Preparation of the GHG Inventory for the Third National Communication to the UNFCCC

National Inventory Summary Report

Final Version

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Authors:

Project Manager: Pavlina Zdraveva

Project supervision: Teodora O.Grncarovska

Inventory experts: Natasa Markovska

Elena Gavrilova

Emilija Poposka

Igor Ristovski

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Abbreviations

BOD	Biological Oxygen Demand
CKD	Cement Kiln Dust
COD	Chemical Oxygen Demand
DOC	Degradable Organic Carbon
FAO	Food and Agriculture Organization
GHG	Greenhouse Gases
GWP	Global Warming Potential
HFC	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
LOE	Law on Environment
LULUCF	Land-use, Land-use Change and Forestry
MAFWE	Ministry of Agriculture, Forestry and Water Economy
MCF	Methane Correction Factor
MIA	Ministry of Internal Affairs
M-NAV	Macedonian Navigation
MNVOC	Non-Methane Volatile Organic Compound
MOE	Ministry of Economy
MoEPP	Ministry of Environment and Physical Planning
MOH	Ministry of Health
MOTC	Ministry of Transport and Communications
MSW	Municipal Solid Waste
SNC	Second National Communication
SSO	State Statistical Office
SWDS	Solid Waste Disposal Site
TNC	Third National Communication
WWT	Wastewater treatment

1. INTRODUCTION

A greenhouse gas inventory is a database of calculated direct and indirect greenhouse gases (GHGs) emitted to or removed from the atmosphere over a period of time. Six direct gases are taken into consideration, i.e., CO_2, CH_4, N_2O, PFCs, HFCs and SF_6, and four indirect gases, i.e., CO, NOx, NMVOC and SO_2.

The Republic of Macedonia ratified the UN Framework Convention on Climate Change (UNFCCC) in December 1997 and the Kyoto Protocol in 2004. Responding to the obligations incurred by signing the Framework Convention as a non-Annex I Party, the country prepared and submitted the First National Communication on Climate Change in 2003 and the Second National Communication in 2008. Preparation of the Third National Communication began in April 2012.

In the previous National Communications, the GHG inventories were prepared for the period 1990–2002, applying the Tier 1 method (i.e., the simplest method) for most sectors. Tier 2 methods were partially applied in the Energy sector as being a key source of GHGs, accounting for over 70% of emissions. The GHG inventories under the Third National Communication (TNC) for the period 2003–2009 were finalized using methodology prescribed in the *1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories, 2000 IPCC Good Practice Guidance.* For the software, an updated version 1.3.2 of the 1996 IPCC Software for National Greenhouse Gas Inventories was used.

The relevant CC provisions are contained in the chapter on Sustainable Development and Global Environmental Issues, wherein a national system for the stabilization of greenhouse gas concentrations in the atmosphere is legally established. The initial version of the Law on Environment (*Official Gazette of RM*, no.53/05) proposed a legal basis for the adoption of ordinances regulating the methodology and detailed contents of the Plan, as well as the conditions and the manner and procedure for the preparation of the inventory of greenhouse gas emissions. The relevant section in the context of the institutionalization of the GHG inventory system is the chapter on the Environmental Information System in the Law on Environment wherein the Macedonian Environmental Information Centre, as an organizational unit in the MEPP (MEIC), is appointed as the body in charge of collecting, processing and presenting official data on the state of environmental media and other areas.

Most of the activity data were available from the State Statistical Office (MAKSTAT), Energy Balances, National Reports from the MAFWE, the MOEPP and other relevant institutions. Some data were obtained from industries and from the FAO database. For emission factors, 90% of values are country-specific (CS) and IPCC default values were used taking into account expert judgment. In TNC, for the first time emissions from aviation have been included, thanks to collaboration with M-NAV. Additional data on agriculture and land use change and forestry were provided by various institutions which had previously not been taken into account.

More accurate inventories will enable the identification of the major sources and removals/sinks of greenhouse gases with greater confidence and thus enable more informed policy decisions with respect to appropriate response measures. Reliable GHG inventories are essential both at national and international level for assessing the community's efforts to address climate change and progress towards meeting the ultimate objective of the United Nations Framework Convention on Climate Change Convention, for evaluating various mitigation options and calculating long-term emission projections.

The national structure for the development of the National GHG inventory within TNC involves the following entities (see Chart on Figure A.1 in the Annex):

- **The Ministry of Environment and Physical Planning**, responsible for supervising the national inventory process and reporting the emissions to UNFCCC
- **The Project Management Unit**, responsible for managing and coordinating the Third National Communication on climate change
- **The GHG Inventory Team**, composed of three junior consultants responsible for preparing the GHG inventory
- **A National Technical Advisor**, responsible for training and transfer of knowledge to the GHG inventory team and for supervision and verification of the GHG inventory
- **The National Communication Support Programme** (**NCSP**), responsible for supporting and revising the GHG inventory

A new institutional system was implemented to ensure the sustainability of the process of preparing GHG inventories. Three young professionals were engaged to form a GHG Inventory Team in order to assure continuous, regular update of the national GHG inventories and the establishment of a Monitoring, Reporting and Verification (MRV) system. Training materials were prepared for each sector, including a step-by-step process for completing inventory tables, explanations of good practices and sources of data and emission factors.

As part of the training materials, a **data documenting structure** was reported for each activity rate, emission or conversion factor directly in the sectorial and sub-sectorial excel worksheets in the IPCC software. This enables long-term sustainability and continuation of the inventorization process.

Quality control/Quality assurance was provided by ensuring that each Expert inter-checked one or two other sectors, sectoral and sub-sectoral worksheets to ensure the entered data was of good quality. QC/QA was ensured through additional reviews from the National Expert on Climate change and the National Communication Support Programme (NCSP) which assists Non Annex I Parties to the UNFCCC in preparing their National Communications.

Direct and indirect gases need to be converted to CO_2-eq. emissions by multiplying the value of each gas with its global warming potential. *Global-warming potential* (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere. Values for the global warming potential of greenhouse gases have been used as suggested by the IPCC Good Practice Guidelines (presented in Table A.1 in Annex). In the Third National Communication, **Country Specific Emission Factors** were established for *key source categories* for the first time. Key source categories are those source categories that contribute more than 95% to the total GHG emissions of the inventory. The five most emitting key source categories in Macedonia are: CO_2 emissions from Energy Industries (coal, lignite); CO_2 emissions from Mobile Combustion, including Road Vehicles; N_2O (Direct and Indirect) emissions from Agriculutural Soils; CH_4 emissions from Solid Waste Disposal Sites; and CH_4 emissions from Enteric Fermentation in Domestic Livestock. A more detailed key source analysis is presented in Chapter 9. Country-specific emission factors are important because they can give a clear representation of national circumstances and improve the quality of Inventory data (using higher Tiers for calculations) based on a specific conditions and process types in the country. These factors showed a slight reduction of emissions in the energy (10%) and industry sectors as well as a slight increase in emissions from the waste sector.

2. SUMMARY OF THE GHG INVENTORY

The total national emissions of CO_2-eq.[kt] by sectors for the period 2003-2009 are presented in Table 2.1.1. In the category Land-Use, Land-Use Change and Forestry CO_2-eq., the emissions are presented with (-) since they are actually removals or carbon sink through the process of carbon sequestration.

Table 2.1.1 GHG emissions/removals by sectors in the period 2003–2009 [kt CO_2-eq]

Year	2003	2004	2005	2006	2007	2008	2009
Energy	9,059.45	8,732.00	9,456.41	8,543.18	9,034.99	9,146.05	8,761.32
Industry	598.35	971.43	1,075.64	784.48	943.50	974.83	434.44
Agriculture	1,733.51	1,787.86	1,581.20	1,677.13	1,495.89	1,403.47	1,321.19
Waste	832.55	838.82	840.22	851.85	862.25	872.21	880.85
LULUCF	-976.71	-988.89	-1,092.57	-927.27	7.76	-717.83	-1,146.25
Total CO_2-eq. excluding	**12,231.43**	**12,329.86**	**12,953.47**	**11,856.64**	**12,336.63**	**12,397.47**	**11,397.83**
Total CO_2-eq. including	**11,254.72**	**11,340.97**	**11,860.90**	**10,929.37**	**12,344.39**	**11,679.63**	**10,251.57**

[1] Emissions / removals from *Land Use. Land Use Change and Forestry* are not included in national totals

Emissions from the Energy sector are in the in range of 8,500–9,000 kt. Emissions from the Industry sector show an increase up to the year 2005, but afterwards gradually decrease, mainly due to the global economic crisis and a decrease in industrial production. Emissions in the Agriculture sector emissions are continually decreasing due to a reduction in livestock populations, while in the Waste sector the situation is the opposite since these emissions are linked to the size of the population (i.e., waste produced per capita) which increases over time. In the category of Land-Use and Forestry, removals (-) are relatively unchanged at around 1,000 kt, except in 2007 when carbon sink was significantly reduced because of emissions resulting from large-scale forest fires.

Table 2.1.2 Direct and indirect GHG emissions/removals [kt] by sectors in the period 2003–2009

Sector	*Year*	CO_2 emissions	CO_2 removal	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs
Energy	**2003**	8,726.56	n/a	13.46	0.16	33.42	136.50	21.33	172.10	n/a
	2004	8,408.33	n/a	13.14	0.15	30.56	126.24	19.34	168.06	n/a
	2005	9,148.49	n/a	12.43	0.15	31.38	116.36	18.01	174.98	n/a
	2006	8,228.19	n/a	12.66	0.16	32.30	118.52	18.13	162.54	n/a
	2007	8,729.15	n/a	12.31	0.15	34.00	111.99	17.62	161.44	n/a
	2008	8,792.57	n/a	14.34	0.17	35.43	126.16	19.46	180.75	n/a
	2009	8,416.22	n/a	14.02	0.16	33.65	137.54	21.01	175.95	n/a
Industry	**2003**	575.86	n/a	0	0	1.46	0.51	81.20	0.51	0.02
	2004	640.91	n/a	0	0	1.14	0.03	209.41	0.31	0.25
	2005	703.45	n/a	0	0	0.74	0.00	163.97	0.35	0.28
	2006	683.39	n/a	0	0	0.71	0.03	56.43	0.37	0.07
	2007	716.65	n/a	0	0	0.30	0.01	34.87	0.32	0.17
	2008	700.53	n/a	0	0	0.51	0.00	70.75	0.30	0.21
	2009	434.44	n/a	0	0	0.43	0.05	64.69	0.31	n/a
Agriculture	**2003**	0	n/a	28.86	3.64	0.32	5.83	n/a	n/a	n/a
	2004	0	n/a	29.47	3.77	0.41	8.84	n/a	n/a	n/a
	2005	0	n/a	27.84	3.21	0.39	8.31	n/a	n/a	n/a
	2006	0	n/a	29.05	3.44	0.37	7.66	n/a	n/a	n/a
	2007	0	n/a	26.24	3.05	0.32	5.97	n/a	n/a	n/a
	2008	0	n/a	26.37	2.74	0.37	7.87	n/a	n/a	n/a
	2009	0	n/a	24.45	2.61	0.38	7.63	n/a	n/a	n/a
Land-use, land-use change Forestry	**2003**	0	-981.81	0.18	0	0.02	2.73	n/a	n/a	n/a
	2004	0	-993.21	0.15	0	0.02	2.21	n/a	n/a	n/a
	2005	0	-1099.55	0.25	0.01	0.03	3.71	n/a	n/a	n/a
	2006	0	-934.10	0.24	0	0.02	3.66	n/a	n/a	n/a
	2007	0	-227.15	6.63	0.31	1.23	77.31	n/a	n/a	n/a
	2008	0	-778.73	1.73	0.08	0.32	20.37	n/a	n/a	n/a
	2009	0	-1155.37	0.29	0.01	0.04	3.78	n/a	n/a	n/a
Waste	**2003**	64.91	n/a	37.56	0.14	n/a	n/a	n/a	n/a	n/a
	2004	65.07	n/a	37.81	0.14	n/a	n/a	n/a	n/a	n/a
	2005	65.18	n/a	37.94	0.14	n/a	n/a	n/a	n/a	n/a
	2006	65.28	n/a	38.44	0.14	n/a	n/a	n/a	n/a	n/a
	2007	63.95	n/a	38.83	0.15	n/a	n/a	n/a	n/a	n/a
	2008	65.65	n/a	39.42	0.14	n/a	n/a	n/a	n/a	n/a
	2009	65.99	n/a	39.79	0.15	n/a	n/a	n/a	n/a	n/a

GHG emissions in the period 1990–2009. are shown in Figure 2.1.1. Year 2000 is chosen as a base year (i.e., a specific year which provides a consistent reference for comparing emissions over time).

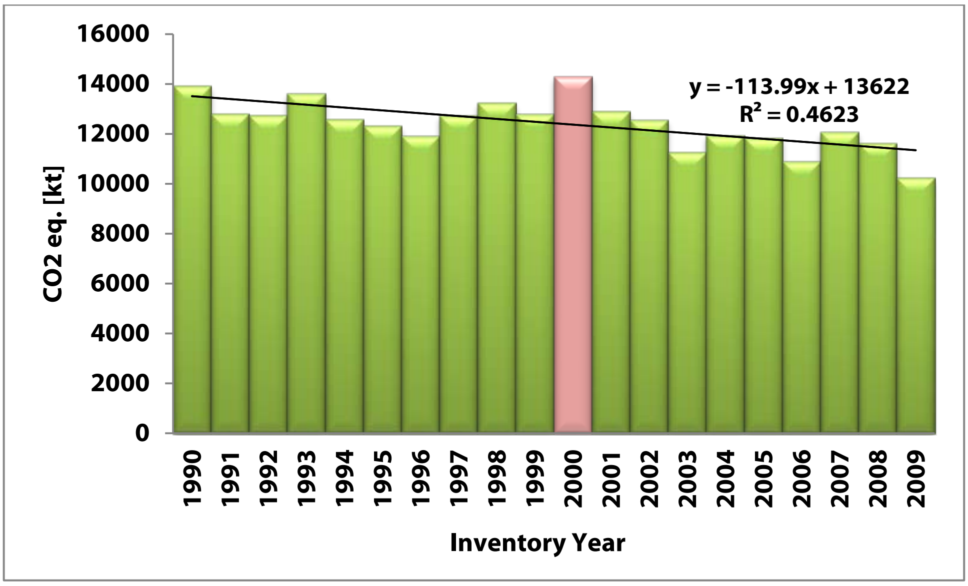
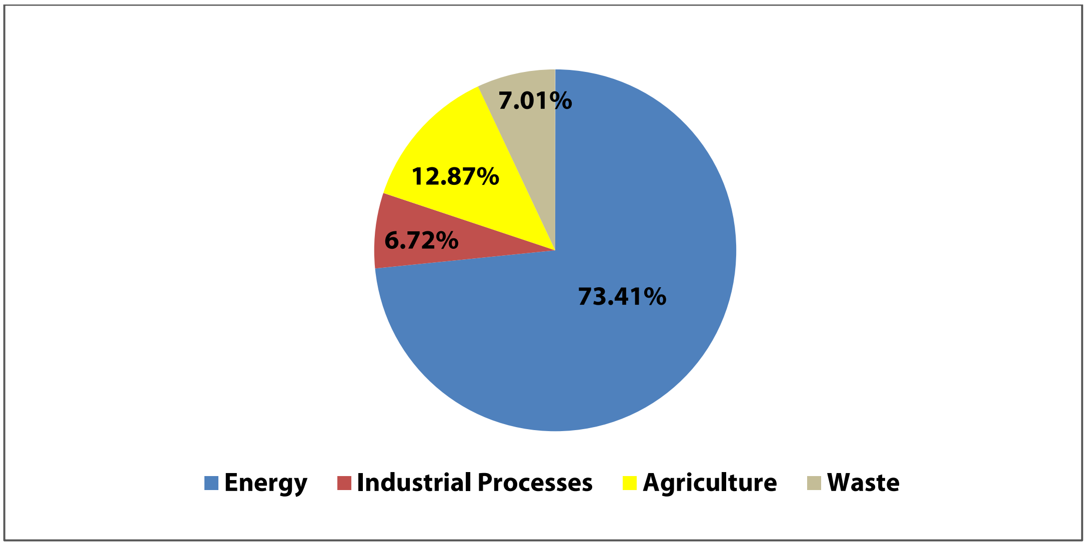


Figure 2.1.1 GHG emissions [kt] CO_2eq.] for the period 1990–2009

The trend line is also presented. For 2009, GHG emissions show a 28.42% reduction compared to emissions from the base year 2000, mostly due to global economic crisis, with lower industrial production and energy demands and the abandonment of some forms of farming.

Greenhouse emissions in Macedonia originate mostly from the Energy sector (73.41%). followed by Agriculture (12.87%) and Waste (7%). The industry sector is accountable for 6.72% of country emissions. Land use, land-use change and the Forestry sector account for 3–10% of emissions, depending on forest fires, the management of soils (limestone and fertilizer application) and the conversion of land in the specified year. The solvents use sector is not presented on the graph (Figure 2.1.2) since emissions have an insignificant share (600 kg) in overall GHG emissions.



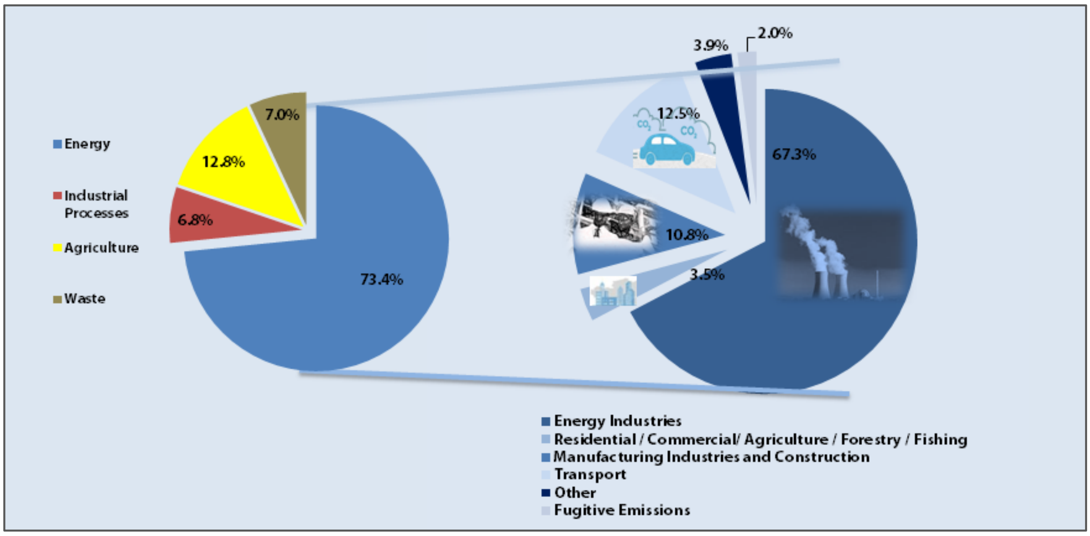


Figure 2.1.2 Share of different sectors in total GHG emissions (excluding the LULUCF sector)

- Within the Energy sector, 73% of emissions are originating from the energy industries sector, including public electricity and heat production, petroleum refining and the manufacture of solid fuels, with 12.55% from the transport sector (mostly road transport), 10.75% from manufacturing industries and construction, and 3.5% from commercial, residential buildings.
- Most emissions from Industrial Processes originate from mineral and metal product processes, with the cement industry and ferroalloys production accounting for over 77% of total emissions. HFCs are responsible for 23% of GHG emissions from industry.
- In the Agriculture sector, 89% of CH_4 emissions originate from livestock farming (enteric fermentation and manure management), whereas 88% of N_2O emissions originate from the management of agricultural soils (use of synthetic fertilizers, use of manure, nitrogen fixation of crops and leaching).
- In the Waste sector, 88% of CH_4 emissions originate from waste disposal at landfills, others from incineration and domestic wastewaters, while N_2O emissions arise from human sewage and industry wastewaters. In this sector there are smaller amounts of CO_2 from waste incineration.

