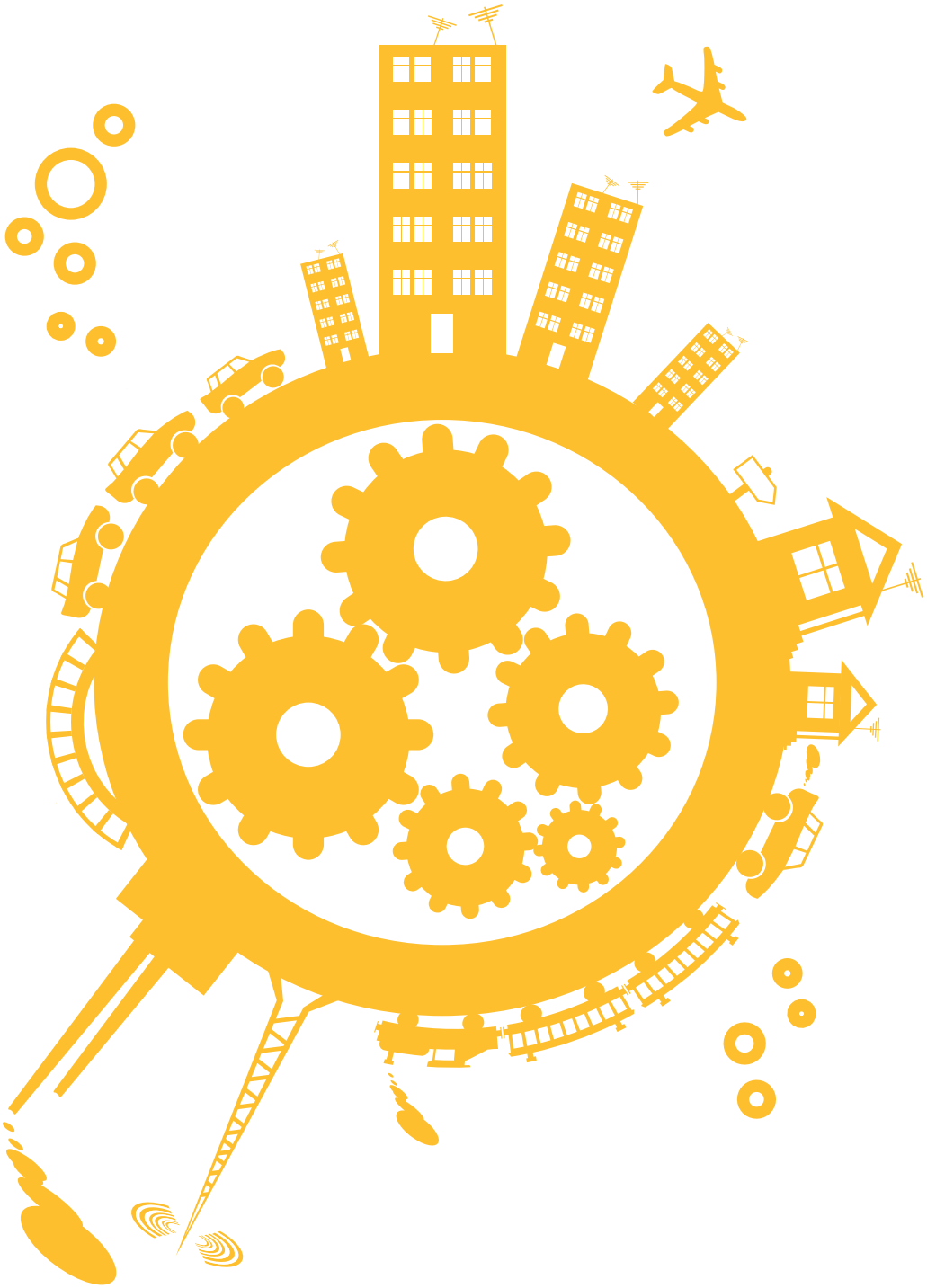
National Greenhouse Gas Inventory



2. National Greenhouse Gas Inventory

2.1 Introduction

In accordance with Article 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC), parties are required to develop and report national inventories on national emissions and removals of greenhouse gases (GHG) using comparable methodologies. As a Non-Annex I party to the UNFCCC, Lebanon has prepared and submitted its Initial National Communication (INC) in 1999, with the year 1994 as the baseline for its national GHG inventory.

This chapter updates the national inventory by summarizing Lebanon's anthropogenic emissions by sources and removals by sinks for the year 2000 of all GHGs covered by the Kyoto Protocol (KP) (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) in addition to the indirect GHGs (CO, NO_x, SO_2, and NMVOCs). It also presents the trend analysis of the national GHG inventory for the period 2000 to 2004, with a revision of the results of the first inventory to allow a complete assessment of trends in national GHG emissions.

The inventory is based on the revised 1996 Intergovernmental Panel on Climate Change (IPCC) guidelines for National Greenhouse Gas Inventories and on the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories that provides methodologies for calculating national inventories and estimating uncertainties (IPCC, 1997 and IPCC, 2000). Tier 1 approach is adopted in calculating the GHG emissions where the appropriate default emission factors are selected from the guidelines. Tier 2 approach is only used for the calculation of emissions from the cement industry where precise data allowed the development of a national emission factor. The reference approach is used for the estimation of the CO_2 emissions from the overall fuel consumption figures. In addition, the sectoral approach is used to estimate the GHG emissions and removals for the following sectors:

- Energy
- Industrial processes
- Solvent and other product use
- Agriculture
- Land-use change and forestry
- Waste

The activity data for the different sectors are collected from various sources (public and private institutions) by conducting sectoral tailored surveys, and complemented by secondary sources such as scientific reports/publications, and academic studies. Estimations, interpolations and extrapolations are made for the sectors characterized with data gaps. Choice of activity data is validated through thorough stakeholders' consultations engulfing the public and private sectors, as well as academic and NGO communities.

2.2 Greenhouse Gas inventory in 2000

In the year 2000, Lebanon's total GHG emissions recorded 18,507 Gg (18.5 Million tonnes (Mt)) of CO_2 equivalent (CO_2 eq.), recording an average of 2.77% per year increase from 1994 (15,901 Gg CO_2 eq.) (Table 2-1). The energy

Table 2-1 GHG Emissions – year 2000

Total GHG Emissions (Gg)	**18,507**
Increase based on 1994 value (Gg)	2,606
Growth rate per year (%)	2.77
Net GHG Emissions (Gg)	**18,363**
Increase based on 1994 value (Gg)	2,462
Growth rate per year (%)	2.58
Removals of GHG (Gg)	**144**

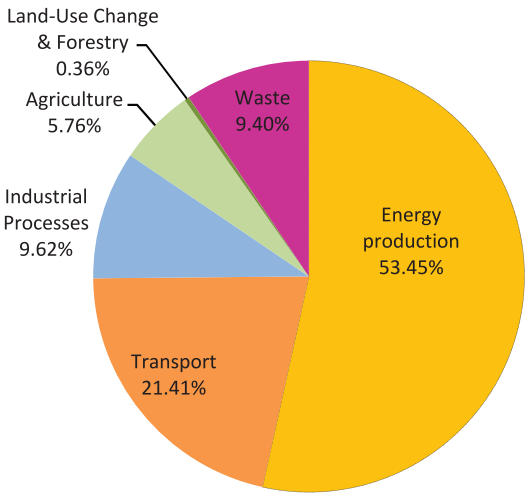


Figure 2-1 GHG emissions by source Energy production or Energy Production

sector is the main source of GHG emissions, accounting for 74.86% of the national emission. This is followed by industrial processes and waste sectors which account for 9.62% and 9.40% respectively. Emissions from agriculture and land use change and forestry make up 5.76%, and 0.36% of total CO_2 eq. respectively. Figure 2-1 shows the GHG emission shares of each of the sectors – the energy sector is divided into its two main subcomponents: energy production and transport. The CO_2 removals from forests and croplands is estimated at -143.87 Gg for the year 2000

Carbon dioxide is the main emitted GHG with 84.13% of emissions in 2000, while CH_4 and N_2O constitute 10.19% and 5.68% respectively. As shown in Figure 2-2, the main contributors of CO_2 emissions are energy production and transport with 63% and 25% respectively whereas the waste sector constitutes the main source of CH_4 emissions (88%). The main contributor to N_2O emissions is the agriculture sector with 88%.

