,363.0	1,441.6
Commercial/Institutional	906.9	860.6	813.3	752.8	753.3	756.8	775.8
Industry	8,317.9	8,057.8	8,637.7	8,449.6	8,866.8	8,688.1	9,179.5
Utilities	1,250.4	1,177.8	933.0	1,052.0	968.2	658.0	735.5
Natural Gas	18,597.9	18,983.5	19,530.2	20,224.9	20,631.3	21,507.3	21,777.8
Residential	4,518.7	4,685.0	4,821.1	5,097.5	4,988.3	4,981.3	5,375.8
Commercial/Institutional	2,698.1	2,807.7	2,884.2	2,995.8	2,980.8	3,185.2	3,289.9
Industry	8,519.7	8,637.2	8,996.4	9,387.4	9,609.3	10,064.3	10,311.3
Utilities	2,861.4	2,853.6	2,828.5	2,744.1	3,052.9	3,276.4	2,800.8
Wood	2,185.0	2,181.0	2,279.0	2,228.0	2,266.0	2,350.0	2,440
Residential	581.0	613.0	645.0	548.0	537.0	596.0	595.0
Commercial/Institutional	30.0	30.0	30.0	44.0	45.0	45.0	49.0
Industrial	1,562.0	1,528.0	1,593.0	1,625.0	1,673.0	1,698.0	1,784.0
Utilities	12.0	10.0	11.0	11.0	11.0	11.0	12.0

Table B-2: CH_4 and N_2O Emission Factors by Fuel Type and Sector (g/GJ)[4]

Fuel/End-Use Sector	CH_4	N_2O
Coal		
Residential	300	1.4
Commercial/Institutional	10	1.4
Industry	10	1.4
Utilities	1	1.4
Petroleum		
Residential	10	0.6
Commercial/Institutional	10	0.6
Industry	2	0.6
Utilities	3	0.6
Natural Gas		
Residential	5	0.1
Commercial/Institutional	5	0.1
Industry	5	0.1
Utilities	1	0.1
Wood		
Residential	300	4.0
Commercial/Institutional	300	4.0
Industrial	30	4.0
Utilities	30	4.0

[4] GJ (Gigajoule) = 10^9 joules. One joule = 9.486×10^{-4} Btu

Table B-3: 1996 NO_x, NMVOC, and CO Emissions from Stationary Sources (Gg)

Sector/Fuel Type	NO_x	NMVOC	CO
Electric Utilities	5,473	341	41
Coal	5,004	238	28
Fuel Oil	87	10	3
Natural gas	244	40	2
Wood	NA	NA	NA
Internal Combustion	137	53	9
Industrial	2,875	972	188
Coal	543	90	5
Fuel Oil	223	65	11
Natural gas	1,212	316	66
Wood	NA	NA	NA
Other Fuels[a]	113	277	46
Internal Combustion	784	224	60
Commercial/Institutional	366	227	21
Coal	35	14	1
Fuel Oil	93	17	3
Natural gas	212	49	10
Wood	NA	NA	NA
Other Fuels[a]	26	148	8
Residential	804	3,866	724
Coal[b]	NA	NA	NA
Fuel Oil[b]	NA	NA	NA
Natural Gas[b]	NA	NA	NA
Wood	44	3,621	687
Other Fuels[a]	760	244	37
Total	9,518	5,407	975

NA (Not Available)
[a] "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1997).
[b] Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1997).
Note: Totals may not sum due to independent rounding.

Table B-4: 1995 NO_x, NMVOC, and CO Emissions from Stationary Sources (Gg)

Sector/Fuel Type	NO_x	NMVOC	CO
Electric Utilities	5,791	40	338
Coal	5,060	26	227
Fuel Oil	87	2	9
Natural gas	510	2	49
Wood	NA	NA	NA
Internal Combustion	134	9	52
Industrial	2,852	187	958
Coal	541	5	88
Fuel Oil	224	11	64
Natural gas	1,201	66	313
Wood	NA	NA	NA
Other Fuels[a]	111	45	270
Internal Combustion	774	59	222
Commercial/Institutional	365	21	211
Coal	35	1	14
Fuel Oil	94	3	17
Natural gas	210	10	49
Wood	NA	NA	NA
Other Fuels[a]	27	8	132
Residential	812	725	3,876
Coal[b]	NA	NA	NA
Fuel Oil[b]	NA	NA	NA
Natural Gas[b]	NA	NA	NA
Wood	44	688	3,628
Other Fuels[a]	768	37	248
Total	9,820	973	5,382

NA (Not Available)
[a] "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1997).
[b] Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1997).
Note: Totals may not sum due to independent rounding.

Table B-5: 1994 NO_x, NMVOC, and CO Emissions from Stationary Sources (Gg)

Sector/Fuel Type	NO_x	NMVOC	CO
Electric Utilities	5,955	41	335
Coal	5,112	26	224
Fuel Oil	148	4	13
Natural gas	536	2	48
Wood	NA	NA	NA
Internal Combustion	159	9	50
Industrial	2,854	178	944
Coal	546	7	91
Fuel Oil	219	11	60
Natural gas	1,209	57	306
Wood	NA	NA	NA
Other Fuels[a]	113	45	260
Internal Combustion	767	58	228
Commercial/Institutional	365	21	212
Coal	36	1	13
Fuel Oil	86	3	16
Natural gas	215	10	49
Wood	NA	NA	NA
Other Fuels[a]	28	8	134
Residential	817	657	3,514
Coal[b]	NA	NA	NA
Fuel Oil[b]	NA	NA	NA
Natural Gas[b]	NA	NA	NA
Wood	40	621	3,271
Other Fuels[a]	777	36	243
Total	9,990	897	5,006

NA (Not Available)
[a] "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1997).
[b] Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1997).
Note: Totals may not sum due to independent rounding.