- In LULUCF, changes in carbon stock in the living biomass from forestlands and croplands have the greatest effect on carbon sink, followed by biomass conversion from one category to another, whereas most of the emissions (releases) are associated with forest fires and management practices in agro-soils, such as lime application.

As far as specific direct GHG gases are concerned, 75–80% of emissions are CO_2 emissions (mostly from the burning of fuels in the energy sector), 12–14% are CH_4 emissions (mostly from agriculture and waste), 7–9% are N_2O emissions (from burning fuels and emissions from soils) and 1–2% are HFCs from the industry sector (see both Figure and Table 2.1.3).

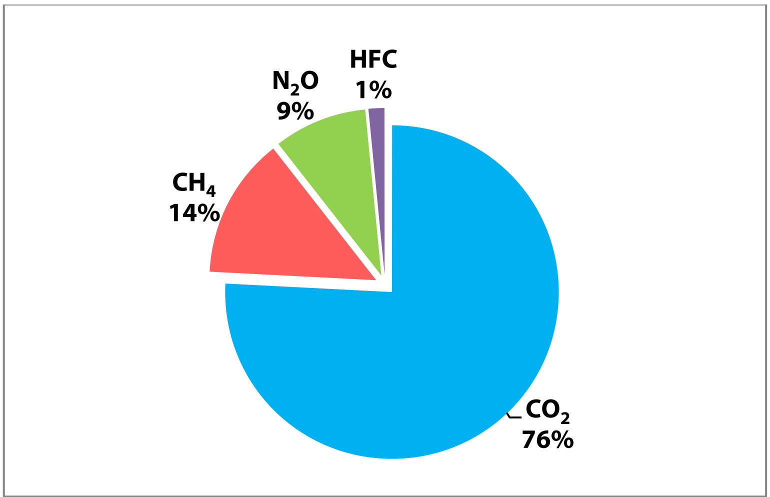


Figure 2.1.3 Direct GHGs in total emissions in the period 2003–2009

Table 2.1.3 Direct greenhouse gas emissions in the period 2003–2009

Year	2003	2004	2005	2006	2007	2008	2009
CO_2	9,302.42	9,049.24	9,851.94	8,911.58	9,445.80	9,493.09	8,850.65
CH_4	1,681.32	1,692.03	1,647.75	1,688.35	1,764.01	1,718.96	1,649.39
N_2O	1,222.70	1,262.01	1,088.57	1,162.45	1,134.89	971.11	906.90
HFC	22.49	330.53	372.19	101.09	226.85	274.30	0.00
Total CO_2-eq. [kt] excluding	**12,231.43**	**12,329.86**	**12,953.47**	**11856.64**	**12336.63**	**12,397.47**	**11,397.83**
Total CO_2-eq. [kt] including	**11,254.72**	**11,340.97**	**11,860.90**	**10929.37**	**12344.39**	**11,679.63**	**10,251.57**

Figure 2.1.4 shows the distribution of CO_2, CH_4 and N_2O gases across sectors, whereas HFCs are only generated by the Industry sector. Values from the LULUCF sector are actually CO_2 removals (-) from biomass absorption.

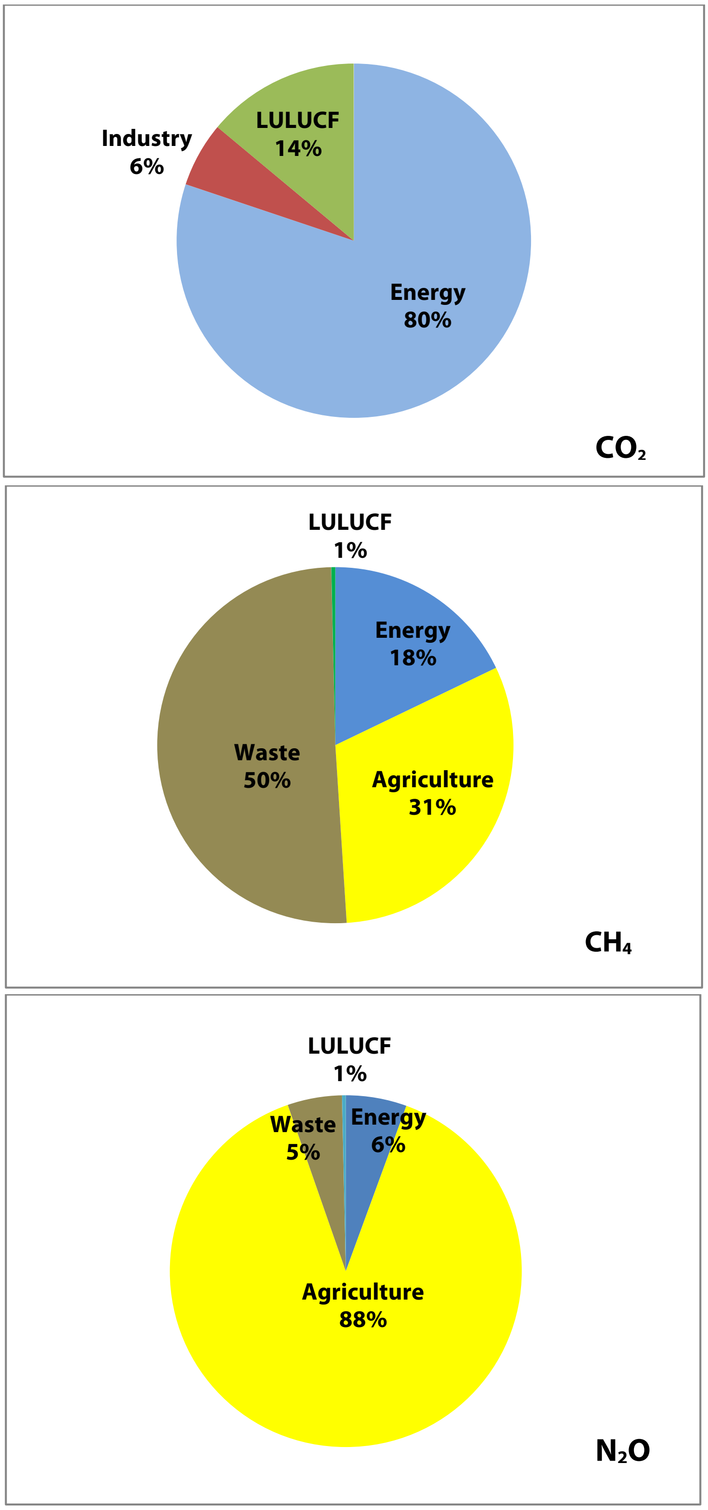


Figure 2.1.4 Distribution of CO_2, CH_4 and N_2O emissions by Sector

The waste sector shows a significant increase in emissions due to the newly adopted methodology (Tier 2 FOD), which produces more accurate estimates of annual emissions, and from additionally added emissions from waste incineration from the Drisla landfill (Skopje region only).

In the LULUCF sector, significant emissions (less carbon sink) were registered in the year 2007 when 39,612 ha of forests and grassland were lost to fires. The level of emissions from the Energy Sector was relatively steady in the period 2003–2009, at the same level as the emissions from industry, which showed a significant reduction only in 2009 when HFC emissions were not taken into account due to a lack of input data. Emissions from agriculture show a continuous reduction, primarily because of a continuous decrease in livestock figures.

Indirect greenhouse gases are those that have indirect radiative effects and can have an impact on climate change. Therefore it is good practice to report these gases separately in national inventories. Most of the NOx and CO emissions come from the energy sector, from the *transport and energy industries (coal, lignite*), and from burning in agriculture *(crop residues)* and LULUCF *(forest fires),* MNVOC emissions are mostly from the industry sector, especially the *mineral production processes,* and a smaller share from the transport sector and from solvent use, while most SO_2 emissions are from *energy industries, construction and transport.*

The results are shown in Table and Figure 2.1.6 below.

Table 2.1.6 Indirect greenhouse gases in the period 2003–2009

Year	2003	2004	2005	2006	2007	2008	2009
NOx	35.22	32.13	32.54	33.41	35.86	36.63	34.50
CO	145.56	137.32	128.38	129.87	195.29	154.40	149.01
NMVOC	102.53	228.75	181.98	74.56	52.48	90.21	85.70
SO_2	172.62	168.38	175.33	162.91	161.76	181.05	176.26

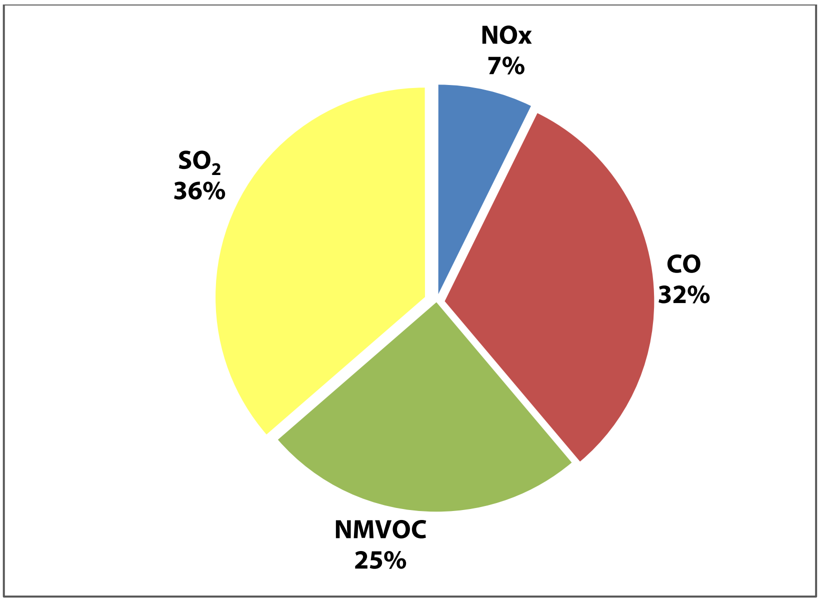


Figure 2.1.5 Share of different gases in total indirect GHG emissions

One of the indicators for the level of emissions which can be used for comparison purposes with other countries is the CO_2***-eq. per capita*** (Table below).

Table 2.1.5 CO_2-eq. per capita in different countries

Developing Countries	tCO_2-eq. per capita	Developed Countries	tCO_2-eq. per capita
Morocco	1.6	Turkey	5.2
Egypt	2.0	Latvia	5.6
Mexico	5.4	France	8.2
Macedonia	***5.6***	Spain	9.0
Romania	6.8	Italy	9.1
Benin	6.8	**EU-28**	**9**
Malaysia	6.8	United Kingdom	10.3
Mongolia	6.8	Poland	10.4
Croatia	7.0	Austria	10.4
Lithuania	7.1	Slovenia	10.6
Armenia	7.1	Norway	11.3
Malta	7.2	Germany	11.7
Uzbekistan	7.5	Denmark	11.7
Argentina	7.6	Belgium	12.5
San Marino	7.6	Netherlands	12.6
Swaziland	7.9	Finland	13.2
Bahamas	7.9	Czech Republic	13.6
Singapore	7.9	Canada	22.08
Ukraine	9.3	USA	22.3
Cameroon	12.1	Qatar	44

Macedonia has 1.6 times lower emissions per capita than the EU28 average, or nearly 4 times lower than highly industrialized countries like the USA. Its levels of emissions are similar to those in Latvia and Turkey.

Another indicator is ***carbon intensity***, or the *energy intensity* indicator. Carbon intensity is the average emission rate of a given pollutant from a given source relative to the intensity of a specific activity and represents the ratio between the gross inland consumption of energy (kg toe) and gross domestic product (GDP in 1,000 EUR/year). Macedonia on average has 652 kg toe or 4.3 times higher carbon intensity than the average in EU 28 countries.

3. ENERGY

3.1. INTRODUCTION

A variety of serious environmental problems are associated with the production and consumption of energy. Anthropogenic carbon dioxide (CO_2) emissions from the energy sector (i.e., emissions produced by human activities) come from the combustion of carbon-based fuels, principally wood, coal, oil, and natural gas.

In Macedonia, where power generation is dominantly based on lignite coal, the energy sector is the main contributor to overall GHG emissions. The contribution of direct GHGs from the Energy sector to total emissions amounted to an average of 73.40% for the period 2003–2009.

Table 3.1.1. – Contribution of the Energy sector to overall GHG emissions

Year	Energy Sector CO_2 eq. [kt]	All Sectors CO_2 eq. [kt]	Contribution of the Energy Sector to direct GHG emissions in the Inventory total [%]
2003	9059.45	12231.43	**74.07**
2004	8732.00	12330.09	**70.82**
2005	9456.41	12953.47	**73.00**
2006	8543.18	11856.64	**72.05**
2007	9034.99	12336.63	**73.24**
2008	9146.95	12397.47	**73.78**
2009	8761.32	11397.83	**76.87**

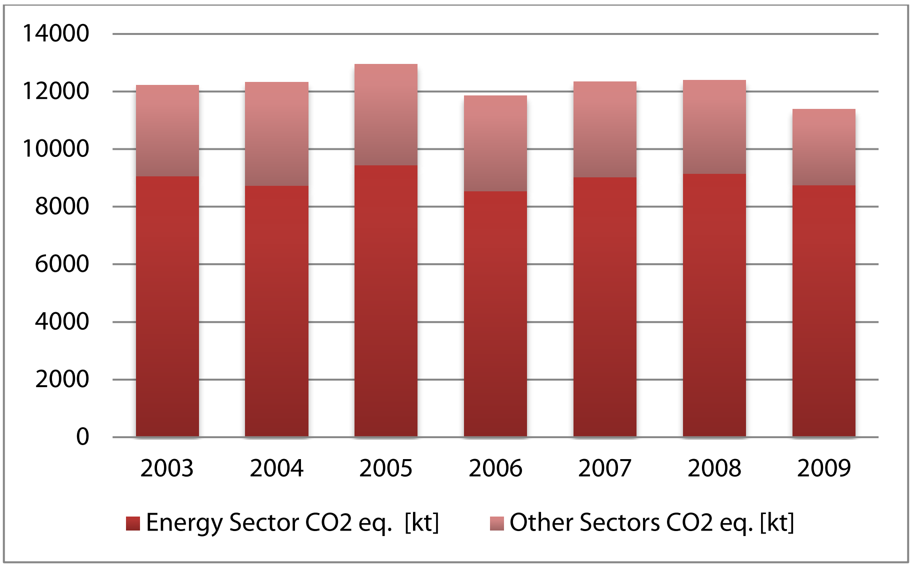


Figure 3.1.1 - Contribution of the Energy sector to overall GHG emissions [kt]

3.1.1. OVERVIEW OF THE MACEDONIAN ENERGY SECTOR

The energy infrastructure of the Republic of Macedonia enables the exploitation of domestic primary energy, the import and export of primary energy, the processing of primary energy and the production of final energy, and the transport and distribution of energy.
The energy infrastructure of the Republic of Macedonia comprises the electricity sector, the coal, oil and petroleum products sectors, the sector for natural gas and the sector for heat production.

Electricity sector
The structure of the electric power system (EPS) of Macedonia comprises:
- Hydropower plants, with a total installed power of 580 MW;
- Thermal power plants fueled by lignite with a total installed power of 800 MW and fueled by heavy fuel-oil fired with an installed power of 210 MW;
- The electricity transmission system, with power lines of a voltage level of 400 kV (594 km), 220 kV (103 km) and 110 kV (1480 km).

Coal sector
The country's existing mines can be subdivided into two groups according to their purpose: mines for the production of lignite for state-owned thermal power plants within the AD ELEM of Macedonia, i.e. the surface mines of Suvodol and Oslomej; and mines for the production of lignite for wide consumption, i.e. the surface lignite mines of BRIK Berovo and Drimkol) which are privately owned shareholding companies.

In order to provide for continuity in the operation of the TPP Bitola and TPP Oslomej in the upcoming period, it is necessary in the shortest time possible to provide for exploitation from the lignite mines in their immediate vicinity (Brod – Gneotino, Suvodol – underlying seams and Popovjani) in accordance with a precisely determined time schedule.

Oil and petroleum products sector
The capacities of the OKTA refinery and the oil pipeline from OKTA to the port of Thessaloniki fully satisfy the demand for petroleum products in Macedonia. However, the refinery needs to be modernized, primarily for the purpose of providing more efficient environmental protection and greater efficiency in its operations.

Natural gas sector
Macedonia is connected to only one main gas pipeline. The entire quantity of natural gas is imported from Russia through the gas pipeline that enters Macedonia at Deve Bair on the border with Bulgaria and stretches through Kriva Palanka, Kratovo and Kumanovo to Skopje. The main gas pipeline has a capacity of 800 million Nm3 per year, with the possibility of being increased to 1.200 million Nm3 per year. At this stage in the development of gasification in the Republic of Macedonia, there is practically no distribution network. Some direct consumers are actually connected directly to the transmission network.

Heat sector
The production of heat in Macedonia is mostly realized at present in boilers using liquid petroleum products, natural gas or coal. Most of these are obsolete with low efficiency coefficients.

The total heating consumption connected to the central heating systems in the Republic of Macedonia and delivered to end-users is about 630 MW. The biggest central heating system is the system operated by Toplifikacija AD Skopje, which connects about 550 MW. Several smaller systems, two of which are out of Skopje, connect about 80 MW. Given this level of connectivity, we can say that about 10% of users in the country are connected to central heating systems.

Energy production in Macedonia is primarily based on domestic lignite, imported fuels, natural gas, hydro potential and wood, all of which are used for electricity production, heat production, as well as mechanical energy in the transport sector.
Increased economic growth in the last decade has determined an increased consumption of energy. Existing high prices for crude oil and petroleum products on the international market have a negative influence on the economical balance and stability of Macedonia.
Macedonia is highly dependent on imported energy. Indeed it imports its entire demand for oil and petroleum products, natural gas and, as from 2000, electricity. Energy imports have grown during the recent period, and imports of electricity have grown rapidly in the latest few years.

Electricity production in Macedonia is based on thermo power plants and hydropower plants. The main portion of the electrical energy is produced by thermo power plants.
The country disposes only with reserves of coal in the category of young lignites.
Coal is the dominant electric power resource for the production of electricity in the electric power system in Macedonia. Lignite coal is applied in industry, heat power plants, and also for a broad expenditure Further exploration, production and exploitation of resources is essential for the country. Macedonia is highly energetically dependent from its exploration, production and usage.

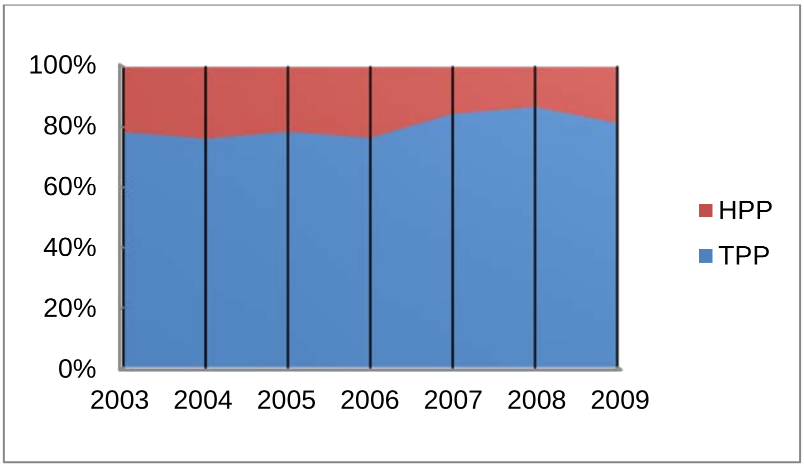


Figure 3.2.2.1.1- Proportion of electricity produced from TPP vs. HPP

Table 3.2.2.1.1 - Proportion of GWh of energy produced by TPP vs. HPP

Proportion of GWh of energy produced in %	2003	2004	2005	2006	2007	2008	2009
TPP	78.35	76.21	78.51	76.45	84.46	86.69	81.39
HPP	21.65	23.79	21.49	23.55	15.54	13.31	18.60

The Republic of Macedonia has exceptionally low energy consumption per capita and exceptionally high energy consumption per unit of GDP in all sectors.
The Energy Intensity indicator represents the ratio between the gross inland consumption of energy (kg toe) and the gross domestic product (GDP in 1000 EUR/ year). Energy intensity is a measure of how much energy is used to produce a unit of economic output. It measures the energy consumption of an economy and its overall energy efficiency.
The presented time series shows a favourable downward trend of energy intensity, indicating that the country is slightly improving through energy efficiency measures and a shift towards EU trends of effective production.