In terms of key categories, the two activities contributing most to Lebanon's emissions are consumption of fuel oil for energy production and land road transport, which account for 43.5% of total emissions in 2000. Energy production in other sectors and solid waste disposal, cement industries and agricultural soils are also among the key categories amounting to 97% of total emissions, as presented in Table 2-2.

Table 2-3 summarizes Lebanon's emissions of CO_2, CH_4 and N_2O for all sectors presented in terms of CO_2 eq. and using the IPCC Second Assessment Report's 100-year Global Warming Potential (GWP) of 21 for CH_4, and 310 for N_2O. Table 2-4 and Table 2-5 present Lebanon's direct and indirect emissions with proper notations as required by decision 17/CP.8.

Table 2-2 Analysis of key categories for the year 2000

Sector	Source Categories	GHG	Emission Estimate (non-LULUCF) (Gg CO_2 eq.)	Total absolute estimate incl. LULUCF (Gg CO_2 eq.)	Percent of total (%)	Cumulative level incl LULUCF (%)
Sum	Sum		12,681.3	12,681.3		
1.A.1 Energy	Stationary Combustion: Fuel oil	CO_2	4,091.5	4,091.5	22.2%	22.2%
1.A.3 Energy	Mobile Combustion: Road Vehicles	CO_2	3,929.4	3,929.4	21.3%	43.5%
1.A.2 Energy	Emissions from Manufacturing Industries and Construction	CO_2	2,830.6	2,830.6	15.4%	58.9%
1.A.1 Energy	Stationary Combustion: Gas diesel oil	CO_2	1,661.4	1,661.4	9%	67.9%
6.A Waste	Emissions from Solid Waste Disposal Sites	CH_4	1,640.0	1,640.0	8.9%	76.8%
2.A Industrial Processes	Emissions from Cement Production	CO_2	1,630.9	1,630.9	8.8%	85.6%
4.D Agriculture	(Direct and Indirect) Emissions from Agricultural Soils	N_2O	820.5	820.5	4.5%	90.1%
1.A.4 Energy	Other Sectors: Agriculture/Forestry/ Fishing	CO_2	493.1	493.1	2.7%	92.7%
1.A.4 Energy	Other Sectors: Residential	CO_2	443.5	443.5	2.4%	95.2%
1.A.4 Energy	Other Sectors: Commercial	CO_2	336.7	336.7	1.8%	97%

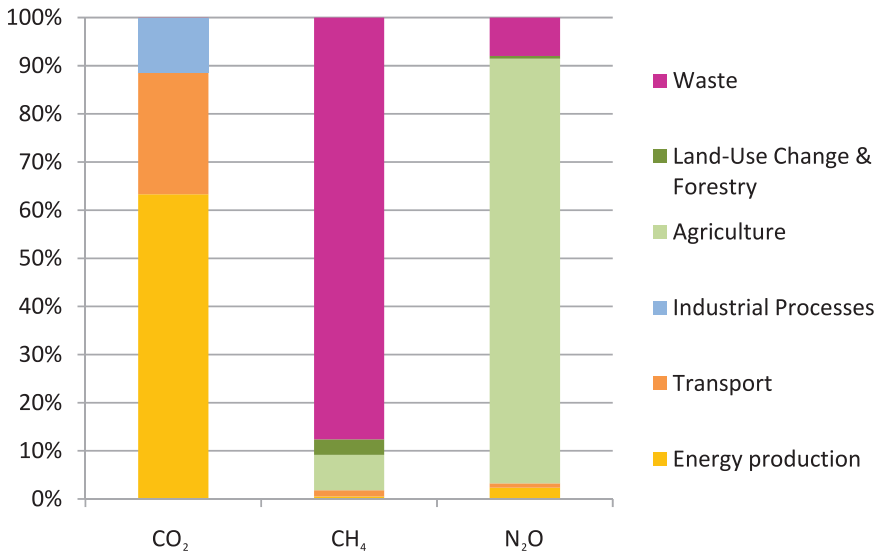


Figure 2-2 GHG emissions by gas

Table 2-3 Lebanon's GHG emissions summary for the year 2000

Greenhouse gas source and sink categories	CO_2 Emissions (Gg)	CO_2 Removals (Gg)	CH_4 (Gg)	CH_4 (Gg CO_2 eq.)	N_2O (Gg)	N_2O (Gg CO_2 eq.)	Total emissions (Gg CO_2 eq.)
Total National Emissions and Removals	15,570.13	-143.87	89.82	1886.22	3.39	1050.90	18507.25
Energy	13,786.19		1.62	34.02	0.11	34.10	13,854.31
Energy Industries	5,752.89		0.23	4.83	0.05	15.50	5,773.22
Manufacturing Industries and Construction	2,830.60		0.06	1.26	0.02	6.20	2,838.06
Transport	3,929.40		1.14	23.94	0.03	9.30	3,962.64
Other Sectors	1,273.30		0.19	3.99	0.01	3.10	1,280.39
Industrial Processes	1,780.98		-	-	-	-	1,780.98
Mineral Products	1,652.98			-	-	-	1,652.98
Metal Production	128.00		-	-	-	-	128.00
Agriculture			6.60	138.60	2.99	926.90	1065.50
Enteric Fermentation	-		6.03	126.63	-	-	126.63
Manure Management	-		0.51	10.71	0.34	105.40	116.11
Agricultural Soils	-			-	2.65	821.50	821.50
Field Burning of Agricultural Residues	-		0.06	1.26	-	-	1.26
Land-Use Change & Forestry		-143.87	2.90	60.90	0.02	6.20	67.10
Changes in Forest and Other Woody Biomass Stocks	-	-807.60	-	-	-	-	-
Forest and Grassland Conversion	663.73		2.90	60.90	0.02	6.20	730.83
Waste	2.96		78.70	1,652.70	0.27	83.70	1,739.36
Solid Waste Disposal on Land	-		78.10	1,640.10	-	-	1,640.10
Wastewater Handling	-		0.60	12.60	0.27	83.70	96.30
Waste Incineration	2.96		-	-	-	-	2.96

Table 2-4 National greenhouse gas inventory of anthropogenic emissions of HFCs, PFCs and SF_6

Greenhouse gas source and sink categories	HFCs (Gg)		PFCs (Gg)		SF_6 (Gg)
	HFC-23	HFC-134	CF_4	C_2F_6	
Industrial processes	NO	0.01	NO	NO	NO
A. Mineral products	NO	0.01	NO	NO	NO
B. Chemical industry					
C. Metal production					
D. Other production	NO	NO	NO	NO	NO
E. Production of halocarbons and SF_6					
F. Consumption of halocarbons and SF_6	NO	NO	NO	NO	NO
G. Other (please specify)	NO	0.01	NO	NO	NO

Table 2-5 Lebanon's National GHG inventory of anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol and GHG precursors