Table B-6: 1993 NO_x, NMVOC, and CO Emissions from Stationary Sources (Gg)

Sector/Fuel Type	NO_x	NMVOC	CO
Electric Utilities	6,033	41	329
Coal	5,210	26	223
Fuel Oil	163	4	15
Natural gas	500	2	45
Wood	NA	NA	NA
Internal Combustion	160	9	46
Industrial	2,858	169	946
Coal	534	5	92
Fuel Oil	222	11	60
Natural gas	1,206	46	292
Wood	NA	NA	NA
Other Fuels[a]	113	46	259
Internal Combustion	782	60	243
Commercial/Institutional	360	22	207
Coal	37	1	14
Fuel Oil	84	3	16
Natural gas	211	10	48
Wood	NA	NA	NA
Other Fuels[a]	28	8	129
Residential	827	670	3,585
Coal[b]	NA	NA	NA
Fuel Oil[b]	NA	NA	NA
Natural Gas[b]	NA	NA	NA
Wood	40	633	3,337
Other Fuels[a]	786	36	248
Total	10,077	901	5,067

NA (Not Available)
[a] "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1997).
[b] Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1997).
Note: Totals may not sum due to independent rounding.

Table B-7: 1992 NO_x, NMVOC, and CO Emissions from Stationary Sources (Gg)

Sector/Fuel Type	NO_x	NMVOC	CO
Electric Utilities	**5,899**	**40**	**318**
Coal	5,060	25	214
Fuel Oil	154	4	14
Natural gas	526	2	47
Wood	NA	NA	NA
Internal Combustion	159	9	43
Industrial	**2,785**	**169**	**866**
Coal	521	7	92
Fuel Oil	222	11	58
Natural gas	1,180	47	272
Wood	NA	NA	NA
Other Fuels[a]	115	45	239
Internal Combustion	748	60	205
Commercial/Institutional	**348**	**20**	**204**
Coal	35	1	13
Fuel Oil	84	3	16
Natural gas	204	9	46
Wood	NA	NA	NA
Other Fuels[a]	25	7	128
Residential	**879**	**782**	**4,194**
Coal[b]	NA	NA	NA
Fuel Oil[b]	NA	NA	NA
Natural Gas[b]	NA	NA	NA
Wood	48	746	3,929
Other Fuels[a]	831	36	265
Total	**9,912**	**1,010**	**5,582**

NA (Not Available)
[a] "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1997).
[b] Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1997).
Note: Totals may not sum due to independent rounding.

Table B-8: 1991 NO_x, NMVOC, and CO Emissions from Stationary Sources (Gg)

Sector/Fuel Type	NO_x	NMVOC	CO
Electric Utilities	**5,913**	**40**	**317**
Coal	5,042	25	212
Fuel Oil	192	5	17
Natural gas	526	2	46
Wood	NA	NA	NA
Internal Combustion	152	9	41
Industrial	**2,702**	**177**	**834**
Coal	517	5	92
Fuel Oil	215	10	54
Natural gas	1,134	54	257
Wood	NA	NA	NA
Other Fuels[a]	117	47	242
Internal Combustion	720	61	189
Commercial/Institutional	**333**	**18**	**196**
Coal	33	1	13
Fuel Oil	80	2	16
Natural gas	191	8	40
Wood	NA	NA	NA
Other Fuels[a]	29	7	128
Residential	**829**	**739**	**3,964**
Coal[b]	NA	NA	NA
Fuel Oil[b]	NA	NA	NA
Natural Gas[b]	NA	NA	NA
Wood	45	704	3,710
Other Fuels[a]	784	35	254
Total	**9,777**	**975**	**5,312**

NA (Not Available)
[a] "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1997).
[b] Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1997).
Note: Totals may not sum due to independent rounding.

Table B-9: 1990 NO_x, NMVOC, and CO Emissions from Stationary Sources (Gg)

Sector/Fuel Type	NO_x	NMVOC	CO
Electric Utilities	**6,043**	**43**	**329**
Coal	5,117	25	213
Fuel Oil	200	5	18
Natural gas	513	2	46
Wood	NA	NA	NA
Internal Combustion	213	11	52
Industrial	**2,753**	**165**	**797**
Coal	530	7	95
Fuel Oil	240	11	67
Natural gas	1,072	52	205
Wood	NA	NA	NA
Other Fuels[a]	119	46	253
Internal Combustion	792	49	177
Commercial/Institutional	**336**	**18**	**205**
Coal	36	1	13
Fuel Oil	88	3	16
Natural gas	181	7	40
Wood	NA	NA	NA
Other Fuels[a]	31	8	136
Residential	**749**	**686**	**3,667**
Coal[b]	NA	NA	NA
Fuel Oil[b]	NA	NA	NA
Natural Gas[b]	NA	NA	NA
Wood	42	651	3,429
Other Fuels[a]	707	35	238
Total	**9,881**	**912**	**4,998**

NA (Not Available)

[a] "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1997).

[b] Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1997).

Note: Totals may not sum due to independent rounding.