Table 3.2.2.1.2 - Energy Intensity: kg toe/000 euros

2003	2004	2005	2006	2007	2008	2009
710.90	681.60	680.30	661.90	646.50	613.90	575.70

* Reference: The data presented in this chapter are taken from the "Strategy for Energy Development in the Republic of Macedonia until 2030", issued by the Ministry of Economy, annual publications of ELEM, the State Statistical Office, and the paper "Assessment of the Energy consumption of the Republic of Macedonia" issued by the National Bank of Macedonia.

3.1.2. THE INVENTORY UP TO 2002

The inventory under the First National Communication (FNC) was prepared for the period 1990–1998 and the inventory for the Second National Communication (SNC) was prepared for the period 1999–2002. These inventories considered the three main GHGs: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as well as CO as an indirect gas. In accordance with the IPCC methodology for the Energy sector, the CO_2 emissions were calculated by both a Reference and a Sectorial Approach (Tier 1). The year 2000 was the base year and more detailed information has been provided for that particular year.
The figure below shows the GHG emissions from the energy sector for the period 1990–2002.
For the Macedonian economy this was a transitional and turbulent period, which is why the emissions have a fluctuating trend depending on the energy needs of the industrial sector.

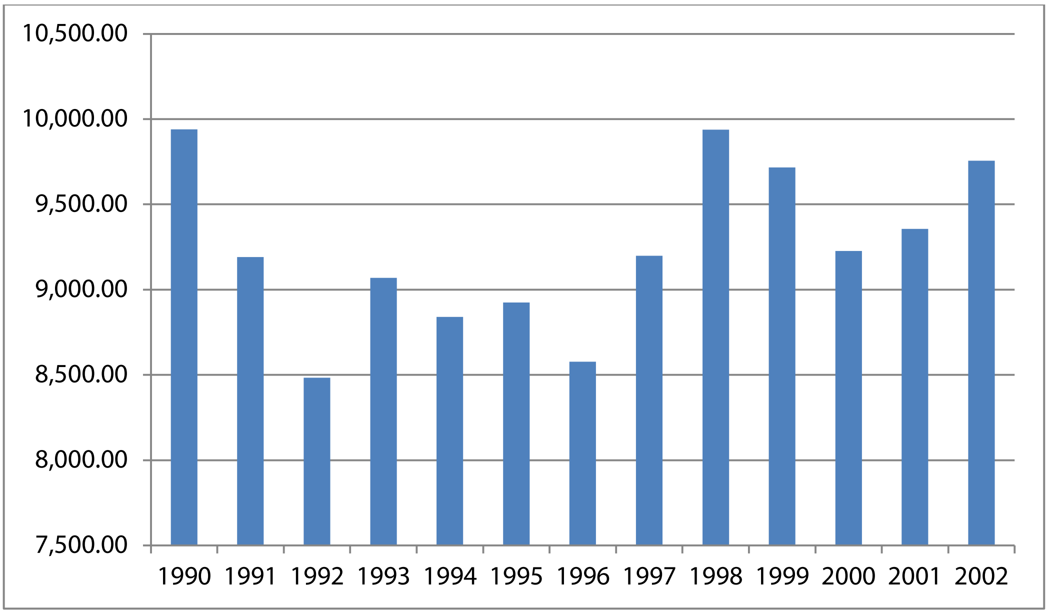


Figure 3.2.2.1.1 - Total GHG emissions from Energy Sector expressed in CO_2 eq. for the period 1990–2002, Sectorial Approach [kt]

Table 3.2.2.1.1 - Contribution of individual subsectors to total CO_2-eq emissions in the Energy Sector

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[kt]	**Energy industries**	6937.77	6314.56	5951.33	6122.00	6333.23	6409.25	5958.26	6583.71	7492.26	7079.01	6876.43	7345.69	6540.73
	Fugitive emissions	151.04	140.24	136.27	139.77	148.13	153.55	146.88	157.48	180.89	169.83	181.08	200.58	190.50
	Transport	1055.46	1032.95	860.25	1209.58	1097.15	1095.50	1145.69	1122.72	1061.92	1191.28	1068.40	1011.43	1083.90
	Manufacturing industries & construction	968.94	918.64	812.91	844.30	656.48	665.07	704.43	731.96	585.36	438.43	569.91	380.54	448.14
	Commercial/Institutional & Residential	580.39	552.11	518.13	531.57	431.88	426.80	436.84	405.71	205.20	222.95	242.60	213.05	223.07
	Agriculture/Forestry/Fishing	246.23	231.97	205.27	221.16	172.69	174.84	186.19	196.72	144.44	102.36	131.13	108.23	59.81
	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	269.08	512.52	157.36	96.18	1209.38
	Total	9939.83	9190.46	8484.17	9068.39	8839.56	8925.01	8578.29	9198.28	9939.14	9716.38	9226.91	9355.70	9755.53
[%]	**Energy industries**	69.80	68.71	70.15	67.51	71.65	71.81	69.46	71.58	75.38	72.86	74.53	78.52	67.05
	Fugitive emissions	1.52	1.53	1.61	1.54	1.68	1.72	1.71	1.71	1.82	1.75	1.96	2.14	1.95
	Transport	10.62	11.24	10.14	13.34	12.41	12.27	13.36	12.21	10.68	12.26	11.58	10.81	11.11
	Manufacturing industries & construction	9.75	10.00	9.58	9.31	7.43	7.45	8.21	7.96	5.89	4.51	6.18	4.07	4.59
	Commercial/Institutional & Residential	5.84	6.01	6.11	5.86	4.89	4.78	5.09	4.41	2.06	2.29	2.63	2.28	2.29
	Agriculture/Forestry/Fishing	2.48	2.52	2.42	2.44	1.95	1.96	2.17	2.14	1.45	1.05	1.42	1.16	0.61
	Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.71	5.27	1.71	1.03	12.40
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 3.2.2.1.2 - Contribution of individual GHGs to total CO_2-eq emissions in the Energy Sector

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
[kt]	CO_2	9469.01	8737.40	8049.03	8592.55	8377.76	8469.74	8136.00	8796.54	9509.59	9288.60	8791.00	8934.37	9348.40
	CH_4	227.78	215.09	213.85	219.34	220.73	222.18	212.38	203.41	228.36	219.41	237.44	245.46	235.07
	N_2O	47.40	44.35	42.83	44.75	43.31	42.96	40.86	39.45	43.91	42.64	42.48	41.78	38.94
	CO	195.65	193.62	178.46	211.75	197.77	190.13	189.05	158.88	157.29	165.72	155.99	134.08	133.12
	Total	9939.83	9190.46	8484.17	9068.39	8839.56	8925.01	8578.29	9198.28	9939.14	9716.38	9226.91	9355.70	9755.53
[%]	CO_2	95.26	95.07	94.87	94.75	94.78	94.90	94.84	95.63	95.68	95.60	95.28	95.50	95.83
	CH_4	2.29	2.34	2.52	2.42	2.50	2.49	2.48	2.21	2.30	2.26	2.57	2.62	2.41
	N_2O	0.48	0.48	0.50	0.49	0.49	0.48	0.48	0.43	0.44	0.44	0.46	0.45	0.40
	CO	1.97	2.11	2.10	2.33	2.24	2.13	2.20	1.73	1.58	1.71	1.69	1.43	1.36
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

3.2. DATA SOURCES FOR THE ENERGY GHG INVENTORY 2003–2009

3.2.1. ACTIVITY DATA

For the period 2005–2009, all activity data are taken from the energy balances prepared by the National State Statistical Office. The energy balances contain data for all fuels by sectors, in line with EUROSTAT methodology. The energy balances are made in both mass (kt or 1000 m3) and energy units (TJ), with average calorific values taken from the domestic fuel producers or from foreign countries in the case of imported fuels. Also for this period, an official statistical database called MAKSTAT base is available on the State Statistical Office webpage. The output results from this database give further possibilities for data gathering and analyses.

For the period 2003–2004, the State Statistical Office was not preparing energy balances as this was a period of adaptation to the EUROSTAT methodology of reporting. Activity data for these years were gathered from the following sources: from the IEA World Energy Statistics and Balances, the Energy Balances prepared by the Ministry of Economy, and the State Statistical Office publication *Energy Statistics 2000–2010*.

In the TNC inventory, Tier 2 methodology was applied for the calculation of emissions from the dominant emissions and energy sources, i.e. from lignite, natural gas, residual fuel oil, fugitive emissions from coal mining and handling, and the aviation sector. This was achieved by the development of country-specific emission factors for the most important GHG sources and by the establishment of official cooperation between the Ministry of Environment and Physical Planning and the Macedonian Navigation Provider, M-NAV, in order to achieve Tier 2 for aviation sector.

3.2.2. COUNTRY-SPECIFIC EMISSION FACTORS

During the preparation of the SNC, a country-specific emission factor was adopted for domestic lignite as being the main contributor to overall GHG emissions. The Country-Specific Emission Factor was calculated according to the following parameters:

Table 3.2.2.1.1 – Carbon content and heat specification of Macedonian lignite

Lignite	Carbon content $\left(\frac{\text{kg C}}{\text{kg}}\right)$	Heating value $\left(\frac{\text{kJ}}{\text{kg}}\right)$	Reference
Bitola	0.2331	7651	B. Andreevski, *Coals in Macedonia*, Stip, 1995. *Carbon content:* p. 181, table 45 *Heatingvalue:* p. 181, table 44
Oslomej	0.2066	7050	B. Andreevski, *Coals in Macedonia*, Stip, 1995.

			Carbon content: p. 194, table 56 *Heatingvalue:* p. 194, table 55

The carbon emission factors for both lignite types are calculated as a ratio of the carbon content and the heating value as follows:

The equivalent carbon emission factor is calculated as a weighted sum of the individual carbon emission factors. The weighting coefficients are actually the share of the lignite consumption from both mines in the total lignite consumption in the country. These coefficients are 0.896 for Bitola and 0.104 for Oslomej and they have been calculated with the lignite consumption data from the annual reports of the National Electric Power Company (ESM) for the period 1997–2002.

The equivalent carbon emission factor is:

$$EF = 0.896 \times EF_{\mathrm{Bitola}} + 0.104 \times EF_{\mathrm{Oslomej}} = 30.4 \frac{\mathrm{t\,C}}{\mathrm{TJ}}.$$

For the purpose of the TNC, an updated emission factor was adopted for domestic lignite. This was done because of the changeable quality of lignite, which is dependent on the depth of expropriation.

Emission factors and emission inventories have long been fundamental tools for air quality management. Emission estimates are important for developing emission control strategies, determining the applicability of permitting and control programs, ascertaining the effects of sources and appropriate mitigation strategies, and a number of other related applications by an array of users, including federal, state, and local agencies, consultants, and industry.

In the framework of the SNC, a country-specific carbon emission factor for domestic lignite combustion and a methane emission factor for coal mining and handling were adopted in light of the significant influence these emissions have on the accuracy of the country's GHG Inventory.

In order to keep track with the SNC and to achieve more improved and more accurate estimations of emissions for the main GHG sources, in the TNC the country-specific emission factor for lignite was updated and additional country-specific emission factors for natural gas and residual fuel oil were estimated. The development of additional country-specific emission factors enabled improved Tier 2 methodology with higher accuracy in calculating emissions from the Energy sector. The estimated country-specific emission factors can be used for both IPCC and CORINAIR methodology Inventories.

The Emission Factors for the key sources were estimated in accordance with the National Roadmap for the Adaptation of Country-Specific Emission factors developed in the framework of the TNC by an international consultant and with the technical assessment of a national consulting company, Technolab DOOEL Skopje.

3.2.2.1. *CARBON EMISSION FACTORS*

Country-Specific Carbon Emission Factors were calculated for the following energy sources as being the three major sources for the production of energy:

- Lignite
- Natural Gas
- Residual Fuel Oil

Lignite

The Lignite country-specific emission factor is calculated for each year, taking into account variations in the lignite and different activity data from the energy industries which use lignite.

For the calculation of the Lignite Carbon emission factor, the following equation recommended by the 1996 IPCC Guidelines for GHG Inventories and the National Document Roadmap for the adaptation of National Emission Factors was used:

EF C [t/TJ] = (C [%] * Ox)/(NCV [TJ/t]*100)

The CO_2 emission factor is calculated by multiplying the C Emission Factor by 44/12. The main consumers of lignite in Macedonia are the main Energy Industries (power plants) in the country, REK Bitola and REK Oslomej. The data gathered for the calculation of the lignite country-specific emission factor were obtained directly from the power plants.

Table 3.2.2.1.1 – Characteristics of the lignite used by the power plant REK Bitola and calculated C and CO_2 emission factors for the period 2003–2009 [t/TJ]

Lignite Bitola	NCV [TJ/kt]	Cfix (%)	Ox factor	EF C [t/TJ]	EF CO_2 [t/TJ]
2003	7.91	23.33	0.98	**28.91**	106.01
2004	7.43	22.76	0.98	**30.02**	110.06
2005	7.43	24.15	0.98	**31.85**	116.78
2006	8.24	21.60	0.98	**25.68**	94.15
2007	8.08	21.60	0.98	**26.21**	96.12
2008	8.08	21.60	0.98	**26.20**	96.07
2009	7.29	21.14	0.98	**28.42**	104.20

Table 3.2.2.1.2 - Characteristics of the lignite used by the power plant REK Oslomej and calculated C and CO_2 emission factors for the period 2003–2009 [t/TJ]

Lignite Oslomej	NCV [TJ/kt]	Cfix (%)	Ox factor	EF C [t/TJ]	EF CO_2 [TJ/t]
2003	7.67	16.00	0.98	**20.45**	74.99
2004	6.01	16.00	0.98	**26.10**	95.69
2005	6.01	16.00	0.98	**26.10**	95.69
2006	7.25	16.00	0.98	**21.62**	79.28
2007	6.62	16.00	0.98	**23.68**	86.81
2008	7.60	16.00	0.98	**20.63**	75.65
2009	6.67	16.00	0.98	**23.51**	86.20

The annual equivalent carbon emission factor is calculated as a weighted sum of the individual annual carbon emission factors. The weighting coefficients are actually the share of the lignite consumption from both mines in the total lignite consumption of the country.

Table 3.2.2.1.3 – Activity rate of the annual electricity production of REK Bitola and REK Oslomej [GWh]

Electrical energy produced	TPP	2003	2004	2005	2006	2007	2008	2009
GWh	Bitola	4,540.50	4,362.20	4,603.50	4,720.00	4,166.50	4,216.00	4,197.20
	Oslomej	365.90	372.80	404.30	404.60	436.20	661.40	591.40
	Total	4,906.40	4,735.00	5,007.80	5,124.60	4,602.70	4,877.40	4,788.60
%	Bitola	92.54	92.13	91.93	92.10	90.52	86.44	87.65
	Oslomej	7.46	7.87	8.07	7.90	9.48	13.56	12.35
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 3.2.2.1.4 – Calculated annual lignite emission factors [t/TJ]

Lignite	2003	2004	2005	2006	2007	2008	2009
EF C [t/TJ]	26.97	29.71	31.38	25.36	25.97	25.45	27.81
EF CO_2 [t/TJ]	98.90	108.93	115.08	92.97	95.24	93.30	101.98

As we can see from table 3.2.2.1.4., the annual lignite carbon emission factor diverges for approximately 20% in the period 2003–2009. The lignite carbon emission factors for this period are in a range from 25.36–31.38 t/TJ.

Natural Gas

Macedonia imports natural gas of Russian origin. For the calculation of the carbon emission factor of the natural gas used in the country, the carbon content is taken from the Russian Natural Gas specification and the Net Calorific Value is taken from the Adopted Energy Balance for 2013–2017 of Macedonia. The carbon emission factor is calculated with the following equation:

$$EF\ C\ [t/TJ] = (C\ [\%] * Ox)/(NCV\ [TJ/t]*100)$$

Table 3.2.2.1.5 – Content of Russian Natural Gas

Component	Share [%]
CH4	97. 88
C2H6	0.86
C3H8	0.27
i-C4H10	0.05
n-C4H10	0.04
i-C5H12	0.01
n-C5H12	0.01
i-C6H14	0.01

N2	0.69
CO_2	0.18

The estimation of the carbon emission factor is shown in table 3.2.2.1.6. The CO_2 emission factor is calculated by multiplying the C Emission Factor with 44/12.

Table 3.2.2.1.6 - Characteristics of the Natural Gas and calculated C and CO_2 emission factors [t/TJ]

Energy Source	NCV [TJ/kt]	Cfix (%)	Ox factor	EF C [t/TJ]	EF CO_2 [TJ/t]
Natural Gas	33.59	68.78	0.995	**14.95**	54.80

Residual Fuel Oil

Residual fuel oil in Macedonia is produced mainly by the OKTA refinery. Data for the carbon content of fuel are obtained from this refinery. The Net Calorific Value for Residual Fuel Oil is taken from the Adopted Energy Balance of Macedonia for 2013–2017.

The carbon emission factor is calculated by the following equation, which is identical with the equation used for the calculation of the C emission factor for Lignite and for Natural Gas.

$$EF\ C\ [t/TJ] = (C\ [\%] * Ox)/(NCV\ [TJ/t]*100)$$

The estimation of the carbon emission factor is shown in Table 3.2.2.1.7. The CO_2 emission factor is calculated by multiplying the C Emission Factor by 44/12, which is the ratio of the molecular weight of CO_2.

Table 3.2.2.1.7 - Characteristics of Residual Fuel Oil and calculated C and CO_2 emission factors [t/TJ]

Energy Source	NCV [TJ/kt]	Cfix (%)	Ox factor	EF C [t/TJ]	EF CO_2 [TJ/t]
Residual Fuel Oil	40.00	85.60	0.99	**21.19**	77.68

3.2.2.2. SO_2 Emission Factor

Lignite

The estimation of the SO_2 Emission Factor for domestic lignite was made according to data gathered from direct measurements of emissions by the main energy industries which are using lignite, REK Bitola and REK Oslomej.

The resulting SO_2 emission factor for REK Bitola is 1599 g/GJ and for REK Oslomej 1628g/GJ.

The annual equivalent SO_2 emission factor for lignite is calculated as a weighted sum of the individual annual SO_2 emission factors. The weighting coefficients are actually the share of the lignite consumption from both mines in the total lignite consumption in the country.

The calculated Annual SO_2 Lignite Emission Factors are presented in Table 3.2.2.2.1.

Table 3.2.2.2.1 – Annual Lignite SO_2 Emission Factors 2003–2009 [kg/TJ]

Lignite	2003	2004	2005	2006	2007	2008	2009
SO_2 EF	1601.16	1601.28	1601.34	1601.29	1601.75	1602.93	1602.58

Residual Fuel Oil

The calculation of the SO_2 emission factor for Residual Fuel Oil was made with the following equation:

$$EFSO_2\ [g/GJ] = (S\ [\%] * 20000)/(NCV\ [GJ/t])$$

The sulphur share in residual fuel oil is taken from the OKTA Refinery Publication, while the Net Calorific Value is taken from the Adopted Energy Balance of Macedonia for 2013–2017.
The resulting SO_2 Emission Factor is presented in Table 3.2.2.2.2.