GHG source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
Total national emissions and removals	15,570.15	-143.87	89.82	3.39	58.69	481.49	128.56	93.43
1. Energy	13,786.19	NA	1.62	0.11	57.95	455.38	85.68	92.59
A. Fuel combustion (sectoral approach)	13,786.19		1.62	0.11	57.95	455.38	85.68	92.59
1. Energy Industries	5,752.89		0.23	0.05	15.22	1.14	0.38	61.19
2. Manufacturing industries and construction	2,830.60		0.06	0.02	6.43	0.32	0.16	23.46
3. Transport	3,929.40		1.14	0.03	34.46	453.55	85.05	2.56
4. Other sectors	1,273.30		0.19	0.01	1.84	0.37	0.09	5.37
5. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO
B. Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO	NO	NO
1. Solid fuels			NA		NA	NA	NA	NA
2. Oil and natural gas			NO		NO	NO	NO	NO
2. Industrial processes	1,780.98	0.00	0.00	0.00	0.00	0.00	38.91	0.84
A. Mineral products	1,652.98				NA	NA	36.12	0.84
B. Chemical industry	NE		NE	NE	NE	NE	NE	NE
C. Metal production	128.00		NE	NA	NE	NE	NE	NE
D. Other production	NA		NA	NA	NA	NA	2.78	NA
E. Production of halocarbons and SF_6								
F. Consumption of halocarbons and SF_6								
G. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO
3. Solvent and other product use	NA			NA			3.97	
4. Agriculture			6.60	2.99	0.03	0.77	NA	NA
A. Enteric fermentation			6.03					
B. Manure management			0.51	0.34			NA	
C. Rice cultivation			NO				NO	
D. Agricultural soils				2.65			NA	
E. Prescribed burning of savannahs			NO	NO	NO	NO	NO	

GHG source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
F. Field burning of agricultural residues			0.06	0.00	0.03	0.77	NA	
G. Other (please specify)			NO	NO	NO	NO	NO	
5. Land-use change and forestry	0.00	-143.87	2.90	0.02	0.72	25.34	0.00	0.00
A. Changes in forest and other woody biomass stocks	0.00	-807.60						
B. Forest and grassland conversion	663.73	NA	2.90	0.02	0.72	25.34		
C. Abandonment of managed lands		NO						
D. CO_2 emissions and removals from soil	NO	NO						
E. Other (please specify)	NO	NO	NO	NO	NO	NO		
6. Waste	2.96		78.70	0.27	NA	NA	NA	NA
A. Solid waste disposal on land			78.70		NA		NA	
B. Wastewater handling			0.60	0.27	NO	NO	NO	
C. Waste incineration	2.96				NA	NA	NA	NA
D. Other (please specify)			NO	NO	NO	NO	NO	NO
7. Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO
Memo items								
International bunkers	408.12		0.00	0.01	2.16	0.90	0.34	NO
Aviation	381.55		0.00	0.01	1.62	0.54	0.27	NO
Marine	26.56		0.00	0.00	0.54	0.36	0.07	NO
CO_2 emissions from biomass	NO							

NA: Not Applicable - NE: Not Estimated - NO: Not Occurring

2.3 GHG Emissions by sector

2.3.1 Energy sector

The energy sector is the most important contributor to GHG emissions, with its sub-categories that include:

- Energy industries: combustion of fuel by power plants for public electricity production
- Manufacturing industries and construction (MIC): combustion of fuel by private generators for energy generation for industrial use and electricity generation for domestic use.
- Transport: combustion of fuel in land transport. Fuel combustion in civil aviation and water-borne navigation are not reported as part of the national inventory but as international bunkers.
- Other categories: fuel combustion for energy generation in the Commercial/institutional/residential sector as well as in agriculture/forestry/fishery.

The fuel types taken into consideration in this section are: gasoline, gas oil, diesel oil, fuel oil, jet kerosene, LPG, and coking coal. The activity data are based on the official amounts of fuel imports for the year 2000 as provided by the Directorate General of Petroleum, cross-checked with information provided by the Association of Petroleum Importing Companies, EDL, and the MoPWT, Directorate General of Land and Maritime Transport. The amounts of coking coal were retrieved from the International Energy Agency database.

In 2000, emissions from the energy sector accounted for 74.86% of the total emissions, reflecting Lebanon's heavy reliance on imported petroleum products to meet its energy requirements. As shown in Table 2-6, the energy industries category is the main source of emissions, followed by land transport. The transport sector, with 28.6% of energy emissions, is also considered a major emitter due to the high per capita car ownership, the age of the fleet and the absence of an efficient public transport system.

Table 2-6 Greenhouse Gas emissions from the Energy Sector per sub-category

Energy sub-sectors	GHG emissions (Gg CO_2 eq.)	Share of total energy emissions	Share of total national emissions
Energy Industries	5,773	42%	31%
Manufacturing Industries and Construction	2,830	20%	15%
Transport	3,963	29%	21%
Other Sectors	1,280	9%	7%
Total	13,854	100%	75%

Energy Industries

The reference approach was also used to estimate the CO_2 emissions of the energy sector based on the Revised 1996 IPCC Guidelines. No difference was detected in the calculations, where both approaches showed CO_2 emissions of 13,786 Gg in the year 2000.

In 2000, 5,773 Gg CO_2 eq. were emitted into the atmosphere from the electric energy production. Heavy fuel oil (HFO) and diesel oil are the major source of energy in Lebanon, with a small share of hydropower generation. HFO with a sulfur content of about 2% by weight is the main fuel used for public electricity generation, constituting 71% of total fuel consumption by this category. Consequently, the energy industries subsector contributed to 61.19 Gg of SO_2 in 2000, or 66% of the total SO_2 emissions from the energy sector and 65% of national SO_2 emissions.

Manufacturing industries and construction

This category covers the emissions resulting from combustion of fuel in industries and construction sites, use of lubricants and private power generation. In fact, due to the interrupted supply and rationing of the electricity supplied by the government, most of the industries generate their own electricity through private power generators. The use of these types of supply is also prominent among households, where individual or community-based back-up generators are used when EDL's supply is unable to meet the demand. These generators are distributed throughout the Lebanese territory and are used by a significant proportion of the population. However, since they are not regulated by any governmental agency, it is difficult to estimate their number and the amount of fuel (diesel oil) used annually. Therefore, the fuel consumption of these generators is accounted for in this sector as an aggregated figure, along with the fuel used by industries and construction sites.

The fuel types used in the manufacturing industries and construction sectors are gas/diesel oil, fuel oil, LPG and coking coal (The use of LPG in this sector is estimated at 15% of the total LPG import to Lebanon). Combustion of these fuels generated 2,830 Gg CO_2 eq. in 2000, comprising 20% of total emissions from the energy sector, and 15% of total national GHG emissions. Figure 2-3 depicts the share of GHG emissions from the MIC by fuel type. This sub-sector also occupies the second place in terms of SO_2 emissions, accounting for 25% of total national SO_2 emissions.

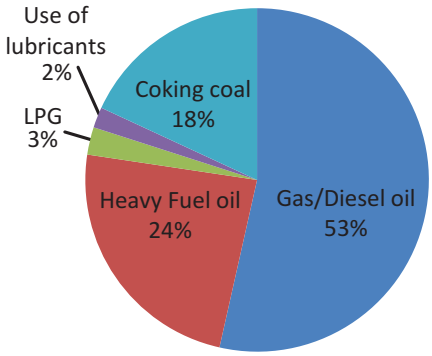


Figure 2-3 Share of GHG emissions by fuel type under MIC

2.3.1.1 Road Transport

Transport is a major sub-sector contributing to GHG emissions from fuel combustion. The GHG emission includes only land transport, since rail transport is inexistent, and both domestic aviation (fleet composed of only 10 light aircrafts) and water-borne navigation are negligible. Road transportation includes all types of light duty vehicles such as automobiles and light trucks, and heavy duty vehicles such as tractor trailers and buses, in addition to on-road motorcycles. These vehicles operate on gasoline (98.8%) while only heavy duty vehicles are allowed to run on diesel (1.2% of transport fuel consumed in Lebanon).

In 2000, 3,962.64 Gg CO_2 eq. were emitted into the atmosphere from transport in Lebanon, comprising 28.6% of total emissions from the energy sector, and 21% of total national GHG emissions. The transport sector is also the main source of CO, NO_x and NMVOC emissions, as presented in Figure 2-4.