Table 3.2.2.2.2 - Characteristics of Residual Fuel Oil and the calculated SO_2 emission factor [kg/TJ]

Energy Source	NCV [TJ/kt]	S fix (%)	EF SO_2 [kg/TJ]
Residual Fuel Oil	40.00	1.00	500

3.2.2.3. NO_2 Emission Factors

Lignite

The estimation of the NO_2 Emission Factor for domestic lignite was made according to data gathered from direct measurements of emissions by the main lignite consumers, REK Bitola and REK Oslomej. The resulting NO_2 emission factors are 265kg/TJ and 318kg/TJrespectively. The annual equivalent NO_2 emission factor for lignite is calculated as a weighted sum of the individual annual NO_2 emission factors, according to the weighting coefficients for the share of lignite consumption from both mines in the total lignite consumption of the country.

The calculated Annual NO_2 Lignite Emission Factors are presented in Table 3.2.2.3.1.

Table 3.2.2.3.1 - Annual Lignite NO_2 Emission Factors 2003–2009 [kg/TJ]

Lignite	2003	2004	2005	2006	2007	2008	2009
NO_2 EF	268.95	269.17	269.28	269.18	270.02	272.19	271.55

3.2.2.4. CH_4 Emissions from Coal Mining and Handling

Lignite

The country-specific Emission Factor for lignite expropriation is estimated according to the Greek Country-Specific Emission Factor for Lignite Mining and Handling. The lignite mines Suvodol and Oslomej are in the vicinity of Greek coal mines which have the same geological structure as the Macedonian mines.

The resulting CH_4 Emission Factor for lignite expropriation is 1.5 m3 CH_4/t.

3.3. GHG ENERGY INVENTORY 2003–2009

The inventory comprises the emissions resulting from fuel combustion as well as fugitive emissions from extraction, transmission and distribution of solid, liquid and gaseous fuels. These emissions are calculated by two methods:

- **Reference approach (top-down)**. This uses apparent fuel consumption figures to account for the fuel flows into and out of the country

- **Sectorial approach (bottom up)**. This accounts for fuel consumption by different sectors.

Applying both the Sectorial and the Reference approaches in the Energy Sector is a very good validation exercise and is used to establish the reliability of the intended applications of the Inventory.

The Reference Approach and the Sectorial Approach often have different results because the Reference Approach is a top-down approach using a country's energy supply data and has no detailed information on how individual fuels are used in each sector. Typically, the gap between the two approaches is relatively small (5 per cent or less) when compared to the total carbon flows involved.

The difference between the Sectorial and Reference Approach in the TNC is shown in the following Table and is in the satisfactory range even for an Annex I reporting country.

Table 3.2.2.4.1- Difference between the Sectorial and Reference Approach results for 2003–2009 in the Energy sector [%]

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Difference between Sectorial and Reference Approach [%]	0.89	2.81	-0.47	1.14	-0.68	0.78	0.69

The assessment of the differences between the Sectorial and the Reference Approach shows that the Energy Inventory estimation methods and data are consistent, accurate and in accordance with the IPCC methodology and Good Practice Guidance for the preparation of GHG Inventories.

The reporting of GHG emissions is done using the Sectorial Approach, and the Reference approach is used for verification of the reported emissions, taking into account the carbon flow in the country.

3.3.1. Reference Approach

The Reference Approach is a top-down approach using a country's energy supply data to calculate the emissions of CO_2 from the combustion of fossil fuels. The Reference Approach is a straightforward method that can be applied on the basis of energy supply statistics that are relatively easily available.

Table 3.2.2.4.1 - CO_2 emissions from the Energy Sector, Reference Approach, 2003–2009 [kt CO_2]

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Energy sector CO_2 emissions	8805.01	8651.63	9106.06	8322.89	8670.12	8861.81	8474.88
Biomass CO_2 emissions	769.20	768.55	694.67	745.02	638.07	772.88	867.36

* Biomass CO_2 emissions are reported separately as Memo Items and they are not included in the total emissions from the Energy sector.

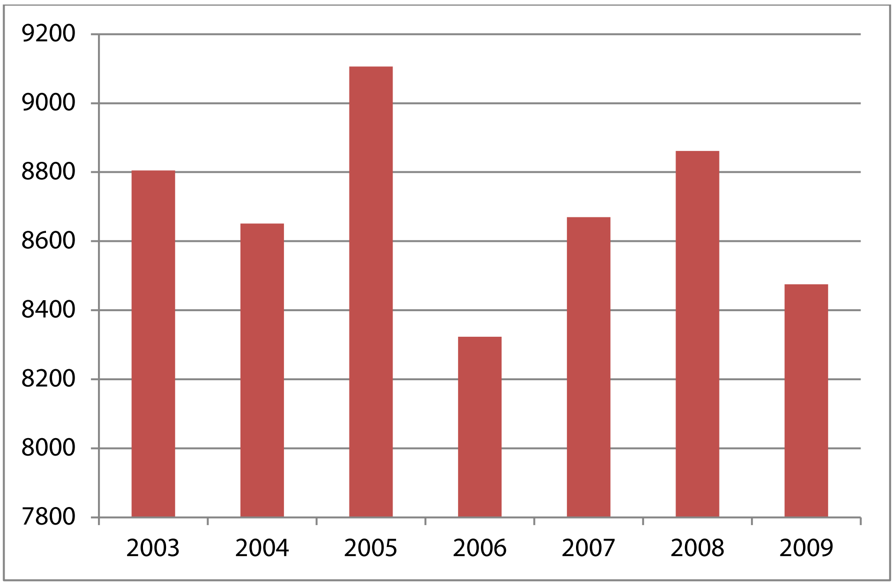


Figure 3.2.2.4.1- CO_2 emissions from the Energy Sector, Reference Approach, 2003–2009 [kt CO_2]

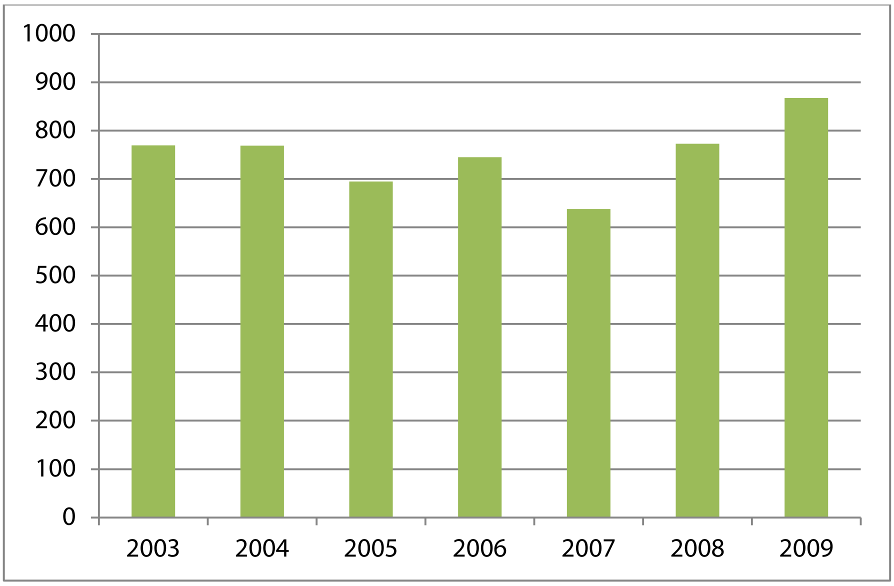


Figure 3.2.2.4.2 - CO_2 emissions from the Biomass reported as Memo Items, Reference Approach, 2003–2009 [kt CO_2]

Tables 3.2.2.4.2–3.2.2.4.3 show the annual Energy sector Fuel Consumption and the CO_2 emissions for each year respectively (2003–2009), using the Reference Approach for estimating emissions from the Energy sector.

Table 3.2.2.4.4- Fuel Consumption and CO_2 emissions from the Energy Sector (Reference Approach, 2003)

No.	Fuels	Production [kt]	Imports [kt]	Exports [kt]	International Bunkers [kt]	Stock Change [kt]	Apparent Consumption [kt]	Conversion Factor [TJ/Unit]	Carbon Emission Factor [t C/TJ]	Actual CO_2 Emissions [kt CO_2]
1	**Crude Oil**	NO	807.74	NO	NO	-15.97	823.71	42.79	20.00	**2558.95**
2	**Gasoline**	NO	0.00	160.24	NO	0.00	-160.24	43.95	18.90	**-483.16**
3	**Jet Kerosene**	NO	12.50	NO	12.24	0.00	0.26	43.95	19.50	**0.81**
4	**Gas / Diesel Oil**	NO	390.09	NO	NO	0.00	390.09	43.95	20.20	**1257.11**
5	**Residual Fuel Oil**	NO	0.00	194.31	NO	0.00	-194.31	43.95	21.19	**-656.87**
6	**LPG**	NO	0.00	19.89	NO	0.00	-19.89	43.95	17.20	**-54.59**
7	**Coking Coal**	NO	37.30	8.39	NO	-0.16	29.08	27.99	25.80	**75.45**
8	**Lignite**	7382.00	205.00	NO	NO	154.00	7433.00	7.89	28.28	**5959.61**
9	**Natural Gas (Dry)**	NO	80867.00	NO	NO	22.00	80845.00	0.03	14.95	**147.69**
	Total									**8805.01**
10	**Solid Biomass***	720.25	1.01	0.14	NA	43.35	677.77	10.56	29.90	**769.20**

* In accordance with the IPCC Methodology, emissions from Solid Biomass are reported as Memo Items and they are not included in the Energy total emissions.

NO – Not Occurring

NA – Not Applicable

Table 3.2.2.4.5 - Fuel Consumption and CO_2 emissions from the Energy Sector (Reference Approach, 2004)

No.	Fuels	Production [kt]	Imports [kt]	Exports [kt]	International Bunkers [kt]	Stock Change [kt]	Apparent Consumption [kt]	Conversion Factor [TJ/Unit]	Carbon Emission Factor [t C/TJ]	Actual CO_2 Emissions [kt CO_2]
1	**Crude Oil**	NO	825.68	0.00	NO	-3.42	829.10	42.79	20.00	**2575.70**
2	**Gasoline**	NO	0.00	123.23	NO	0.00	-123.23	44.06	18.90	**-372.51**
3	**Jet Kerosene**	NO	12.07	0.00	11.89	0.00	0.18	44.06	19.50	**0.56**
4	**Gas / Diesel Oil**	NO	336.17	0.00	NO	0.00	336.17	44.06	20.20	**1086.08**
5	**Residual Fuel Oil**	NO	0.00	216.10	NO	0.00	-216.10	44.06	21.19	**-732.39**
6	**LPG**	NO	30.33	0.00	NO	0.00	30.33	44.06	17.20	**83.44**
7	**Coking Coal**	NO	18.08	11.98	NO	0.58	5.52	27.99	25.80	**14.33**
8	**Lignite**	7245.00	191.00	2.00	NO	-74.00	7508.00	7.32	29.71	**5866.46**
9	**Natural Gas (Dry)**	NO	71273.00	0.00	NO	128.00	71145.00	0.03	14.95	**129.96**
	Total									**8651.63**
10	**Solid Biomass***	654.41	0.05	2.14	NA	-24.87	677.20	10.56	29.90	**768.55**

* In accordance with the IPCC Methodology, emissions from Solid Biomass are reported as Memo Items and they are not included in the Energy total emissions.

NO – Not Occurring

NA – Not Applicable

Table 3.2.2.4.6- Fuel Consumption and CO_2 emissions from the Energy Sector (Reference Approach, 2005)

No.	Fuels	Production [kt]	Imports [kt]	Exports [kt]	International Bunkers [kt]	Stock Change [kt]	Apparent Consumption [kt]	Conversion Factor [TJ/Unit]	Carbon Emission Factor [t C/TJ]	Actual CO_2 Emissions [kt CO_2]
1	**Crude Oil**	NO	960.57	NO	NO	13.82	946.75	42.79	20.00	**2941.18**
2	**Gasoline**	NO	19.78	84.78	NO	0.78	-65.79	43.64	18.90	**-196.98**
3	**Jet Kerosene**	NO	5.57	21.13	6.18	0.70	-22.44	43.28	19.50	**-68.74**
4	**Gas / Diesel Oil**	NO	89.86	139.93	NO	1.63	-51.70	42.07	20.20	**-159.47**
5	**Residual Fuel Oil**	NO	13.84	54.66	NO	-1.43	-39.39	41.41	21.19	**-125.44**
6	**LPG**	NO	25.78	4.18	NO	0.76	20.85	47.46	17.20	**61.78**
7	**Other Oil**	NO	149.72	23.01	NO	5.66	121.05	33.66	20.00	**295.84**
8	**Coking Coal**	NO	16.82	0.39	NO	-0.03	16.45	27.99	25.80	**42.68**
9	**Other Bituminous Coal**	NO	2.80	NO	NO	NO	2.80	24.24	25.80	**6.30**
10	**Lignite**	6880.51	287.70	0.90	NO	-304.46	7471.77	7.32	31.38	**6163.87**
11	**Natural Gas (Dry)**	NO	77214.45	NO	NO	-371.63	77586.09	0.03	15.30	**145.05**
	Total									**9106.06**
12	**Solid Biomass***	600.30	0.02	3.22	NA	-15.00	612.10	10.56	29.90	**694.67**

* In accordance with the IPCC Methodology, emissions from Solid Biomass are reported as Memo Items and they are not included in the Energy total emissions.

NO – Not Occurring

NA – Not Applicable

Table 3.2.2.4.7 - Fuel Consumption and CO_2 emissions from the Energy Sector (Reference Approach, 2006)

No.	Fuels	Production [kt]	Imports [kt]	Exports [kt]	International Bunkers [kt]	Stock Change [kt]	Apparent Consumption [kt]	Conversion Factor [TJ/Unit]	Carbon Emission Factor [t C/TJ]	Actual CO_2 Emissions [kt CO_2]
1	**Crude Oil**	NO	1056.81	0.00	NO	-10.29	1067.10	42.89	20.00	**3322.71**
2	**Gasoline**	NO	10.78	90.43	NO	3.00	-82.64	43.72	18.90	**-247.91**
3	**Jet Kerosene**	NO	0.11	27.56	4.51	0.64	-32.61	43.29	19.50	**-99.92**
4	**Gas / Diesel Oil**	NO	82.08	172.15	NO	10.26	-100.33	42.45	20.20	**-312.29**
5	**Residual Fuel Oil**	NO	0.00	38.92	NO	-11.12	-27.80	41.33	21.19	**-88.40**
6	**LPG**	NO	27.85	6.19	NO	-1.10	22.76	47.46	17.20	**67.45**
7	**Other Oil**	NO	149.28	20.20	NO	12.76	116.32	33.23	20.00	**280.58**
8	**Coking Coal**	NO	14.61	0.47	NO	0.54	13.60	26.34	25.80	**33.21**
9	**Other Bituminous Coal**	NO	56.95	0.00	NO	0.00	56.95	25.98	25.80	**137.18**
10	**Lignite**	6638.89	231.73	0.17	NO	45.61	6824.84	8.17	25.36	**5078.47**
11	**Natural Gas (Dry)**	NO	83451.56	0.00	NO	361.78	83089.78	0.03	14.95	**151.79**
	Total									**8322.89**
12	**Solid Biomass**	661.24	0.00	3.09	NA	10.84	647.31	10.71	29.90	**745.02**

* In accordance with the IPCC Methodology, emissions from Solid Biomass are reported as Memo Items and they are not included in the Energy total emissions.

NO – Not Occurring

NA – Not Applicable

Table 3.2.2.4.8 - Fuel Consumption and CO_2 emissions from the Energy Sector (Reference Approach, 2007)

No.	Fuels	Production [kt]	Imports [kt]	Exports [kt]	International Bunkers [kt]	Stock Change [kt]	Apparent Consumption [kt]	Conversion Factor [TJ/Unit]	Carbon Emission Factor [t C/TJ]	Actual CO_2 Emissions [kt CO_2]
1	**Crude Oil**	NO	1060.35	0.00	NO	10.34	1050.01	42.79	20.00	**3262.13**
2	**Gasoline**	NO	4.42	66.08	NO	2.99	-64.65	43.84	18.90	**-194.44**
3	**Jet Kerosene**	NO	0.01	11.91	6.65	-1.41	-17.14	43.40	19.50	**-52.65**
4	**Gas / Diesel Oil**	NO	33.77	111.48	NO	-17.76	-59.94	42.61	20.20	**-187.31**
5	**Residual Fuel Oil**	NO	0.02	52.10	NO	-17.64	-34.44	41.31	21.19	**-109.45**
6	**LPG**	NO	42.25	2.25	NO	1.39	38.61	47.35	17.20	**114.15**
7	**Other Oil**	NO	125.84	17.54	NO	-16.64	124.94	33.07	20.00	**299.97**
8	**Coking Coal**	NO	58.95	0.05	NO	0.50	58.40	26.02	25.80	**140.86**
9	**Other Bituminous Coal**	NO	17.60	0.00	NO	0.00	17.60	24.99	25.80	**40.78**
10	**Lignite**	6509.54	250.62	2.09	NO	-211.46	6969.54	7.94	25.97	**5162.40**
11	**Natural Gas (Dry)**	NO	106126.13	0.00	NO	108.37	106017.76	0.03	14.95	**193.68**
	Total									**8670.12**
12	**Solid Biomass**	583.17	0.00	4.30	NA	32.47	546.40	10.76	29.90	**638.07**

* In accordance with the IPCC Methodology, emissions from Solid Biomass are reported as Memo Items and they are not included in the Energy total emissions.

NO – Not Occurring

NA – Not Applicable

Table 3.2.2.4.9 - Fuel Consumption and CO_2 emissions from the Energy Sector (Reference Approach, 2008)

No.	Fuels	Production [kt]	Imports [kt]	Exports [kt]	International Bunkers [kt]	Stock Change [kt]	Apparent Consumption [kt]	Conversion Factor [TJ/Unit]	Carbon Emission Factor [t C/TJ]	Actual CO_2 Emissions [kt CO_2]
1	**Crude Oil**	NO	1055.85	NO	NO	-5.89	1061.74	42.89	20.00	**3306.02**
2	**Gasoline**	NO	2.28	75.03	NO	-14.09	-58.66	43.74	18.90	**-176.06**
3	**Jet Kerosene**	NO	0.18	12.91	5.98	0.50	-19.21	43.39	19.50	**-59.00**
4	**Gas / Diesel Oil**	NO	44.83	148.18	NO	-0.20	-103.16	42.83	20.20	**-323.99**
5	**Residual Fuel Oil**	NO	0.56	110.61	NO	-4.57	-105.48	41.20	21.19	**-334.26**
6	**LPG**	NO	43.07	6.52	NO	-1.12	37.66	47.39	17.20	**111.43**
7	**Other Oil**	NO	153.08	26.94	NO	1.41	124.74	33.37	20.00	**302.17**
8	**Coking Coal**	NO	45.45	0.15	NO	-1.91	47.21	26.11	25.80	**114.29**
9	**Other Bituminous Coal**	NO	14.66	0.00	NO	0.00	14.66	24.14	25.80	**32.79**
10	**Lignite**	7630.42	260.32	2.38	NO	154.25	7734.11	8.01	25.45	**5668.20**
11	**Natural Gas (Dry)**	NO	120512.17	NO	NO	-31.89	120544.05	0.03	14.95	**220.21**
	Total									**8861.81**
12	**Solid Biomass***	645.56	0.00	2.36	NA	-31.46	674.66	10.66	29.90	**772.88**

* In accordance with the IPCC Methodology, emissions from Solid Biomass are reported as Memo Items and they are not included in the Energy total emissions.