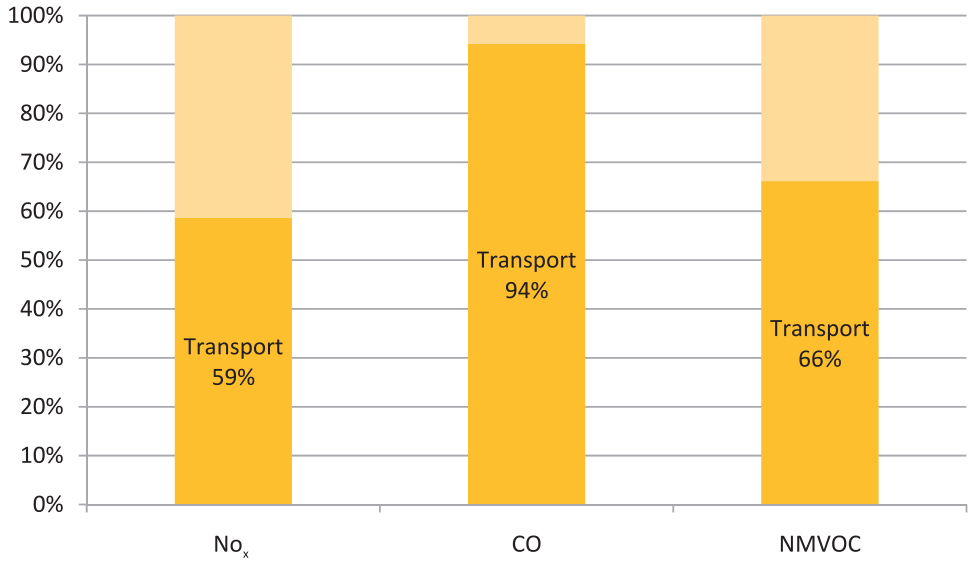


Figure 2-4 Share of emissions of NO_x, CO and NMVOC from the transport sector

2.3.1.2 International Bunkers

International bunkers include international aviation and marine navigation. Emissions of CO_2 accounted for 408 Gg of which 93.6% is from aviation. These emissions are not counted in Lebanon's national inventory.

2.3.1.3 Other sectors

The other sectors category includes emissions from commercial, institutional, residential and agriculture/ forestry/fishing sub-categories where the consumption of diesel oil (for space heating), LPG (for cooking), and kerosene (for space heating and cooking) are considered. Since no accurate data on the share of fuel consumption by the different sectors are available for analysis, it is estimated that 21% of total gas/diesel import, 85% of total LPG import and 100% of total kerosene is used in these sectors.

In the year 2000, the emissions generated from these sectors are estimated to be 1,280 Gg of CO_2 eq., with CO_2 being the major GHG (99.7%). This represents 9% and 7% of the emissions from the energy sector and of total national GHG emissions respectively. Figure 2-5 presents the share of emission by fuel type.

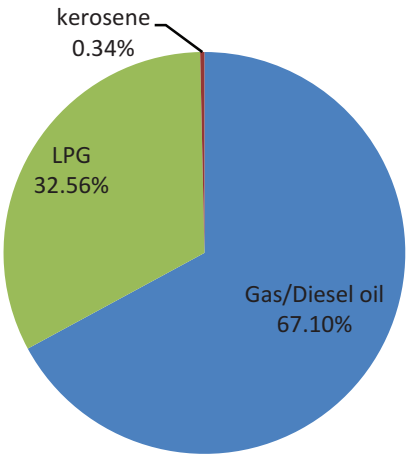


Figure 2-5 Share of GHG emissions by fuel type under other sectors

2.3.2 Industrial Processes

GHG emissions from this sector are produced from a variety of industrial activities that are not related to energy generation and use. The main emission sources are industrial production processes which chemically or physically transform materials. Emissions related to energy generation activities within the industrial sector are covered under the energy sector (manufacturing, industries and construction section). The main sources of emissions from industrial processes in Lebanon are:

- Cement production
- Lime production
- Soda ash production and use
- Asphalt roofing production
- Road paving with asphalt
- Glass production
- Iron and steel production
- Food and alcoholic beverages production

- HFC Emissions from Refrigeration and Air Conditioning
- Consumption of halocarbons and SF_6

Activity data were collected directly from the relevant industries and from the Directorate General of Customs, complemented with secondary data whenever primary data were unavailable. Tier 1 default emission factors are used for emission calculation estimations except for cement industries where the appropriate data were available, therefore allowing the use of the Tier 2 approach, thus establishing a local emission factor. Emissions of some industries such as chemicals industries were not taken into account due to the absence of activity data.

In 2000, emissions from the industrial processes sector amounted to a total of 1,781Gg of CO_2 eq. at 9.62% of Lebanon's total GHG emissions. The emissions primarily entail the CO_2 gas, with the largest contributor being cement production with 91.6%, followed by iron and steel production with 7.2%. The emissions from steel production may be over or underestimated since a simple approach was used in the calculation due to the absence of data on the consumption of reducing agents in this industry. Cement industries are also the main emitters of SO_2 within this sector while road paving and food production the main emitters of NMVOCs (Figure 2-6). Since direct and indirect emissions from the industrial processes sub-categories are insignificant, they are not reported in the inventory.

Refrigeration and air conditioning are the only sources of HFC gas emissions recorded in Lebanon since HFC 134a is serving as an alternative to ozone depleting substances

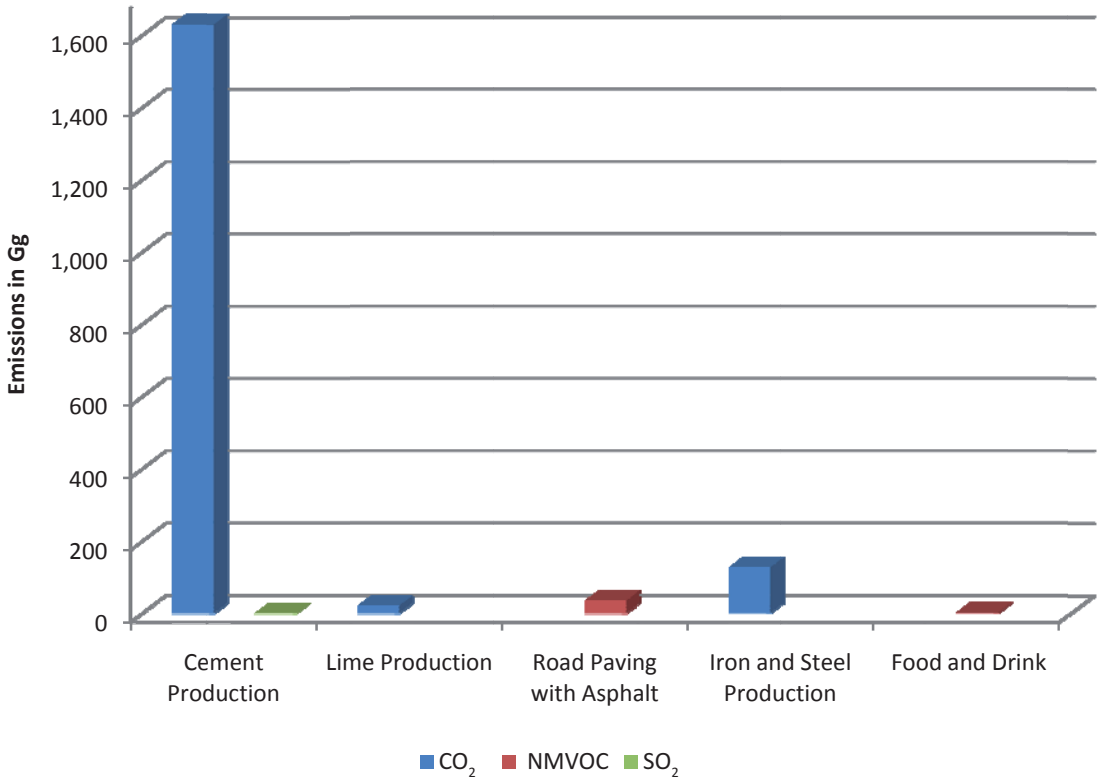


Figure 2-6 GHG direct and indirect emissions from industrial processes

Table 2-7 GHG emissions from the sub-categories of the Lebanese industrial sectort

Industrial processes sub-sectors	GHG emissions (Gg CO_2 eq.)	Share of total industrial processes emissions	Share of total national emissions
Cement Production	1,631	91.58%	8.81%
Lime Production	22	1.24%	0.12%
Iron and Steel Production	128	7.19%	0.69%
Total	1,781	100.00%	9.62%

being phased out under the Montreal Protocol. The total HFC emissions in 2000 are insignificant in absolute terms (0.01 Gg) but amount to approximately 11 Gg CO_2 eq. when converted to CO_2 eq. emissions since they have a high global warming potential. However, they were not reported as part of this national inventory.

As for SF_6 emissions for the year 2000, they are estimated to be null since SF_6 has only been imported to Lebanon starting the year 2002.

2.3.3 Solvents and Other Product Use

This category covers the emissions resulting from the use of solvents and other products containing volatile compounds. The major sub-categories of this sector in Lebanon are:

- Paint application
- Degreasing and dry-cleaning
- Printing industries

Other activities such as textile finishing, leather tanning, etc. are thought to be insignificant at the national level (less than 1% of national emissions) therefore emissions resulting from these activities are not reported in this inventory (EEA, 2005). Since these subcategories only emit NMVOC, the methodology and emission factors used for estimating these emissions are taken from the EMEP/ CORINAIR Emission Inventory Guidebook (EEA, 2005). Activity data are based on the values of imports/exports of white spirit, paint and ink from the Lebanese Customs.

In the year 2000, NMVOC emissions generated from solvents and other products use amount to 3.97 Gg or around 3% of Lebanon's total NMVOC emissions. Degreasing and dry cleaning are the major source of NMVOC with 2.47 Gg, followed by paint application (0.98 Gg) and printing industries (0.54 Gg).

2.3.4 Agriculture

Despite the limited land area under agricultural uses, the agricultural sector is a significant contributor to national GHG emissions, with 1,065.5 Gg CO_2 eq., representing 5.76% of national emissions in 2000. This sector includes the following emission sources:

- Enteric fermentation - CH_4
- Manure management - CH_4, N_2O
- Agricultural soils - N_2O
- Field burning of agricultural residues- CH_4, NO_x and CO

As shown in Table 2-8, the main source of GHG emissions is "agricultural soils", where N_2O is directly and indirectly generated, as a result of biological nitrogen fixation and nitrogen input to the soils through the application of synthetic fertilizers, animal waste, crop residues or (sewage sludge). Activity data on the consumption of synthetic fertilizers are retrieved from the International Fertilizer Industry Association (IFA, 2008). The values of the animal population used for the estimation of the nitrogen excreted from animal waste and the values used for the estimation of N-fixing and Non-N fixing crops, are retrieved from FAO (FAO, 2008).

Methane emissions from the agricultural sector are produced mainly from the enteric fermentation in livestock, accounting for 11.88% of the total emissions from the sector, followed by manure management and field burning of residues.

Manure management produces both CH_4 and N_2O during the storage, treatment and disposal of manure. Based on experts' consultations, the portion of manure managed in each management system for each representative livestock category has been identified and taken into account in the calculations (Table 2-9).

Emissions of NO_x and CO result from field burning of agricultural residues, where it is estimated that 10% of the residues of wheat, barley and oats are burned every year. Other residues are not taken into account since they are collected and used either as a source of energy in rural areas (could not be estimated) or as animal feed and bedding. The NO_x and CO emissions from field burning of residues are estimated at 0.03 Gg and 0.77 Gg respectively.

2.3.5 Land Use Change and Forestry

The GHG emissions and removals of Land Use Change and Forestry in Lebanon are calculated for the year 2000 according to the Revised 1996 IPCC guidelines (IPCC, 1997). Due to unavailability of data to accurately estimate how changing land use patterns affects CO_2 emissions and removals unavailability, the Good Practice Guidance for Land use, Land-use Change and Forestry (GPG-LULUCF) could not be used in this inventory. The only available and complete national information is the land-use land-cover map which is not sufficient to make a comparative analysis on land changes for the year 2000. Therefore, the CO_2 removal data presented in this report must be treated with caution.

Table 2-8 GHG emissions from the Agriculture sector.

Agriculture sub-sectors	CH_4 emissions	N_2O emissions	GHG emissions (Gg CO_2 eq.)	Share of total agriculture emissions	Share of total national emissions
Enteric Fermentation	6.03	-	126.70	11.88%	0.68%
Manure Management	0.51	0.34	115.62	10.90%	0.63%
Agricultural soils	-	2.65	629.03	77.10%	4.44%
Field burning of agricultural residues	0.06		1.00	0.12%	0.01%
Total	6.60	2.99	872.35	100.00%	5.76%

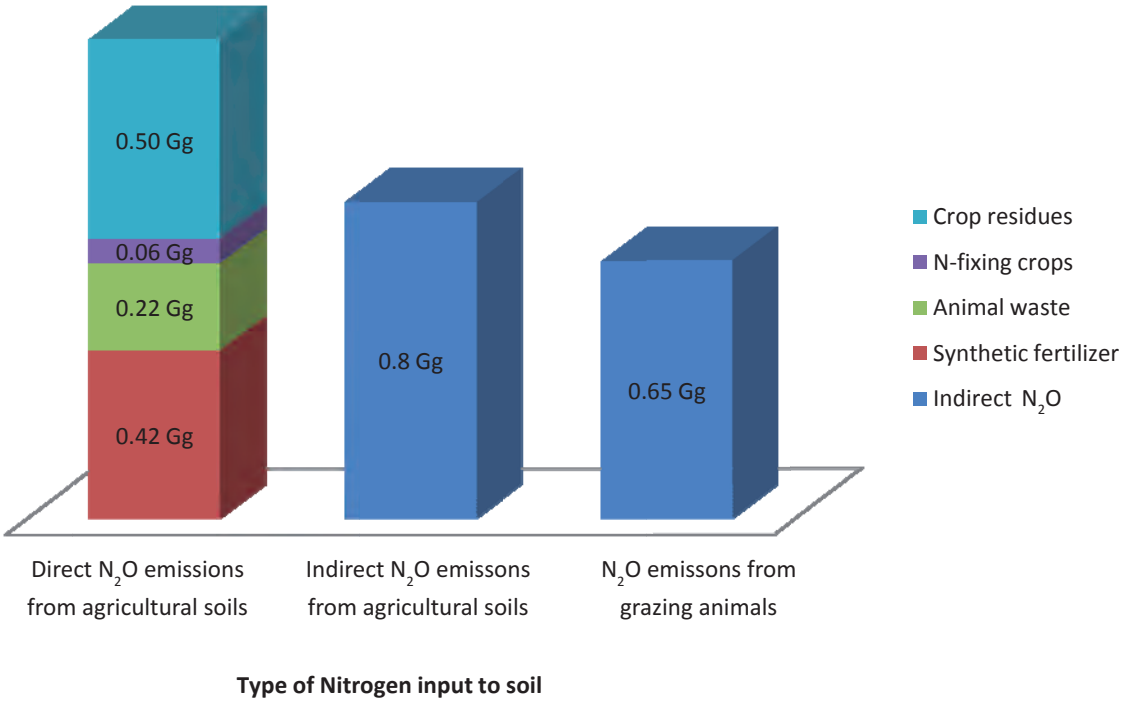


Figure 2-7 presents N_2O emissions according to the type of nitrogen input to the soil.