NO – Not Occurring

NA – Not Applicable

Table 3.2.2.4.10 – Fuel Consumption and CO_2 emissions from the Energy Sector (Reference Approach, 2009)

No.	Fuels	Production [kt]	Imports [kt]	Exports [kt]	International Bunkers [kt]	Stock Change [kt]	Apparent Consumption [kt]	Conversion Factor [TJ/Unit]	Carbon Emission Factor [t C/TJ]	Actual CO_2 Emissions [kt CO_2]
1	**Crude Oil**	NO	998.49	0.00	NO	25.96	972.53	42.89	20.00	**3028.41**
2	**Gasoline**	NO	29.52	67.34	NO	15.10	-52.92	43.59	18.90	**-158.26**
3	**Jet Kerosene**	NO	0.01	16.02	2.71	1.16	-19.88	43.39	19.50	**-61.06**
4	**Gas / Diesel Oil**	NO	185.27	163.47	NO	5.81	15.98	45.31	20.20	**53.10**
5	**Residual Fuel Oil**	NO	19.24	80.53	NO	21.53	-82.82	42.06	21.19	**-267.98**
6	**LPG**	NO	43.17	5.97	NO	0.58	36.63	47.40	17.20	**108.42**
7	**Other Oil**	NO	95.91	21.80	NO	-11.41	85.52	34.81	20.00	**216.13**
8	**Coking Coal**	NO	1.88	0.04	NO	-0.45	2.29	26.93	25.80	**5.73**
9	**Other Bituminous Coal**	NO	5.34	0.00	NO	0.00	5.34	25.71	25.80	**12.73**
10	**Lignite**	7426.05	94.31	18.09	NO	22.40	7479.87	7.21	27.81	**5391.78**
11	**Natural Gas (Dry)**	NO	79762.94	0.00	NO	-105.41	79868.35	0.03	14.95	**145.89**
	Total									**8474.88**
12	**Solid Biomass***	768.83	32.46	0.21	NA	38.40	762.69	10.58	29.90	**867.36**

* In accordance with the IPCC Methodology, emissions from Solid Biomass are reported as Memo Items and they are not included in the Energy total emissions.

NO – Not Occurring

NA – Not Applicable

3.3.2. The Sectorial Approach – An Overview of Fuel Consumption and GHG emissions

With the sectorial approach, emissions are segregated into the following categories:

1. Energy Industries
2. Manufacturing industries and construction
3. Transport
4. Commercial / Institutional sector
5. Residential sector
6. Agriculture / Forestry / Fishing
7. Other sectors
8. Emissions from fugitive emissions from coal mining and handling

* Memo Items

- Emissions from international bunkers – international aviation, which are excluded from the energy total and reported separately as international emissions.
- CO_2 emissions from biomass. Biomass fuels are included in the national energy and CO_2 emissions accounts for information purposes only. Within the energy module, biomass consumption is assumed to equal its regrowth.

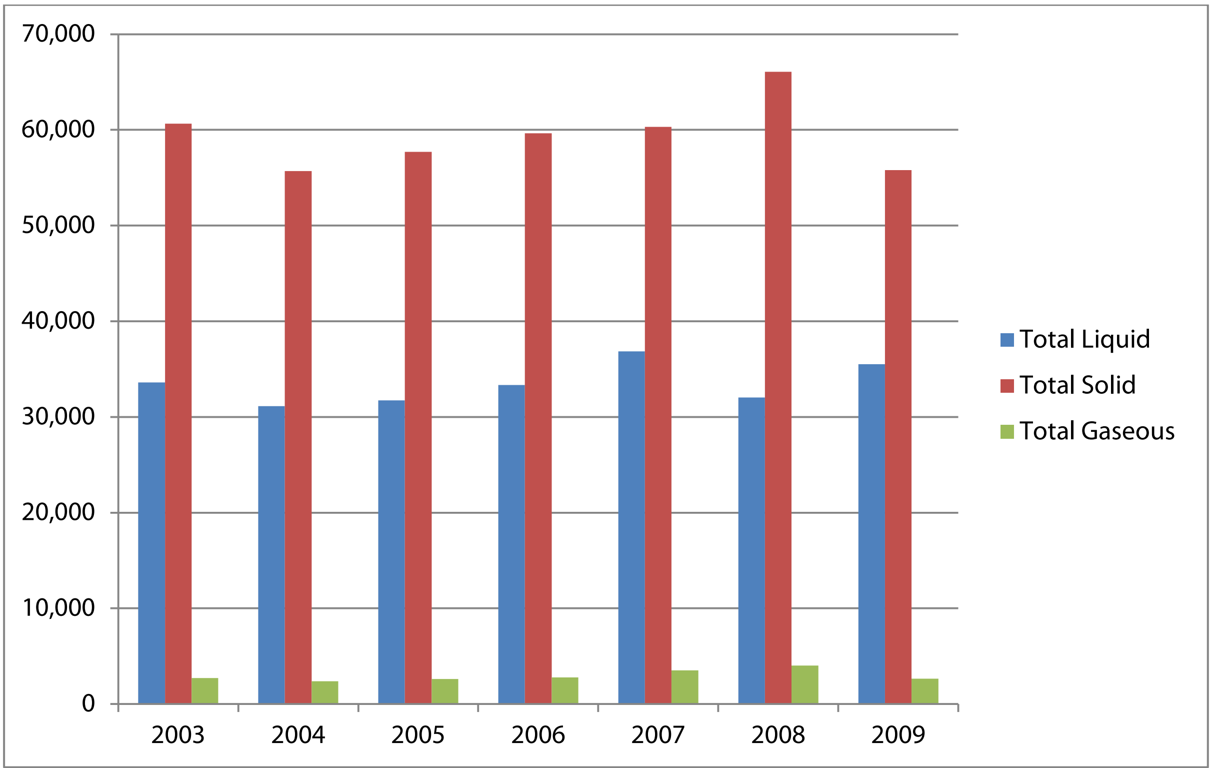


Figure 3.2.2.4.1- Consumption of Liquid, Solid and Gaseous Fuel, 2003–2009 [TJ]

Table 3.2.2.4.1 - Fuel Consumption Energy Sector, 2003–2009, [TJ]

Fuel consumption [TJ]	Gasoline	Jet Kerosene	Gas / Diesel Oil	Residual Fuel Oil	LPG	Coking Coal	Other Bituminous coal	Lignite	Natural Gas	Additional Fuels
2003	7,042.44	11.60	17,144.16	8,539.66	874.33	813.88	NE	59,831.28	2,707.81	NE
2004	5,429.58	7.93	14,811.60	9,560.69	1,336.35	154.53	NE	55,530.28	2,382.65	NE
2005	5,134.11	12.10	14,683.02	9,818.00	2,099.76	460.38	67.95	57,161.47	2,598.62	2,658.74
2006	4,714.71	8.01	14,718.19	11,492.68	2,415.28	358.26	1,479.74	57,822.95	2,772.83	2,725.94
2007	5,002.81	10.24	15,627.27	13,215.42	2,985.36	1,519.39	439.91	58,349.53	3,530.14	2,993.31
2008	5,181.04	7.20	14,989.91	8,738.02	3,125.03	1,232.80	353.70	64,489.25	4,006.06	2,864.57
2009	5,450.04	3.52	16,988.42	10,053.93	3,026.45	61.76	137.29	55,613.18	2,649.50	1,547.94

Table 3.2.2.4.2 – Share of fuel consumption by Energy Sector, 2003–2009

Fuel consumption [%]	Gasoline	Jet Kerosene	Gas / Diesel Oil	Residual Fuel Oil	LPG	Coking Coal	Other Bituminous coal	Lignite	Natural Gas	Additional Fuels
2003	7.26	0.01	17.68	8.81	0.90	0.84	NE	61.70	2.79	NE
2004	6.09	0.01	16.60	10.72	1.50	0.17	NE	62.24	2.67	NE
2005	5.42	0.01	15.51	10.37	2.22	0.49	0.07	60.36	2.74	2.81
2006	4.79	0.01	14.94	11.67	2.45	0.36	1.50	58.70	2.81	2.77
2007	4.83	0.01	15.07	12.75	2.88	1.47	0.42	56.28	3.41	2.89
2008	4.93	0.01	14.28	8.32	2.98	1.17	0.34	61.43	3.82	2.73
2009	5.70	0.00	17.78	10.52	3.17	0.06	0.14	58.21	2.77	1.62

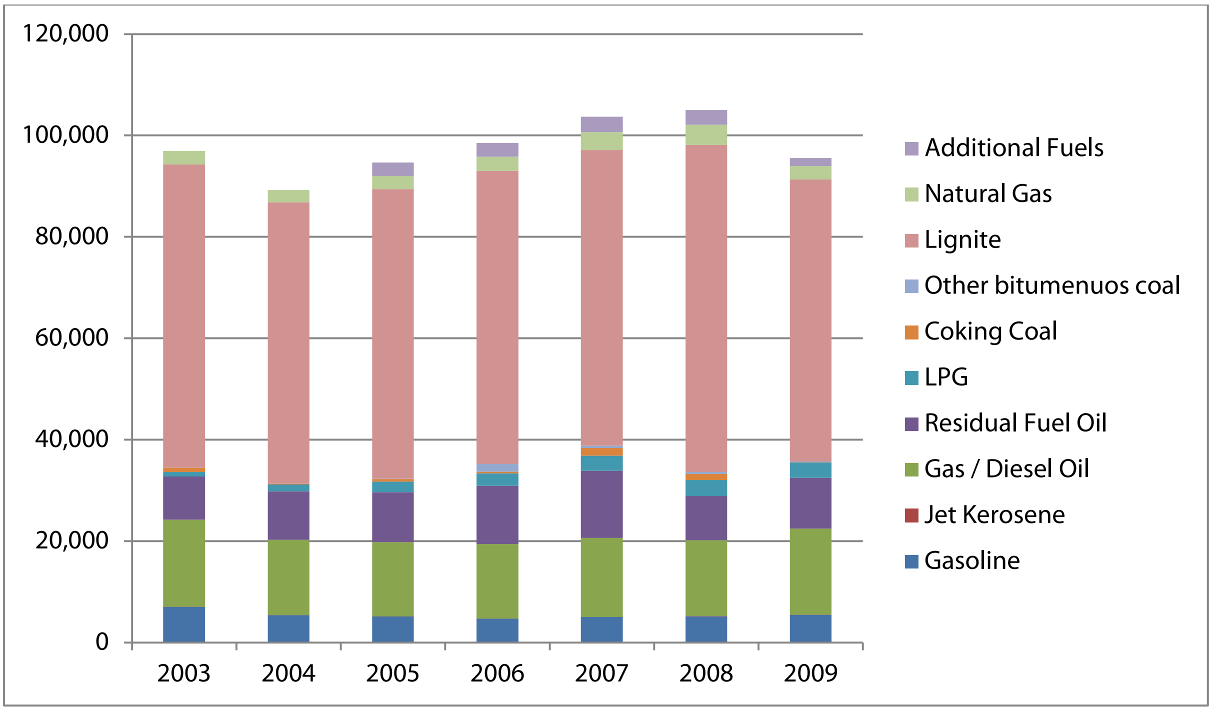


Figure 3.2.2.4.2 Fuel Consumption in the Energy Sector, 2003–2009 [TJ]

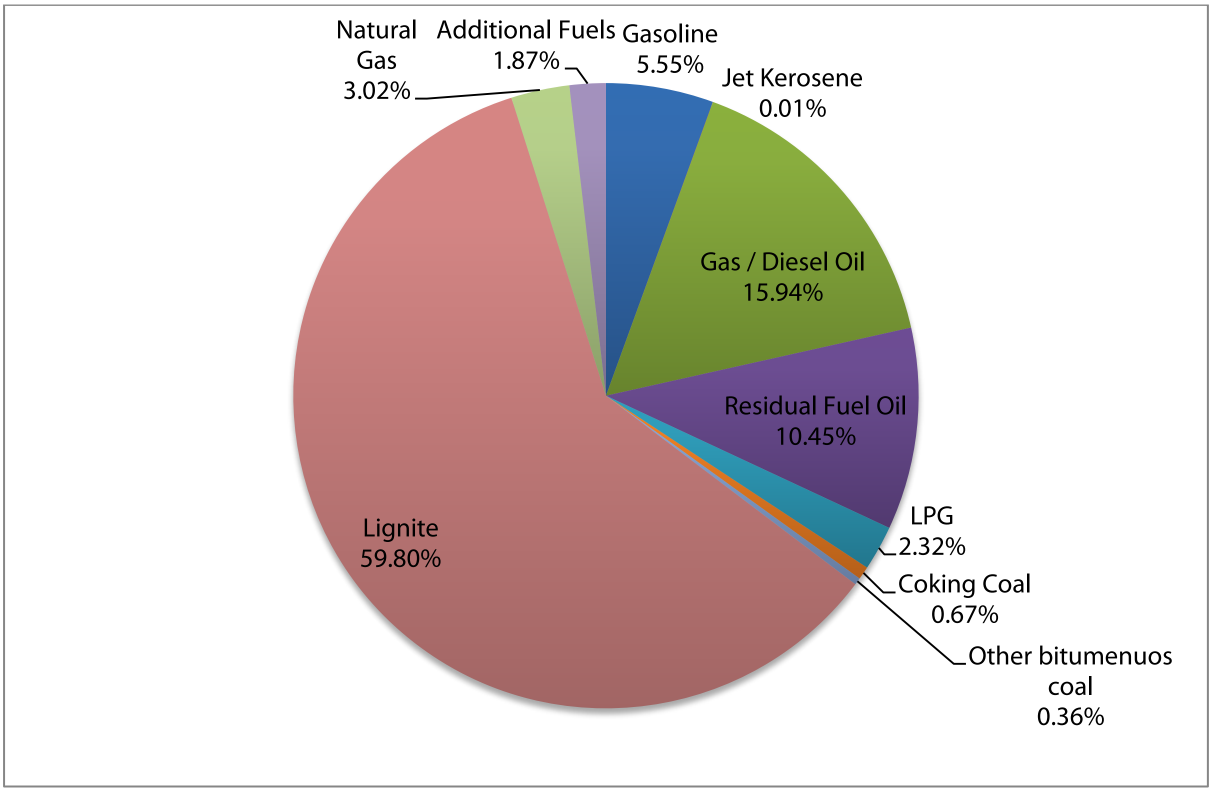


Figure 3.2.2.4.3 Average proportion of fuel consumption, by fuel type, 2003–2009, TJ

Table 3.2.2.4.3 CO_2 emissions by fuel type, 2003–2009, [kt]

CO_2 emissions [kt]	Gasoline	Jet	Gas / Diesel	Residual	LPG	Coking Coal	Other bituminous coal	Lignite	Natural Gas	Additional Fuels
2003	483.16	0.82	1,257.11	656.87	54.59	76.22	NE	6,080.02	147.69	NE
2004	372.51	0.56	1,086.08	735.41	83.44	14.47	NE	5,986.06	129.96	NE
2005	352.24	0.86	1,076.65	755.20	131.10	42.68	6.30	6,445.46	145.05	193.02
2006	323.46	0.57	1,080.74	884.01	150.80	33.21	137.18	5,269.23	151.24	197.90
2007	343.23	0.72	1,145.89	1,016.53	186.39	140.86	40.78	5,445.11	192.54	217.31
2008	355.46	0.51	1,099.15	672.13	195.11	114.29	32.79	5,897.56	218.50	207.97
2009	373.91	0.25	1,247.35	773.35	188.96	5.73	12.73	5,557.46	144.51	112.38

Table 3.2.2.4.4 – Share of CO_2 emissions by fuel type, 2003–2009

CO_2 emissions [%]	Gasoline	Jet	Gas / Diesel	Residual	LPG	Coking Coal	Other bituminous coal	Lignite	Natural Gas	Additional Fuels
2003	5.52	0.01	14.36	7.50	0.62	0.87	NE	69.43	1.69	NE
2004	4.43	0.01	12.92	8.75	0.99	0.17	NE	71.19	1.55	NE
2005	3.85	0.01	11.77	8.25	1.43	0.47	0.07	70.45	1.59	2.11
2006	3.93	0.01	13.13	10.74	1.83	0.40	1.67	64.04	1.84	2.41
2007	3.93	0.01	13.13	11.64	2.14	1.61	0.47	62.38	2.21	2.49
2008	4.04	0.01	12.50	7.64	2.22	1.30	0.37	67.07	2.48	2.37
2009	4.44	0.00	14.82	9.19	2.25	0.07	0.15	66.03	1.72	1.34

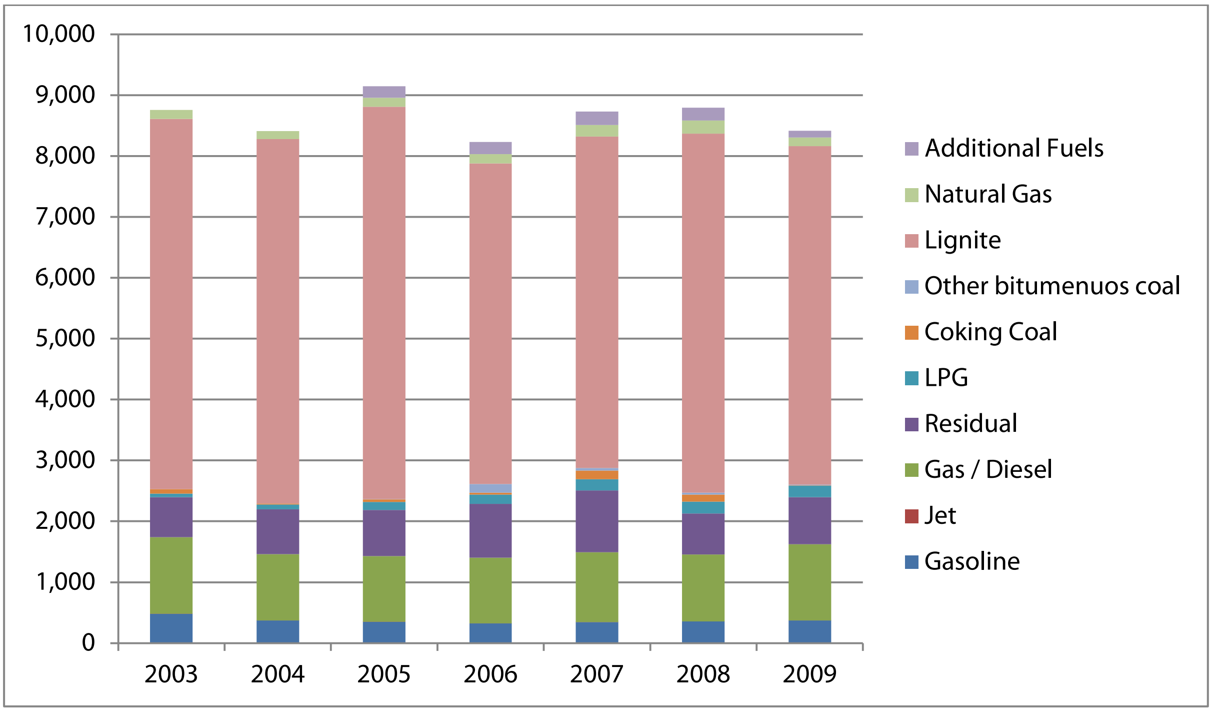


Figure 3.2.2.4.4 CO_2 emissions by fuel type from the Energy Sector, 2003–2009 [kt]