Table 2-9 Fraction of Manure Nitrogen per Animal Waste Management System

	Anaerobic Lagoons	Liquid systems	Solid storage and drylot	Pasture range and paddock
Dairy Cows	0.05	-	0.85	0.1
Other Cattle	-	-	0.9	0.1
Sheep	-	-	-	1
Swine	0.17	0.14	0.69	-
Poultry	-	-	1	-

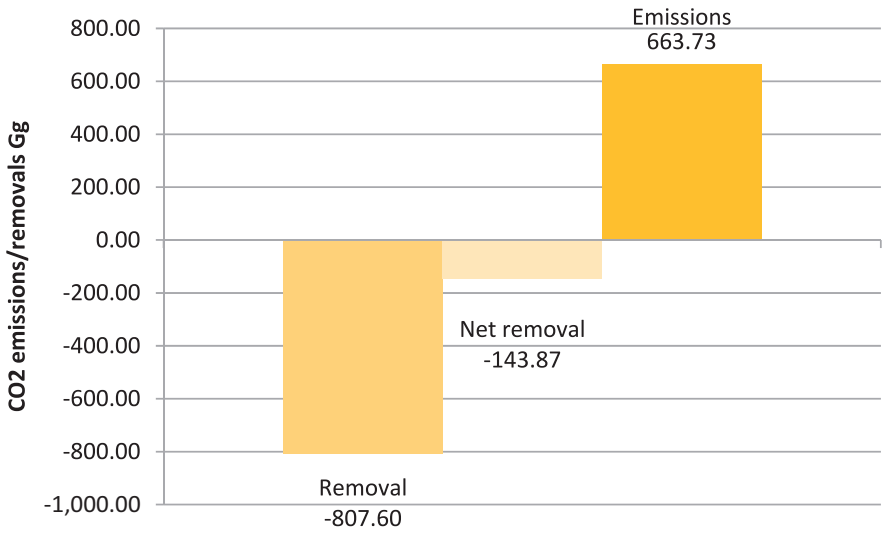


Figure 2-8 Emissions and removals from LUCF for 2000

The emission assessment is based on the idea that the flow of CO_2 from or to the atmosphere is equal to the changes in carbon stocks existing in biomass or soils and that the changes in carbon stocks can be estimated by establishing the rates of change in land use and the practice used to bring about these changes (burning, clear-cutting, etc.). Accordingly, this inventory examines changes in carbon stocks caused by 1) changes in changes in forest and other woody biomass stocks and 2) forest and grassland conversion.

The estimate of CO_2 removals from forests and changes in carbon stocks due to logging and fuelwood extraction presented in this report are based on the forest report assessment (MoA and FAO, 2005c) and the FAO's statistical database (FAO, 2008). Due to the absence of disaggregated data on the nature of fires (natural or anthropogenic) and the type of forest affected (managed or unmanaged), a total value of the area ravaged by forest fires is used from the Association for Forest Development and Conservation (AFDC) and the MoE database. In order to ensure consistency in calculations, the values of annual growth rate of forest used in the INC were used (MoE et al., 1999).

In Lebanon, the land use change and forestry sector acts as both a source and a sink where results of the year 2000 show that 807.6 Gg CO_2 are removed by sinks and 663.73 Gg CO_2 are emitted from forest fires (Figure 2-8). The net result labels this sector as a sink with -143.87 Gg CO_2 as a net removal.

Removals of CO_2 from changes in forest and other woody biomass stocks are caused by the changes in carbon stocks as a result of increase in forested areas or number of trees and decrease in commercial harvest of roundwood and fuelwood. Table 2-10 presents the values used for the calculations of the emissions and removals from this category for the year 2000.

Emissions of CO_2, CH_4, N_2O, NO_x and CO are emitted as GHGs and precursors from biomass burning, which emanates mainly from natural and man-made forest fires. It is estimated that fires have ravaged an area of 3,337 ha in 2000, made of 38.45% of coniferous and 61.55% broadleaf trees (MoA and FAO, 2005c; AFDC, 2007).

2.3.6 Waste

The emissions from the waste sector are calculated using the mass balance approach which estimates the Degradable Organic Carbon (DOC) content of solid waste. It is worth noting that this default methodology results in an overestimation of the emissions since it does not account for time factors in the waste accumulation and decomposition.

The categories of waste for which emissions are accounted for consist of:

- Solid waste disposal on land: emissions resulting from managed semi-aerobic sites (landfills such as Nehmeh and Zahleh), unmanaged deep sites (open dumpsites with a depth of more than 5 m such as Tyre, Saida, and Tripoli dumpsites) and other disposal methods on land. Activity data on the annual amount of Municipal Solid Waste (MSW) disposed in Solid Waste Disposal Sites (SWDS) use a population of 4.12 million in 2000 with an average urban MSW generation rate of 339.62 kg/cap/yr and a percent disposal in SWDS of 77%.

Table 2-10 Activity data for LUCF calculations

Activity data		CO_2 Uptake (Gg)	CO_2 release (Gg)	Balance (Gg)
Temperate commercial Evergreen (kha)	131.24	-601.5		
Temperate commercial Deciduous (kha)	5.11	-14.1		
Non-Forest Trees- evergreen fruits and olive trees (banana, citrus, olive) (1000 trees)	24024	-181.68		
Deciduous fruit trees (apple, cherries, peaches, pears, plums, etc.) (1000 trees)	19349	-87.8		
Roundwood commercial harvest (Kt dm)	9.19		16.9	
Fuelwood and charcoal consumed (kt dm)	21		38.5	
Other wood use (sawnwood, roundwood non-commercial) (kt dm)	12.05		22.1	
Total		-885.1	77.5	-807.6

- Wastewater handling: emissions resulting from the biodegradation of domestic and commercial wastewater disposed in water bodies or collected in septic tanks. Emissions from Industrial wastewater handling are not considered due to the absence of industrial wastewater treatment in Lebanon.
- Waste incineration: emissions resulting from the incineration of clinical waste.

The waste sector is the largest source of CH_4 emissions in Lebanon, accounting for 87.5% of the total national CH_4 emissions. The sector generated 1,739.36 Gg CO_2 eq. in 2000, or 9.4% of the total GHG emissions for the same year. Figure 2-9 illustrates the relative share of the different GHG emissions from the waste sector while Table 2-11 presents the contributions of the different categories to GHG emissions.

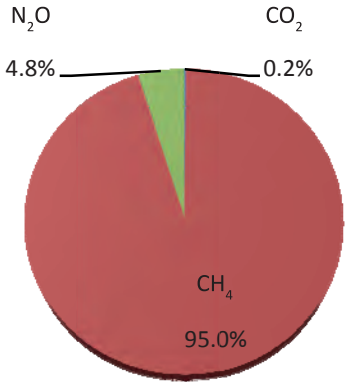


Figure 2-9 Composition of GHG emissions from the waste sector

Solid waste disposal on land remains the highest emitting category, constituting 94.3% of waste emissions in 2000, or 1,640 Gg CO_2 eq., with CH_4 being the main gas emitted. For calculation purposes, and based on an analysis of compiled data on waste generation in the Greater Beirut Area, the solid waste generated in Lebanon for the year 2000 is estimated to amount to 1,400,567 tonnes, of which 77% is being discharged in solid waste disposal sites. Since no information on the amount of gas flared in Zahle and Tripoli landfill are available for the year 2000, CH_4 flaring is only considered for the Nehmeh landfill, amounting to 3.9 Gg CH_4 (Table 2-11).

Emissions from wastewater handling emitted 96.3 Gg CO_2 eq. in 2000, where 59.3% of wastewater is estimated to be discharged directly in the sea, 26.1% is collected in septic tanks, and 14.6% is discharged in rivers.

As for waste incineration, although open burning of municipal waste is commonly practiced in Lebanon, data on such practices are unavailable. Therefore, this inventory only records emissions from the controlled incineration of medical waste, which constituted in 2000 0.2% of all waste GHG emissions, or 3 Gg CO_2 eq.

Table 2-11 GHG emissions from the waste sector.

Waste sub-sectors	GHG emissions (Gg CO_2 eq.)	Share of total waste emissions	Share of total national emissions
Solid Waste Disposal on Land	1,640.1	94.29%	8.86%
Wastewater Handling	96.30	5.54%	0.52%
Waste Incineration	2.96	0.17%	0.02%
Total	1,739.36	100.00%	9.40%

2.4 GHG Emissions by Gas

Carbon dioxide is by far the most important GHG emitted in Lebanon in 2000, accounting for 84% of total CO_2 eq. emissions. The major emitter of CO_2 is fuel combustion (energy industries, manufacturing industries or transport), constituting 88% of total CO_2 emissions. Industrial processes, namely cement industries, are also a significant source of CO_2 with 11% of emissions in 2000 (Figure 2-10).

Methane emissions have the second largest share of Lebanon's GHG emissions, with 89.82 Gg at 10.19% of the total GHG emissions in 2000. The waste sector, and namely solid waste disposal on land, is the largest contributor to these emissions with approximately 87% of emissions. This is followed by enteric fermentation and forest and grassland conversion (forest fires) with 6.7% and 2.3% respectively (Figure 2-11).

Nitrous oxide emissions have the smallest share of emissions in Lebanon, amounting to 3.39 Gg CO_2 eq. at 5.68% of total GHG emissions. In 2000, the main emitter of N_2O was the agriculture sector, namely agricultural soils and manure management, at 78% and 10% of total N_2O emissions respectively. This is followed by wastewater handling with 8% of N_2O emissions (Figure 2-12).

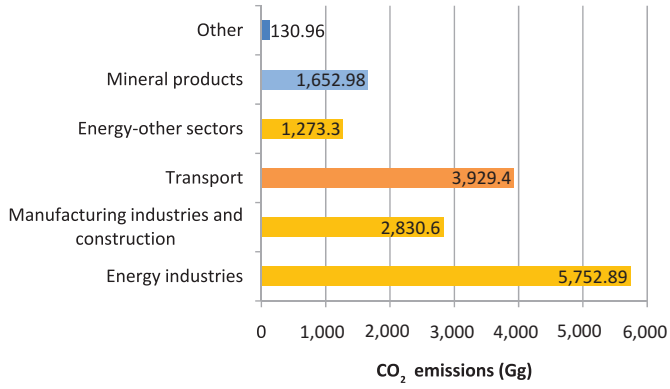


Figure 2-10 CO_2 emissions from major sources

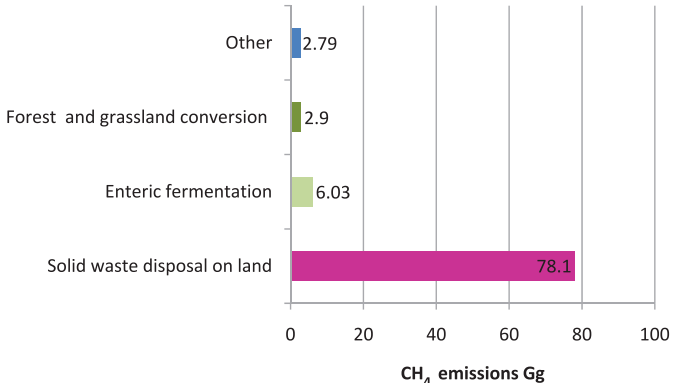


Figure 2-11 CH_4 emissions from major sources

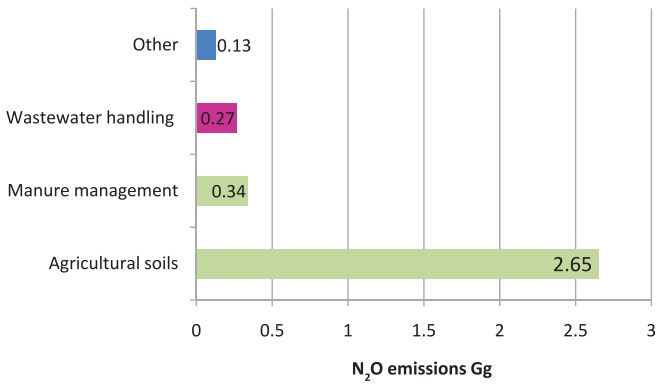


Figure 2-12 N_2O emissions from major sources

2.5 Trend in Lebanon's GHG Emissions: 1994-2004

An inventory of greenhouse gas emissions for the years 1994-2004 is undertaken in order to allow a complete assessment of trends in national GHG emissions and accordingly, design appropriate mitigation measures. The emissions of 1994 reported in the INC are used as the baseline for the extrapolation of results for the period 1994-1999. Emissions of the years 2000 to 2004 are calculated using the revised 1996 IPCC guidelines and based on recently collected activity data. For analysis purposes, the energy sector is divided between Energy production (EI, MIC, other) and transport. Table 2-12 and Figure 2-13 show the percent change and trend of GHG emissions during 1994-2004 for all sectors under study.

Table 2-12 Trend of emissions during the period 1994-2004

	Total GHG emissions ($Gg\ CO_2$ eq.)	Energy ($Gg\ CO_2$ eq.)	Transport ($Gg\ CO_2$ eq.)	Industry ($Gg\ CO_2$ eq.)	Agriculture ($Gg\ CO_2$ eq.)	Land Use and Forestry ($Gg\ CO_2$ eq.)	Waste ($Gg\ CO_2$ eq.)
1994	15,901	7,743	3,991	1,924	1,130	210	902
2000	18,507	9,892	3,963	1,781	1,066	67	1,739
2004	20,299	10,979	3,976	2,178	925	12	2,227
% change 1994-2004	27.66%	41.79%	-0.39%	13.19%	-18.12%	- 94.42%	146.99%
Average % change/yr	2.77%	4.18%	-0.04%	1.32%	-1.81%	-9.44%	14.70%

Lebanon's GHG emissions have increased by 27.6% since 1994, when total emissions were approximately 15,901 tCO_2 eq. This represents an average annual growth rate of 2.77%. As can be seen in Table 2-12, the fastest rate of growth occurred in the waste sector followed by the energy and industrial sector. A significant decrease in emissions is noted in the Land Use and Forestry sector in addition to a slight decrease in the agriculture sector.

As shown in Figure 2-13, the trend of increase in total GHG emissions closely follows the trend of emissions from the energy sector, which constituted 49 to 58% of total emissions during this period. This significant growth in emissions reflects the growing demand for electricity, due in part to the changing socio-economic conditions and to the expansion of the national grid. In fact, the sharp increase noticed between the 1994 and 2000 emissions is due to the increase in gas/diesel oil consumption (Figure 2-14) that accompanied the installation and operation of the Baalbeck, Tyre, Beddawi and Zahrani diesel power plants during this period.

As for the transport sector, GHG emissions have conserved a steady state throughout the 1994-2004 period. Despite a vehicle fleet increase during this period, the increased efficiency in fuel consumption of new cars, the ban to import cars older than 8 years that was introduced in Lebanon and the inspection system that was established in Lebanon in 2001 contributed to the stabilization of the emission trend from the transport sector.

The increasing emission trend is also caused by development of the industrial sector during this period, and namely the increase in cement and lime production by 40% and 32% respectively, with limited technological changes over the same period. Consequently, emissions from cement and lime industries increased by 45% and 37.5% respectively from 1994 to 2004. However, the soda ash use and steel production have witnessed a sharp decrease from their 1994 values, reaching a decrease in emissions of 90% for soda ash use, and 100% for steel production after the shutdown of the only steel plant in 2002. The averaged sectoral percent change during the 1994-2004 period is estimated at 13.19%.