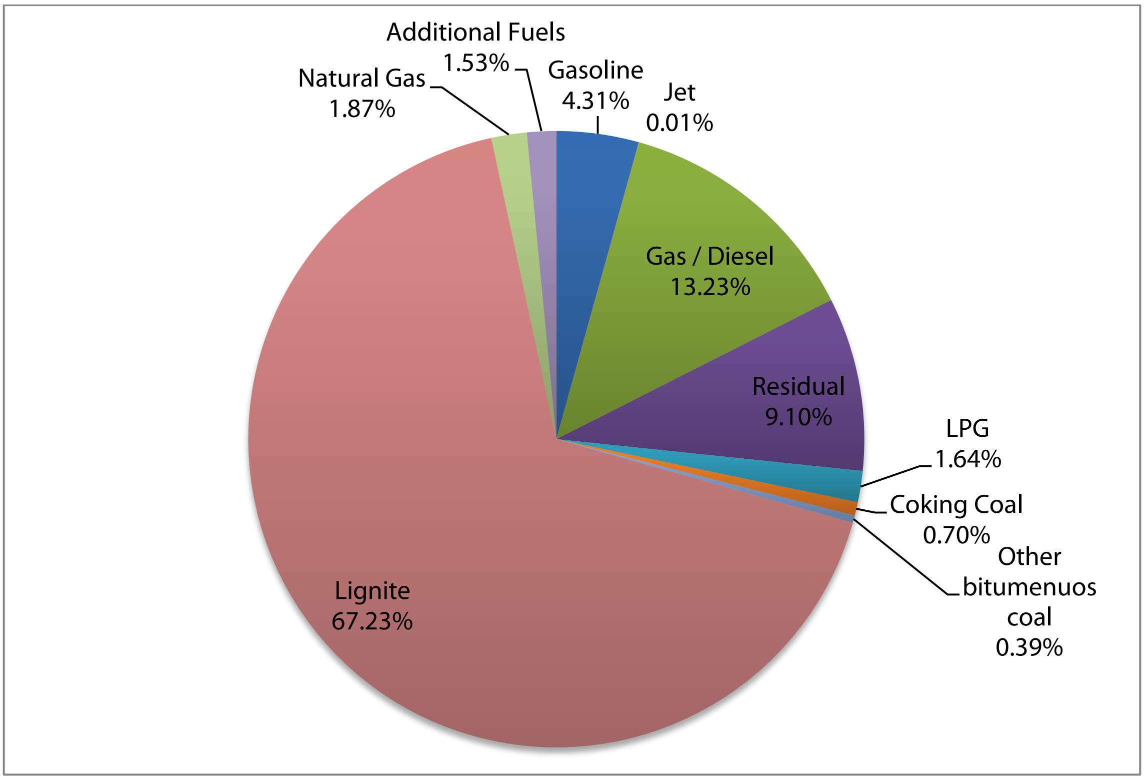


Figure 3.2.2.4.5 Average share of CO_2 emissions by fuel type from the Energy Sector, 2003–2009

Table 3.2.2.4.5 Energy sector GHG emissions by subsectors 2003–2009 [kt]

Energy	[kt]						
	2003	2004	2005	2006	2007	2008	2009
Energy Industries							
CO_2	6259.54	6195.75	6390.83	5561.40	5726.88	6010.81	5895.50
CH_4	0.09	0.08	0.08	0.08	0.09	0.08	0.08
N_2O	0.08	0.08	0.08	0.08	0.08	0.09	0.08
NOx	16.66	15.56	15.40	16.23	16.38	17.73	15.95
CO	1.72	1.54	1.47	1.45	1.41	1.52	1.33
NMVOC	0.34	0.32	0.31	0.33	0.33	0.35	0.31
SO_2	154.17	154.68	152.76	142.33	144.29	159.49	157.62
Manufacturing Industry and Construction							
CO_2	620.81	539.75	1117.25	1113.64	1345.95	1184.55	793.26
CH_4	0.04	0.04	0.08	0.08	0.09	0.08	0.04
N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NOx	1.76	1.48	2.52	2.75	3.37	2.94	1.91
CO	0.75	0.79	1.95	1.66	1.65	1.28	0.68
NMVOC	0.08	0.07	0.14	0.15	0.18	0.15	0.09
SO_2	5.15	0.00	10.58	8.79	5.57	10.02	6.15
Transport							
CO_2	1160.91	1005.51	1011.59	1011.27	1156.72	1191.49	1285.27
CH_4	0.20	0.19	0.21	0.21	0.25	0.26	0.27
N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NOx	11.68	10.14	10.21	10.27	11.77	12.12	13.11
CO	62.25	51.68	49.36	46.21	50.07	51.74	54.94
NMVOC	11.75	9.73	9.27	8.66	9.36	9.67	10.29
SO_2	4.58	3.96	4.09	4.19	4.86	4.97	5.46
Commercial / Institutional / Residential / Agriculture / Forestry / Fishing							
CO_2	240.62	246.95	228.31	219.27	198.12	184.25	174.93
CH_4	4.03	4.01	3.65	3.92	3.31	4.03	4.45
N_2O	0.05	0.05	0.05	0.05	0.04	0.05	0.06
NOx	2.62	2.72	2.62	2.48	1.94	2.19	2.12
CO	67.55	67.72	60.75	64.84	54.72	67.01	73.99
NMVOC	8.16	8.19	7.37	7.84	6.61	8.09	8.91
SO_2	4.05	4.82	3.80	3.85	3.39	3.70	3.86
Other sectors							
CO_2	444.67	420.38	400.50	322.61	301.47	221.47	267.25
CH_4	0.38	0.41	0.26	0.36	0.33	0.31	0.44
N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NOx	0.65	0.61	0.57	0.50	0.47	0.39	0.49
CO	4.15	4.43	2.75	4.27	4.03	4.52	6.52

NMVOC	0.49	0.52	0.33	0.51	0.48	0.55	0.79
SO_2	3.41	3.83	2.86	2.40	2.34	1.59	1.93
Fugitive emissions from fuels							
CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	8.71	8.43	8.16	8.02	8.24	9.58	8.75
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NOx	0.05	0.05	0.06	0.06	0.06	0.06	0.06
CO	0.07	0.07	0.09	0.10	0.10	0.10	0.09
NMVOC	0.50	0.51	0.60	0.66	0.66	0.65	0.62
SO_2	0.75	0.77	0.89	0.98	0.99	0.98	0.93

Table 3.2.2.4.6 Contribution of individual subsectors to overall GHG emissions from direct gasses in CO_2 eq. [kt]

Energy	**CO_2 eq. [kt]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Energy Industries							
CO_2	6259.54	6195.75	6390.83	5561.40	5726.88	6010.81	5895.50
CH_4	1.84	1.72	1.68	1.78	1.82	1.75	1.66
N_2O	26.32	24.53	24.15	25.13	24.89	27.26	24.48
Manufacturing Industry and Construction							
CO_2	620.81	539.75	1117.25	1113.64	1345.95	1184.55	793.26
CH_4	9.09	7.36	15.75	15.89	19.23	16.45	9.17
N_2O	2.02	1.67	3.39	3.50	4.25	3.63	2.14
Transport							
CO_2	1160.91	1005.51	1011.59	1011.27	1156.72	1191.49	1285.27
CH_4	4.30	3.96	4.31	4.41	5.21	5.43	5.59
N_2O	2.96	2.52	2.48	2.44	2.74	2.81	3.06
Commertial / Institutional / Residential / Agriculture / Forestry / Fishing							
CO_2	240.62	246.95	228.31	219.27	198.12	184.25	174.93
CH_4	84.69	84.14	76.62	82.22	69.54	84.63	93.47
N_2O	16.98	16.99	15.29	16.33	13.87	16.91	18.67
Other sectors							
CO_2	444.67	420.38	400.50	322.61	301.47	221.47	267.25
CH_4	7.99	8.52	5.54	7.47	6.99	6.52	9.15
N_2O	1.98	1.96	1.56	1.75	1.65	1.65	2.26
Fugitive emissions from fuels							
CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	182.90	176.94	171.33	168.38	172.94	201.24	183.71
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**9067.63**	**8738.63**	**9470.59**	**8557.48**	**9052.30**	**9160.86**	**8769.57**

Table 3.2.2.4.7 Shares of the subsectors in direct GHG emissions from the Energy Sector [%]

Energy	**[%]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Energy Industries							
CO_2	69.03	70.90	67.48	64.99	63.26	65.61	67.23
CH_4	0.02	0.02	0.02	0.02	0.02	0.02	0.02
N_2O	0.29	0.28	0.26	0.29	0.27	0.30	0.28
Total	**69.34**	**71.20**	**67.75**	**65.30**	**63.56**	**65.93**	**67.52**
Manufacturing Industry and Construction							
CO_2	6.85	6.18	11.80	13.01	14.87	12.93	9.05
CH_4	0.10	0.08	0.17	0.19	0.21	0.18	0.10
N_2O	0.02	0.02	0.04	0.04	0.05	0.04	0.02
Total	**6.97**	**6.28**	**12.00**	**13.24**	**15.13**	**13.15**	**9.17**
Transport							
CO_2	12.80	11.51	10.68	11.82	12.78	13.01	14.66
CH_4	0.05	0.05	0.05	0.05	0.06	0.06	0.06
N_2O	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Total	**12.88**	**11.58**	**10.75**	**11.90**	**12.87**	**13.10**	**14.75**
Commertial / Institutional / Residential / Agriculture / Forestry / Fishing							
CO_2	2.65	2.83	2.41	2.56	2.19	2.01	1.99
CH_4	0.93	0.96	0.81	0.96	0.77	0.92	1.07
N_2O	0.19	0.19	0.16	0.19	0.15	0.18	0.21
Total	**3.77**	**3.98**	**3.38**	**3.71**	**3.11**	**3.12**	**3.27**
Other sectors							
CO_2	4.90	4.81	4.23	3.77	3.33	2.42	3.05
CH_4	0.09	0.10	0.06	0.09	0.08	0.07	0.10
N_2O	0.02	0.02	0.02	0.02	0.02	0.02	0.03
Total	**5.01**	**4.93**	**4.30**	**3.88**	**3.43**	**2.51**	**3.18**
Fugitive emissions from fuels							
CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CH_4	2.02	2.02	1.81	1.97	1.91	2.20	2.09
N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.02**	**2.02**	**1.81**	**1.97**	**1.91**	**2.20**	**2.09**
Total Energy	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

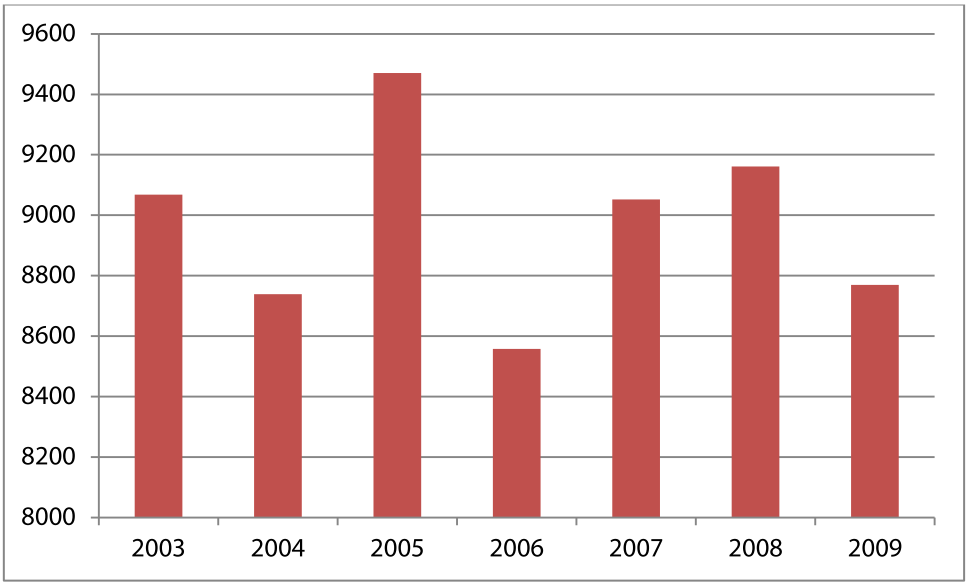


Figure 3.2.2.4.6 Energy sector emissions from direct gases in CO_2 eq, Sectorial Approach, 2003–2009 [kt]

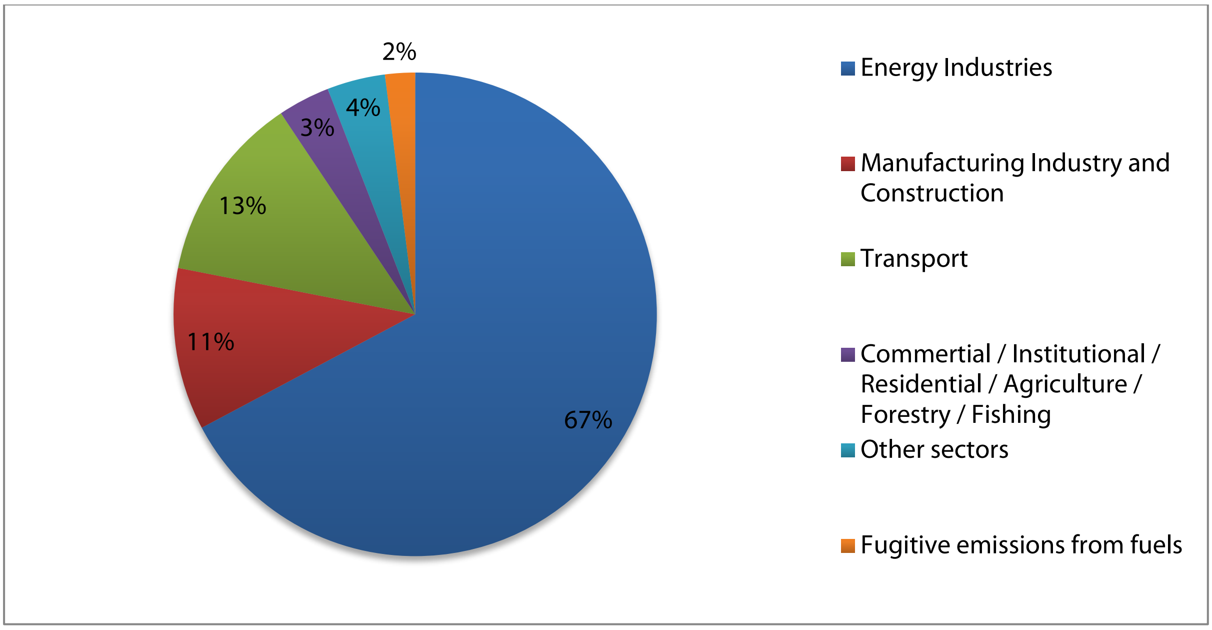


Figure 3.2.2.4.7 Average share of subsectors in direct GHG emissions from the Energy sector, 2003–2009 [%]

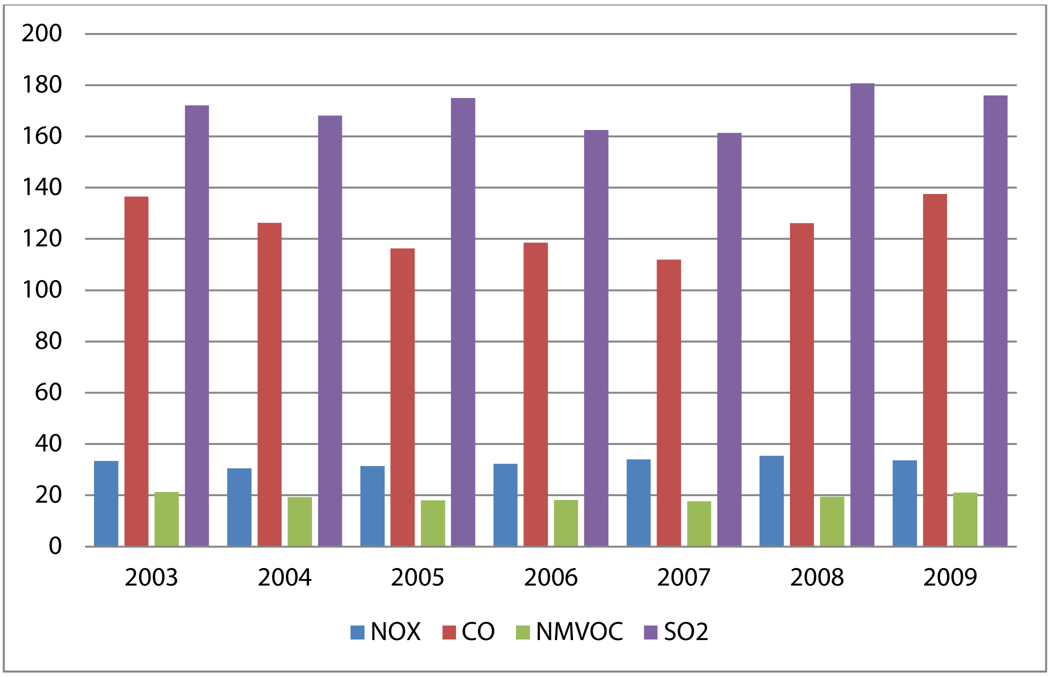


Figure 3.2.2.4.8 – Indirect GHG emissions from the Energy Sector, Sectorial Approach, 2003–2009 [kt]

3.3.2.1. ENERGY INDUSTRIES

The energy industry comprises three kinds of activities:

1. Conversion to non-fossil energy vectors (e.g. from fossil fuel into electricity and/or heat)
2. Primary fuel production (e.g. coal mining and oil and gas extraction);
3. Conversion to secondary or tertiary fossil fuels (e.g. crude oil to petroleum products in refineries. coal to coke, and coke oven gas in coke ovens). Emissions from the secondary fuels produced by the energy industries are counted in the sector where they are used.

Emissions from combustion during production and conversion processes are counted under energy industries.

The main activity, i.e. electricity and heat production (formerly known as public electricity and heat production), converts chemical energy stored in fuels either to electrical power (counted under electricity generation) or heat (counted under heat production) or both (counted under combined heat and power, or CHP).

The natural conditions and determined reserves of coal deposits, as well as the technical possibilities of the power system, serve as a guarantee that thermal power plants will go on being used continuously in the following period. The ELEM assessment reports declare that, of the overall determined 664 million tons of geological coal reserves in Republic of Macedonia, 38% could be exploited with surface excavation and the rest with underground technology. Cavity coal excavations are still not applied in this country.

The greatest producing capacity is the mining and power complex "Bitola" with three blocks each of 225 MW and a net production of about 1.434 GWh per block. The complex is entirely encircled production union with more units. This thermal plant uses coal-lignite as the basic fuel, which has an average caloricity of 7.900 kJ/kg.

The other thermal capacity included in the power system is the mining power complex "Oslomej" in Kicevo with an installed block capacity of 125 MW and annual net production of about 700 GWh. This thermal capacity uses coal-lignite as basic fuel with average caloricity of 7.660 kJ/kg. These thermo power plants have an important role in covering the basic part of the intake diagram of the Republic of Macedonia.
The third thermal capacity is the subsidiary "Energetika", which is projected and built in order to supply all consumers of RZS with electricity, technological steam and hot water for warming.

Table 3.3.2.1.1 Electrical Energy Produced by the Energy Industries, 2003–2009, [GWh]

Electrical Energy Produced [GWh]	2003	2004	2005	2006	2007	2008	2009
Bitola	4,540.50	4,362.20	4,603.50	4,720.00	4,166.50	4,216.00	4,197.20
Oslomej	365.90	372.80	404.30	404.60	436.20	661.40	591.40
Total	4,906.40	4,735.00	5,007.80	5,124.60	4,602.70	4,877.40	4,788.60

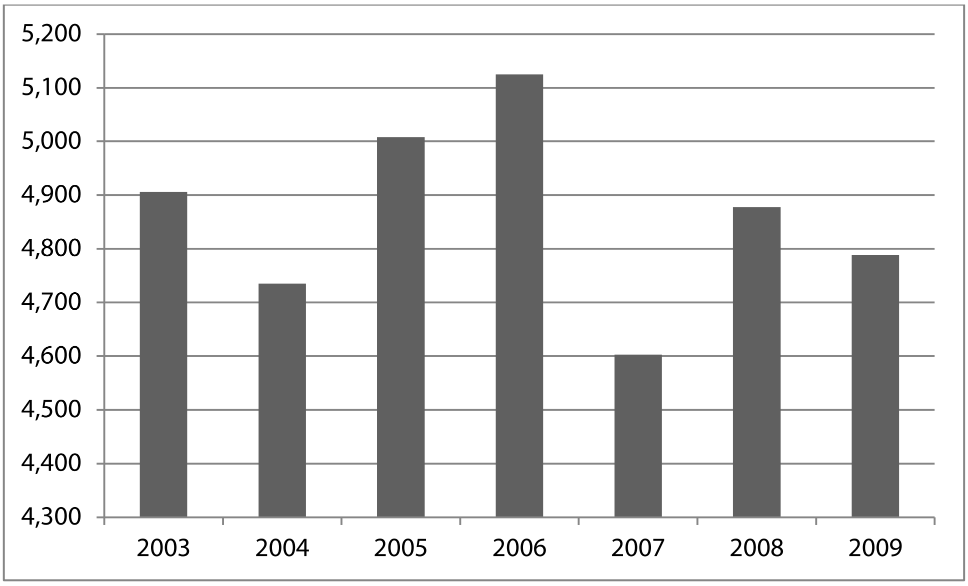


Figure 3.3.2.1.1 Electrical Energy Produced by the Energy Industries, 2003–2009, [GWh]

The main energy source used by the energy industries is domestic lignite, followed by residual fuel oil and natural gas. In the scope of the inventory process, country-specific emission factors for the most used energy sources were developed. Thus the estimations of GHGs emissions from the Energy Industries were made using the Tier 2 approach.