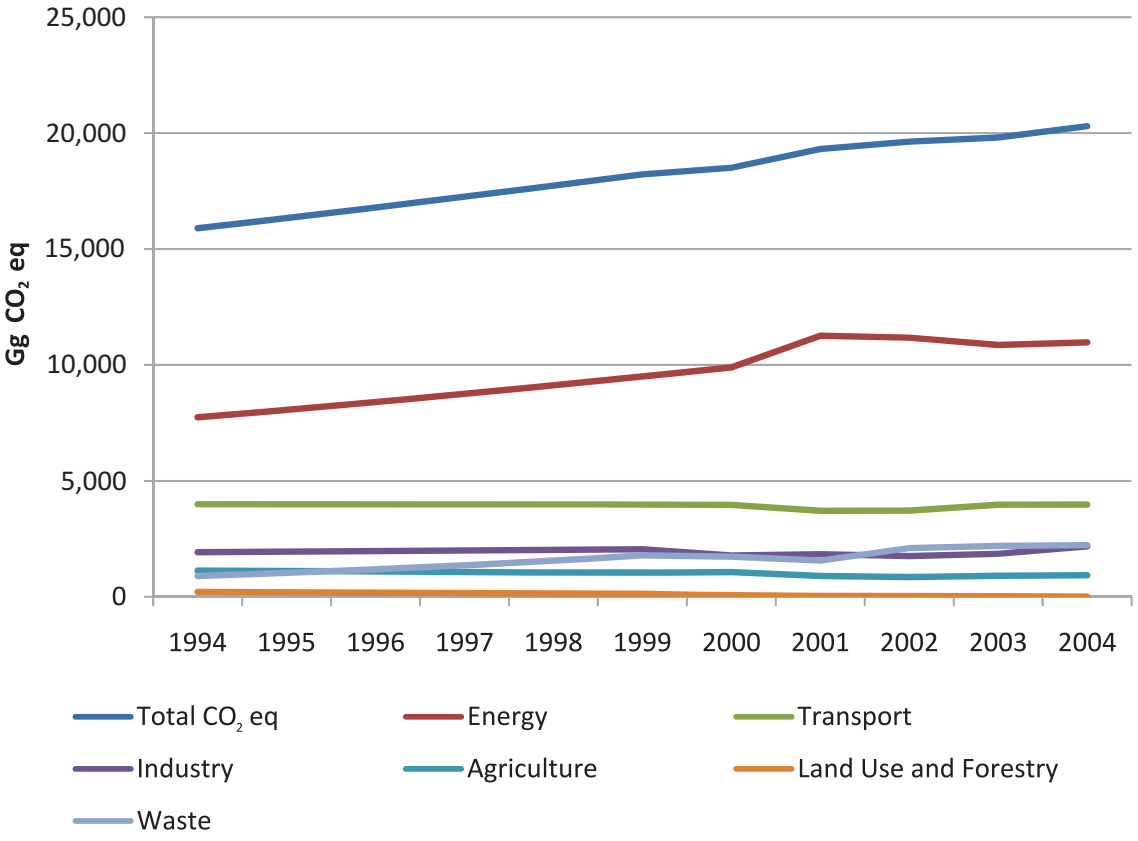


Figure 2-13 Trend in emissions

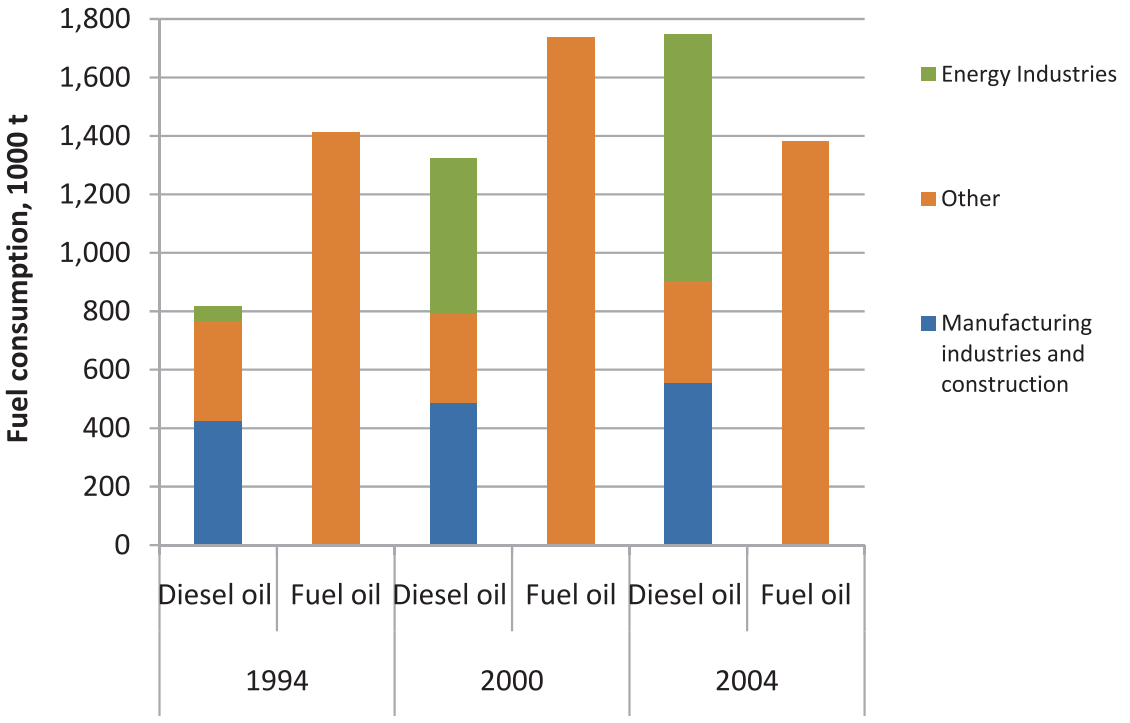


Figure 2-14 Consumption of fuel and diesel oil in the Energy sector

The sector with the most significant change in emissions is the waste sector with an increase of 147% from the 1994 values. With an increase in population, in waste generation and in percent of waste deposited in landfills, methane emissions from solid waste disposal on land have increased by 135% during the same period. Although flaring was introduced in 2000 with the establishment of the Naameh landfill, the amount of methane recovered is insignificant, constituting only 5% and 8% of the total annual methane generated from waste disposal on land in 2000 and 2004 respectively (Figure 2-15).

This sharp increase in emissions from the waste sector is countered by a decrease in emissions from agriculture and land use change and forestry. Indeed, during the 1994-2004 period, emissions from agriculture and LUCF decreased by 18% and 94.44% respectively. Possible causes for these changes in emissions are:

- Decrease in the population of livestock such as sheep, swine and other cattle. This decrease not only reduced the amount of CH_4 generated from manure management systems but also the N_2O emissions produced from the nitrogen excreted during grazing.
- Decrease in forest fires from 1994 to 2004, not only due to increase awareness of forest management from local communities but also due to increase wood harvesting during this period.

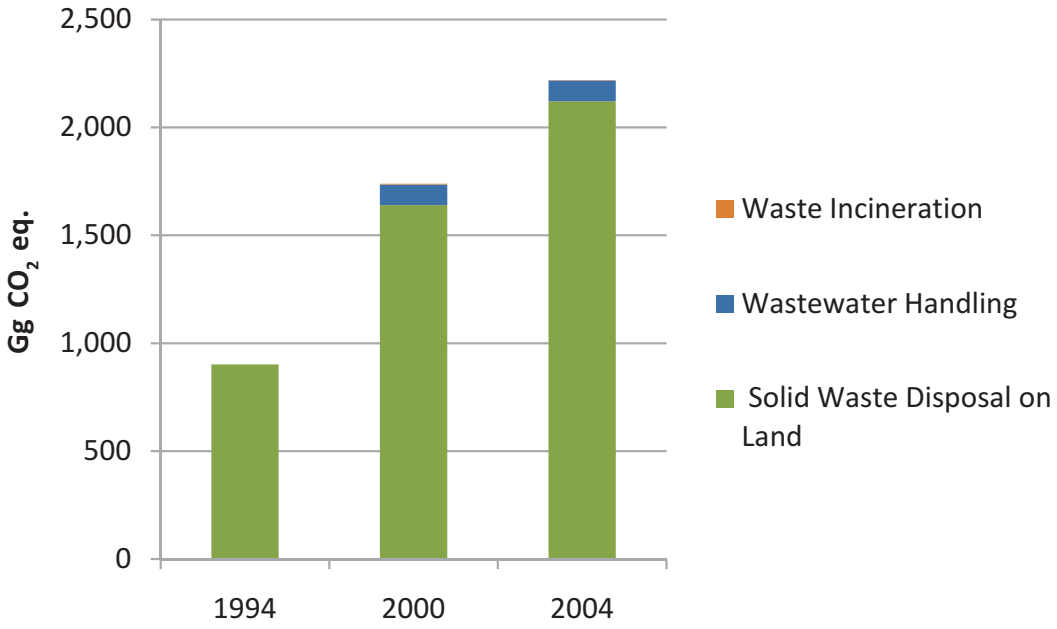


Figure 2-15 Trend in GHG emissions from the waste sector from 1994 to 2004