Table 3.3.2.1.2 Fuel Consumption by Energy Industries, 2003–2009 , [TJ]

Fuel Consumption [TJ]	Gas / Diesel Oil	Residual Fuel Oil	LPG	Lignite	Natural Gas
2003	654.38	4,323.78	43.18	57,036.81	1,470.95
2004	565.34	4,840.75	66.00	53,026.16	1,083.57
2005	556.55	4,971.03	103.71	52,251.82	1,241.89
2006	474.45	6,922.54	97.09	53,920.10	1,365.78
2007	455.19	8,263.40	67.03	52,920.80	2,111.99
2008	412.40	4,530.83	69.67	59,926.31	2,703.00
2009	418.81	6,290.29	84.50	53,006.93	1,441.98

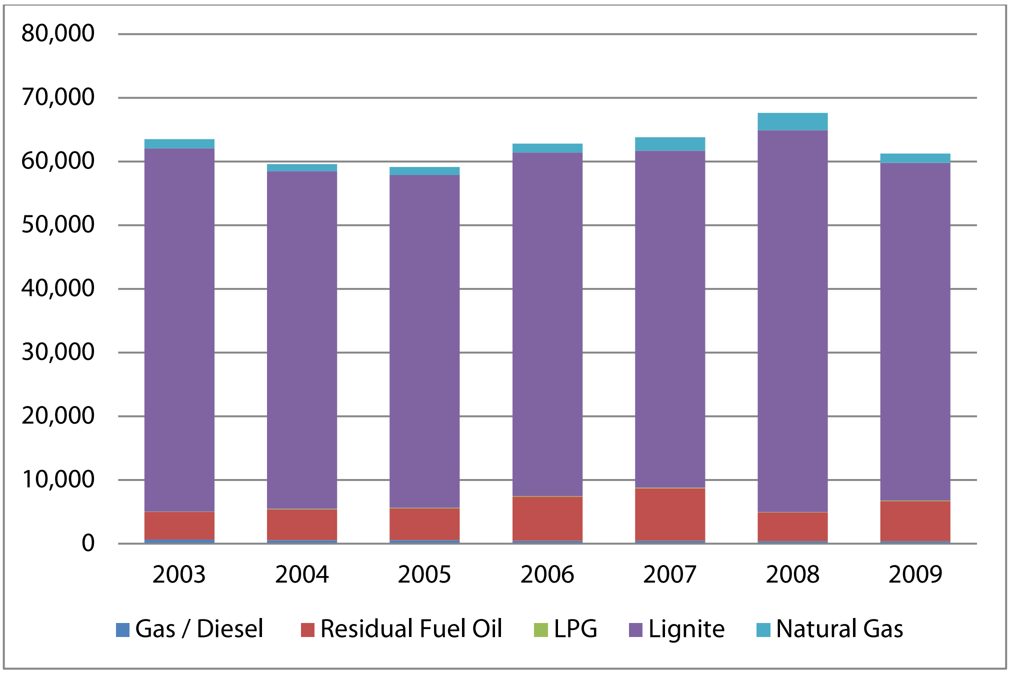


Figure 3.3.2.1.2 - Fuel Consumption by Energy Industries, 2003–2009 , [TJ]

The energy industries subsector accounts for an average of 67.23% of the total amount of GHG emissions from the overall direct gas emissions of the Energy Sector for the period 2003–2009.
Non-CO_2 emissions from the Energy Industries are generally dependent on the technology used in the Energy Industries and emissions controls mechanisms implemented in the installations. Power plants in Macedonia generally use quite dated technology, but modernization of these industrial facilities is considered an asset and is already underway.

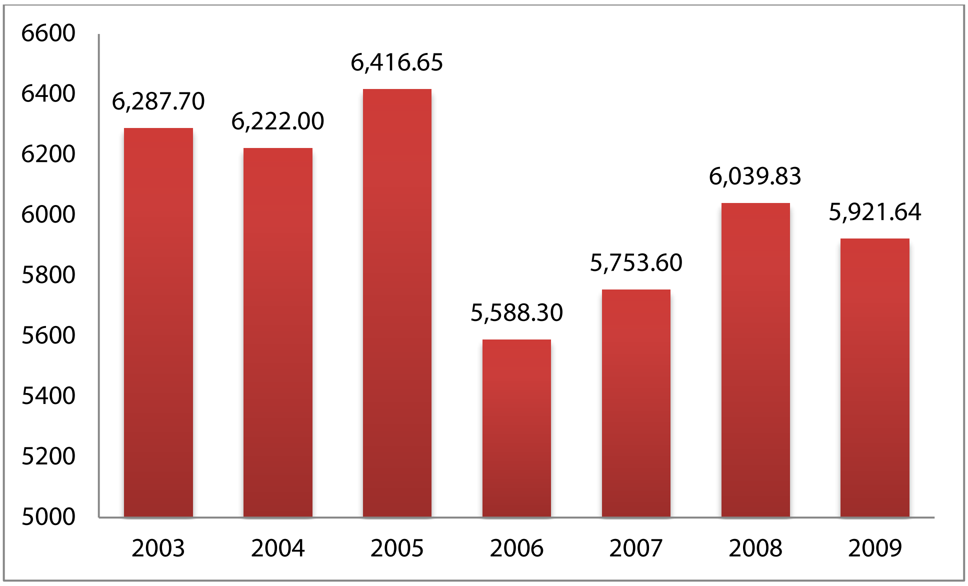


Figure 3.3.2.1.3 CO_2 eq .emissions from Energy Industries [kt]

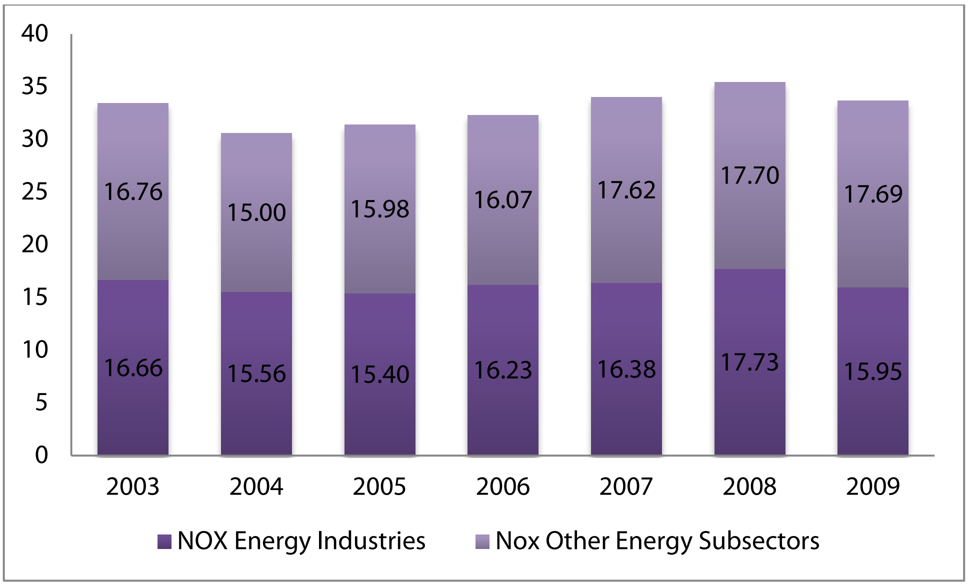


Figure 3.3.2.1.4 NOx emissions from the Energy Industries subsector and overall NOx emissions from the Energy sector [kt]

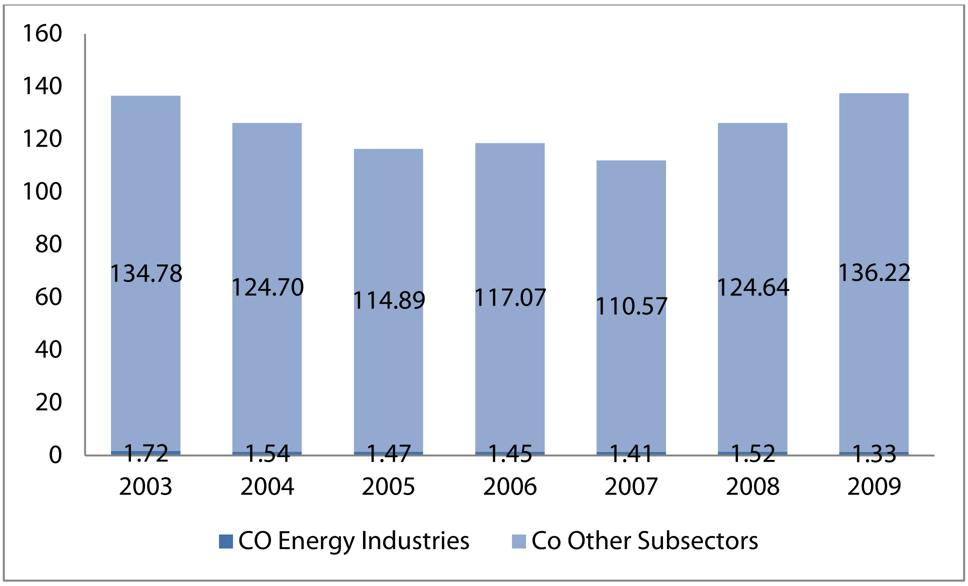


Figure 3.3.2.1.5 - CO emissions from the Energy Industries subsector and overall CO emissions from the Energy sector [kt]

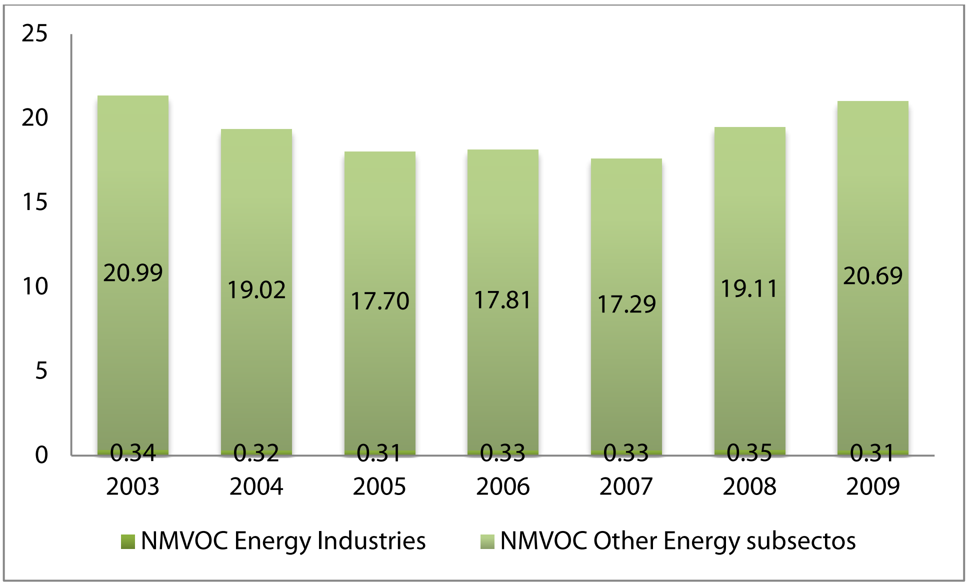


Figure 3.3.2.1.6 NMVOC emissions from the Energy Industries subsector and overall NMVOC emissions from the Energy sector [kt]

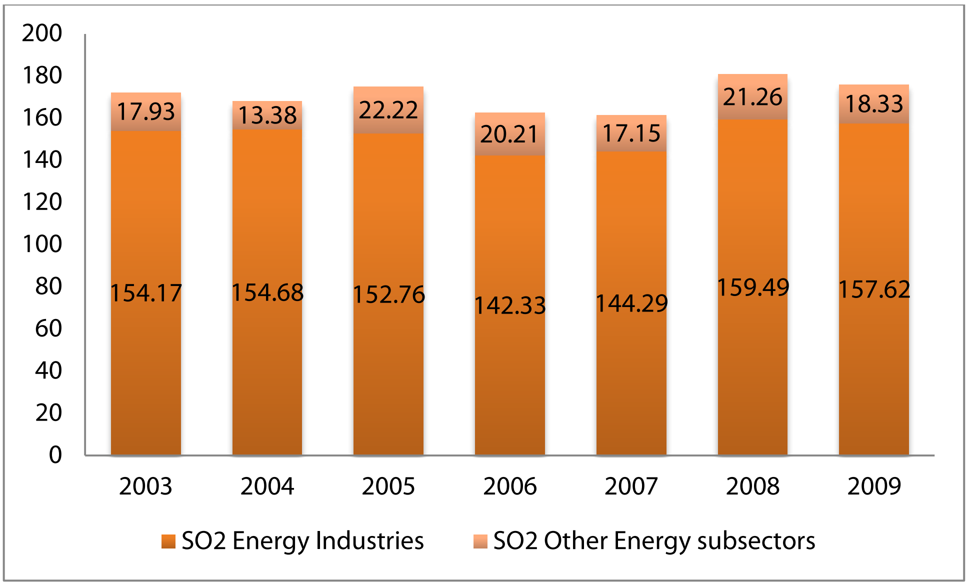


Figure 3.3.2.1.7 – SO_2 emissions from the Energy Industries subsector and overall SO_2 emissions from the Energy sector [kt]

3.3.2.2. MANUFACTURING INDUSTRY AND CONSTRUCTION

This chapter details emissions from the combustion of fuels in industry and also includes combustion for the generation of electricity and heat for own use in these industries.

In order to estimate the full emissions of the industry sector. emissions from auto-production are included with emissions from other fuel use within industry.

GHG emissions from the manufacturing industries and construction are dependent on the activity of the Industrial Sector.

From the figures for energy usage in the subsector of fuel consumption activities, and from the table of Chain Indices of Industrial Production, it can be seen that Industrial Production experienced a significant reduction in 2004 and 2009. The spike is greatest in 2009, reflecting the influence of the world economic crisis.

Table 3.3.2.2.1 Chain Indices of Industrial Production, 2003–2009. (Source: State Statistical Office)

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Chain Indices of Industrial Production	104.7	97.8	107	105.9	103.9	105.1	91.3

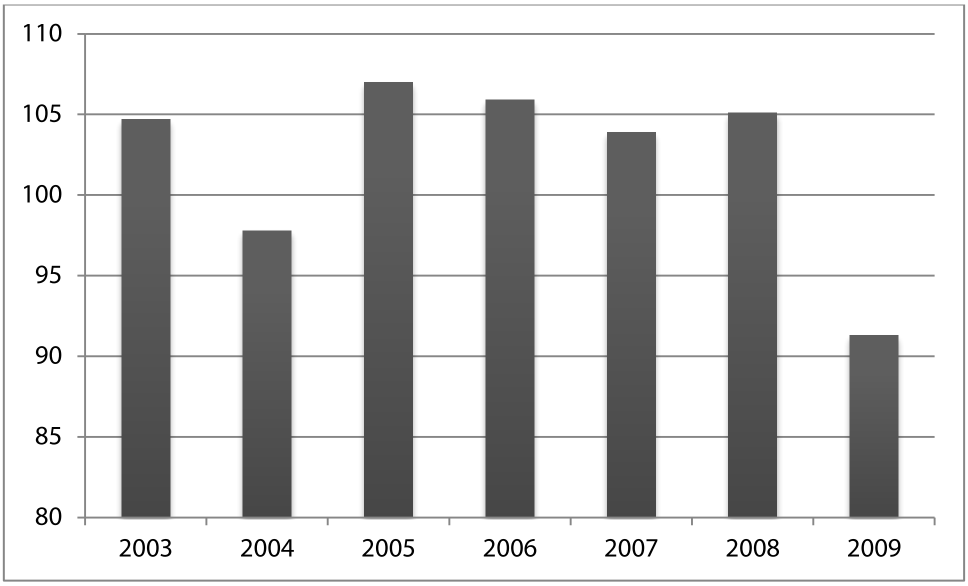


Figure 3.3.2.2.1 - Chain Indices of Industrial Production, 2003–2009. (Source: State Statistical Office)

Table 3.3.2.2.2- Fuel Consumption by Manufacturing Industry and Consumption, 2003–2009 , [TJ]

Fuel Consumption [TJ]	Gas / Diesel Oil	Residual Fuel Oil	LPG	Coking Coal	Lignite	Other Bituminous Coal	Natural Gas	Additional Fuels
2003	1,197.80	2,547.91	70.24	813.88	1,859.18	NE	1,236.86	NE
2004	1,034.83	2,852.55	107.35	154.53	1,427.73	NE	1,299.08	NE
2005	1,018.36	2,929.34	168.69	460.38	67.95	4,347.49	1,334.63	2,658.74
2006	1,083.38	3,675.76	208.59	358.26	1,479.74	3,237.82	1,376.66	2,725.94
2007	955.18	4,351.63	189.29	1,519.39	439.91	4,876.49	1,381.35	2,993.31
2008	934.49	3,645.03	209.34	1,232.80	353.70	4,356.78	1,267.01	2,864.57
2009	1,094.76	3,413.92	180.91	61.76	137.29	2,449.36	1,164.14	1,547.94

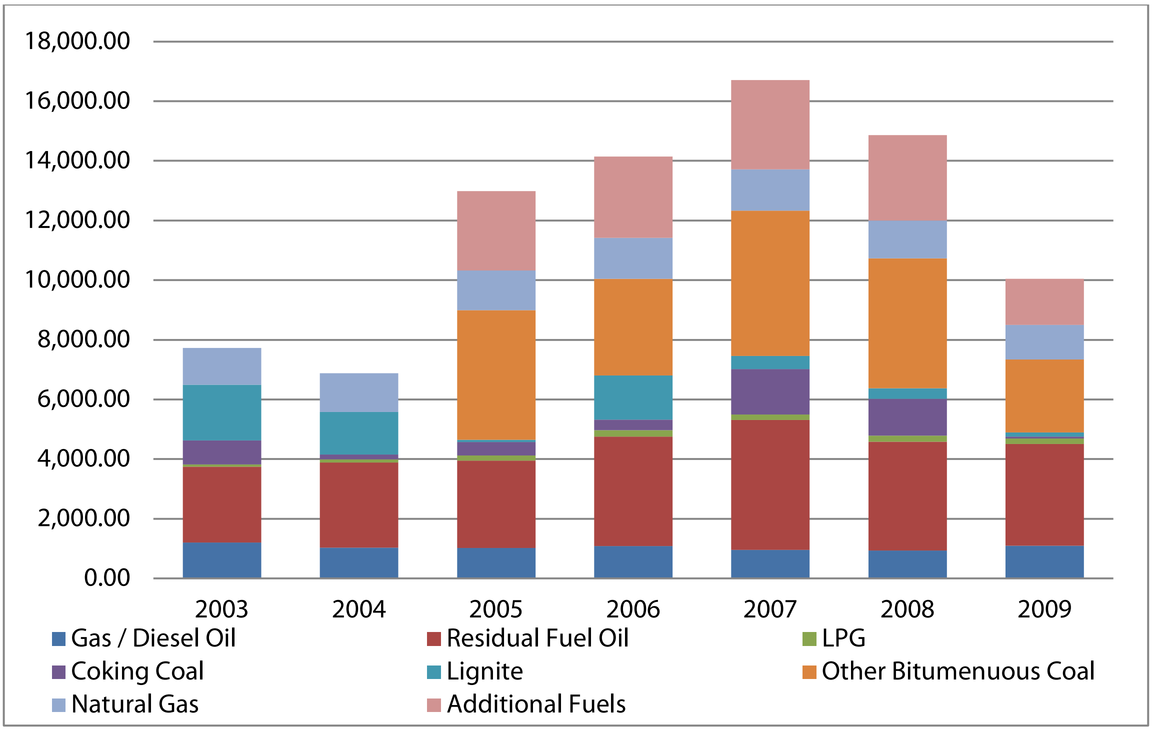


Figure 3.3.2.2.2 - Fuel Consumption by Manufacturing Industry and Consumption, 2003–2009 , [TJ]

The manufacturing industries and construction accounts for an average of 10.85% of the total amount of direct GHG emissions from the Energy sector in the period 2003–2009.

The largest industrial energy consumers in Macedonia are Bucim, OKTA, Maksteel, Mitalsteel, USJE, Silmak and FENI Industry.

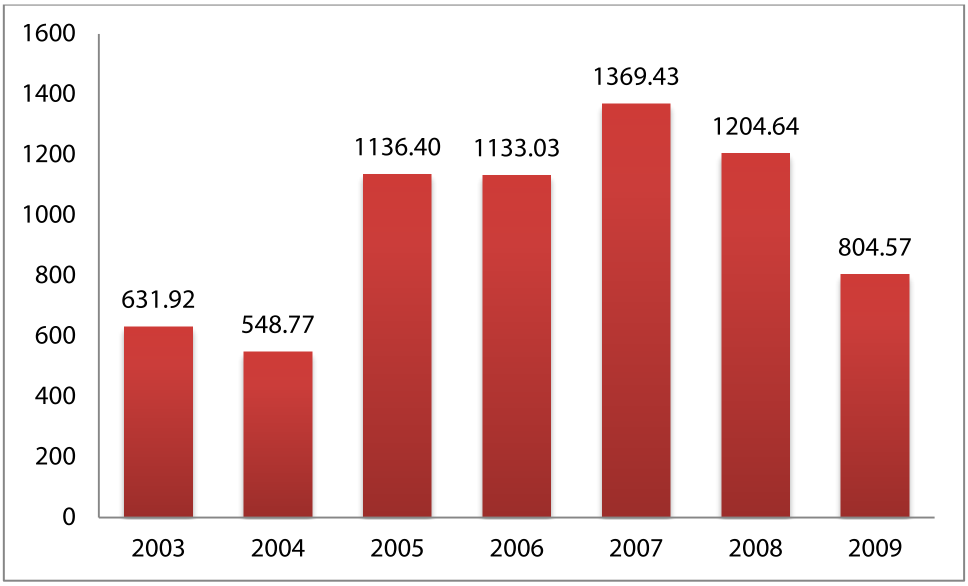


Figure 3.3.2.2.3 CO_2 eq. emissions from Manufacturing Industries and Construction [kt]

Non-CO_2 emissions from Manufacturing Industries and Construction are generally dependent on the technology of auto-production of energy used in Industry, emissions-control mechanisms implemented in the technological process, as well as regulatory requirements and market issues. The Industrial Facilities in the country are generally using dated technology of auto production and this is the main reason why non-CO_2 emissions from this subsector are significant compared to the activity data of this sector.

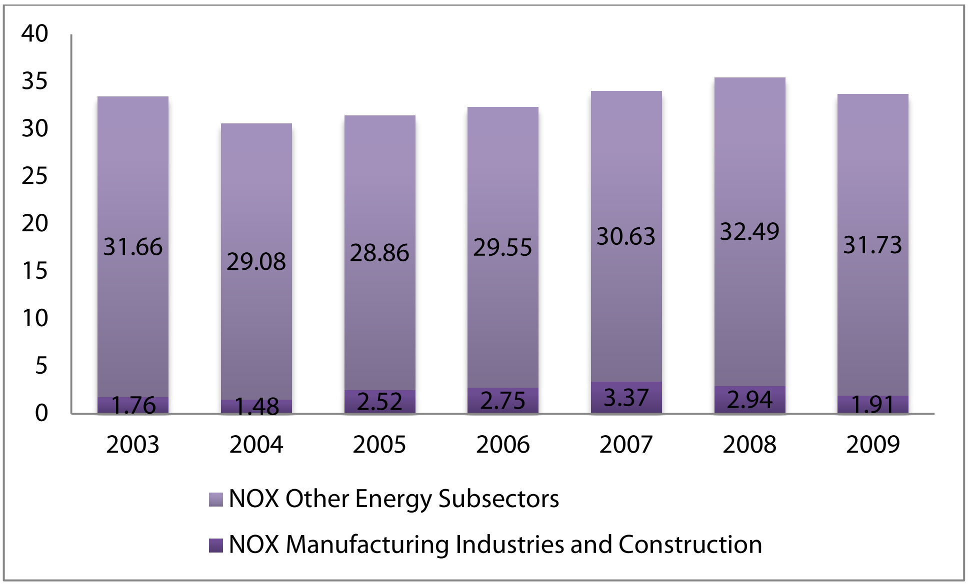


Figure 3.3.2.2.4 - NOx emissions from the Manufacturing Industry and Construction and overall NOx emissions from the Energy Sector [kt]

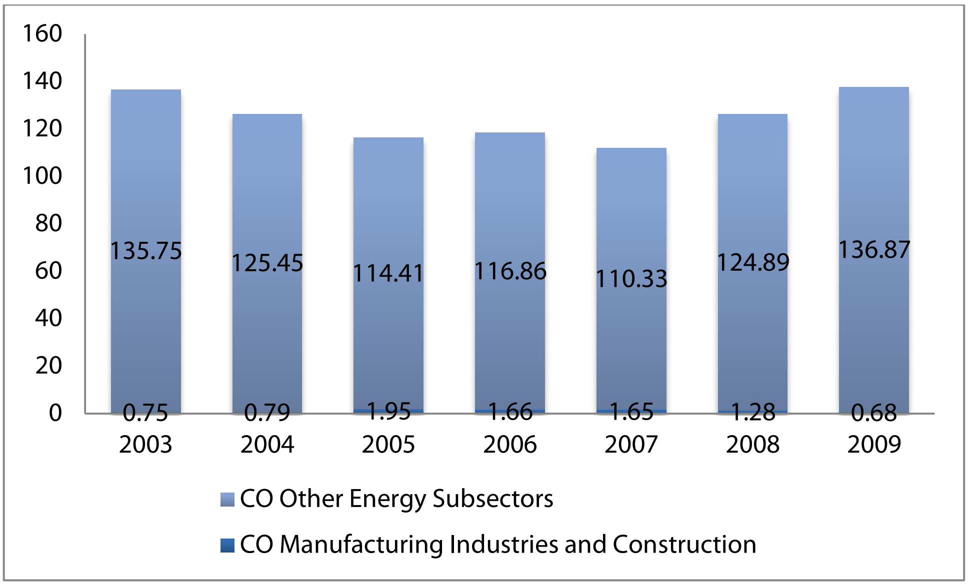


Figure 3.3.2.2.5 CO emissions from the Manufacturing Industry and Construction and overall CO emissions from the Energy Sector [kt]

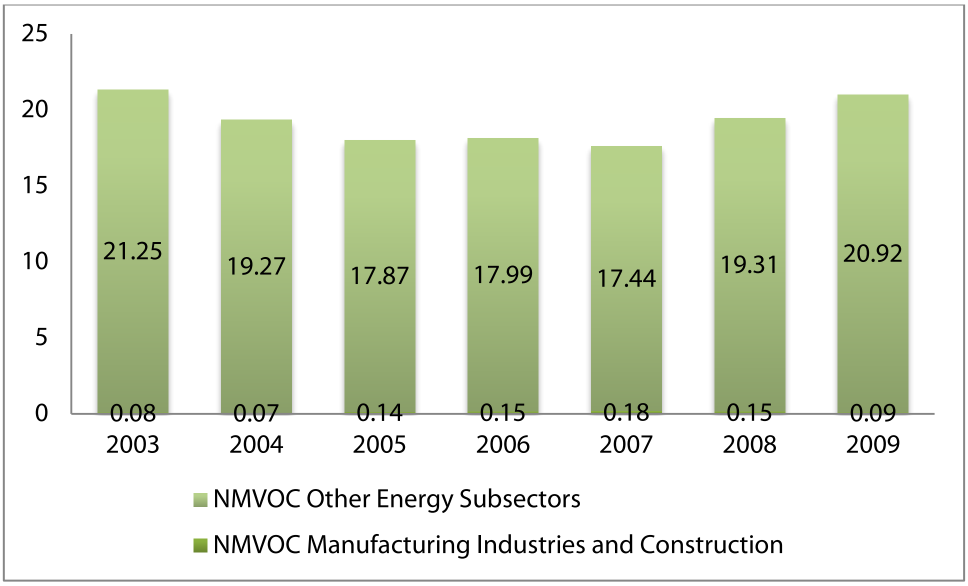


Figure 3.3.2.2.6 NMVOC emissions from the Manufacturing Industry and Construction and overall NMVOC emissions from the Energy Sector [kt]

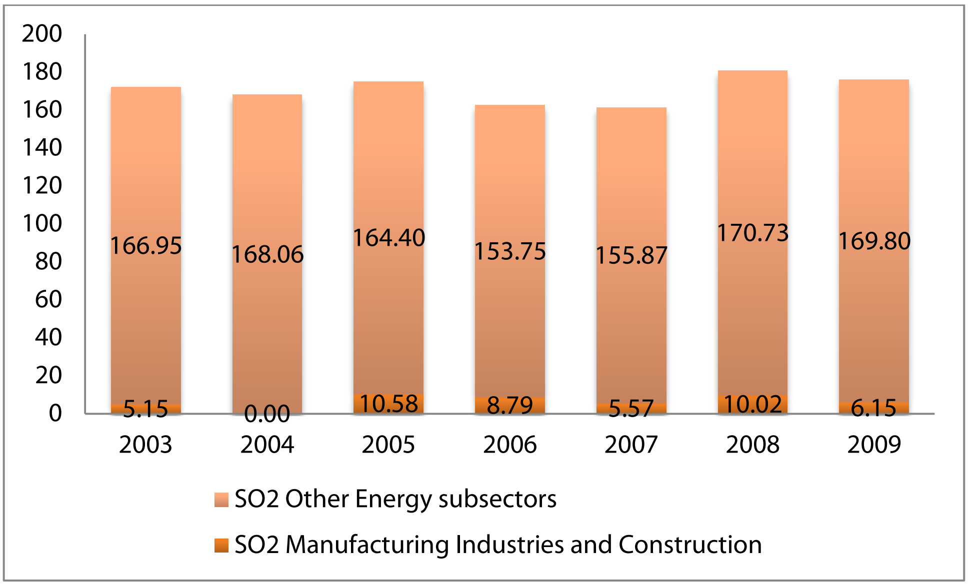


Figure 3.3.2.2.7 –SO_2 emissions from the Manufacturing Industry and Construction and overall SO_2 emissions from the Energy Sector [kt]

3.3.2.3. TRANSPORT

This category comprises emissions from fuels combusted in transportation, including civil aviation, road transport, rail transport and national navigation. Emissions aviation bunkers are reported but not included in the total emissions.

The transportation subsector accounts for an average of 12.55 % of total direct GHG emissions from the Energy Sector in the period 2003–2009.

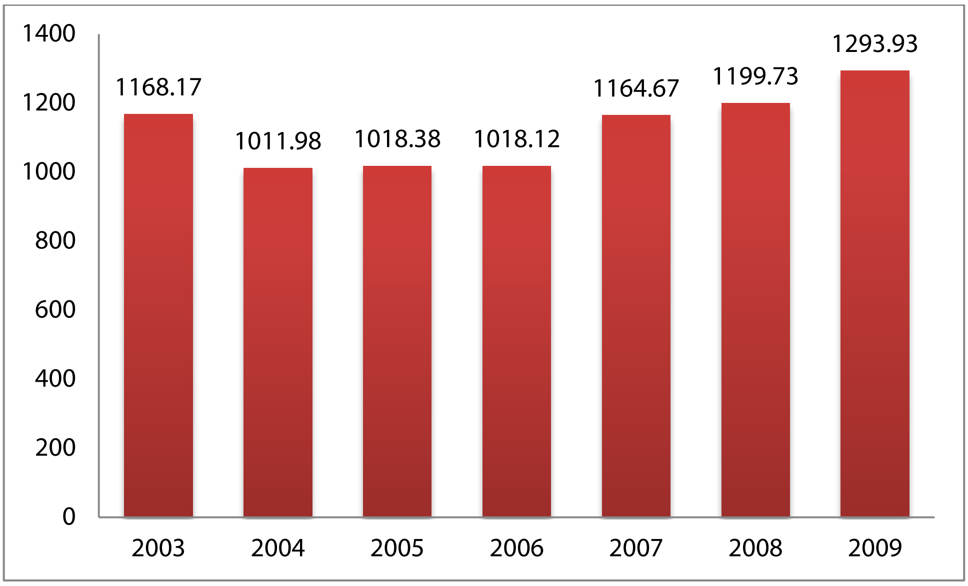


Figure 3.3.2.3.1- CO_2 eq. emissions from the Transport Sector [kt]

Civil Aviation

In the framework of the TNC, emissions from the Civil Aviation Subsector were calculated for the first time using the Tier 2 approach. This was achieved through the establishment of a memorandum of cooperation between the MoEPP and the Macedonian Provider for Navigational services M-NAV.

A detailed database for the inventory period 2003–2009 was prepared, and all civil flights were extracted from the database. The exact number of over flights, take-offs and landings for the period 2003–2009 was recorded and the entire number of operations were divided by aircraft type, engine type, flight path, flight altitude and operating performances. Afterwards, following the IPCC methodology, the flights were divided between domestic and international flights. This allowed the aircraft type and the operational type specific emission factors and parameters to be identified .

In accordance with the IPCC methodology, emissions from domestic flights—i.e., emissions between the two domestic airports, have been introduced and reported in the national totals. These are presented in this chapter.

The emissions from the international flights are elaborated in the chapter International Bunkers - International Aviation. Flights considered as international flights are those flights whose destination or starting point is outside of the state borders. International flight emissions are excluded from the national total emissions and are reported as international emissions.

The average proportion of GHG emissions from domestic aviation in the overall emissions of direct GHGs from the transport sector for the inventory period 2003–2009 was 0.05%. The percentage is very small because of the very low number of flights between the two domestic airports.

Table 3.3.2.3.1 Fuel consumption by Domestic Aviation, Tier 2 Approach, 2003–2009 [TJ]

Fuel Consumption [TJ]	Gasoline	Jet
2003	2.22	11.60
2004	2.20	7.93
2005	1.26	12.10
2006	2.64	8.01
2007	3.52	10.24
2008	5.82	7.20
2009	5.99	3.52

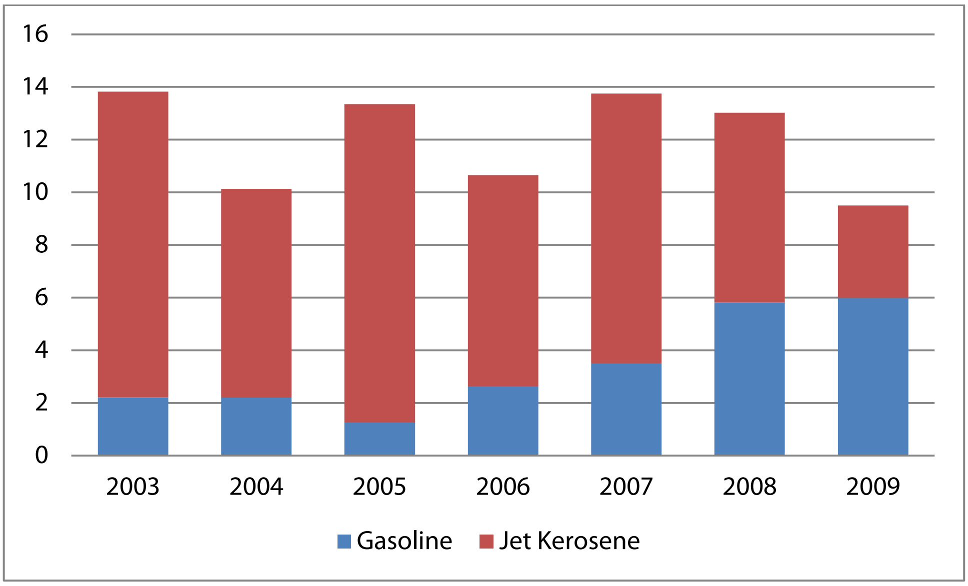


Figure 3.3.2.3.2 Fuel consumption by the Domestic Aviation Subsector [TJ]

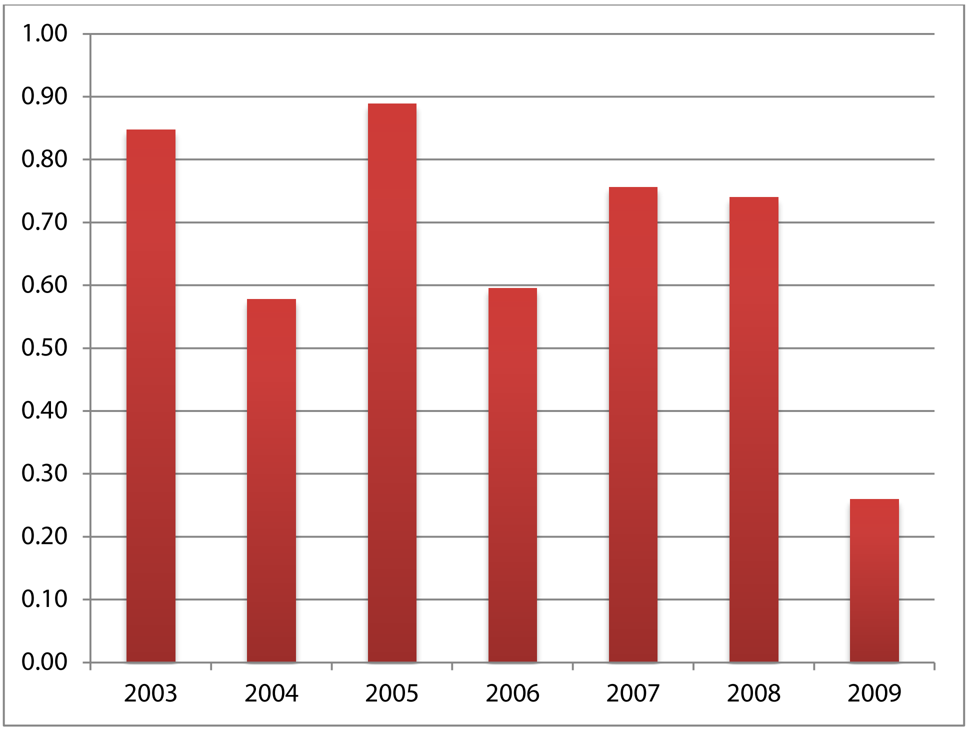


Figure 3.3.2.3.3 CO_2 eq. emissions from Domestic Aviation, [kt]

Table 3.3.2.3.2 Number of flights, 2003–2009. (Source: M-NAV)

Type of Operation	2003	2004	2005	2006	2007	2008	2009
Total Number of flights	95,118	104,111	108,838	116,744	122,168	124,186	124,358
Overflights	82,621	93,634	97,441	105,100	110,035	111,973	113,274
Total Number of Landing and Take-Off Operations	12,497	10,477	11,397	11,644	12,133	12,213	11,084
Domestic Landing and Take-Off Operations	**360**	**143**	**245**	**223**	**232**	**133**	**58**
International Landing and Take-Off Operations	12,137	10,334	11,152	11,421	11,901	12,080	11,026
Domestic Landing and Take-Off Operations from Total Landing and Take-Off Operations [%]	**2.88**	**1.36**	**2.15**	**1.92**	**1.91**	**1.09**	**0.52**

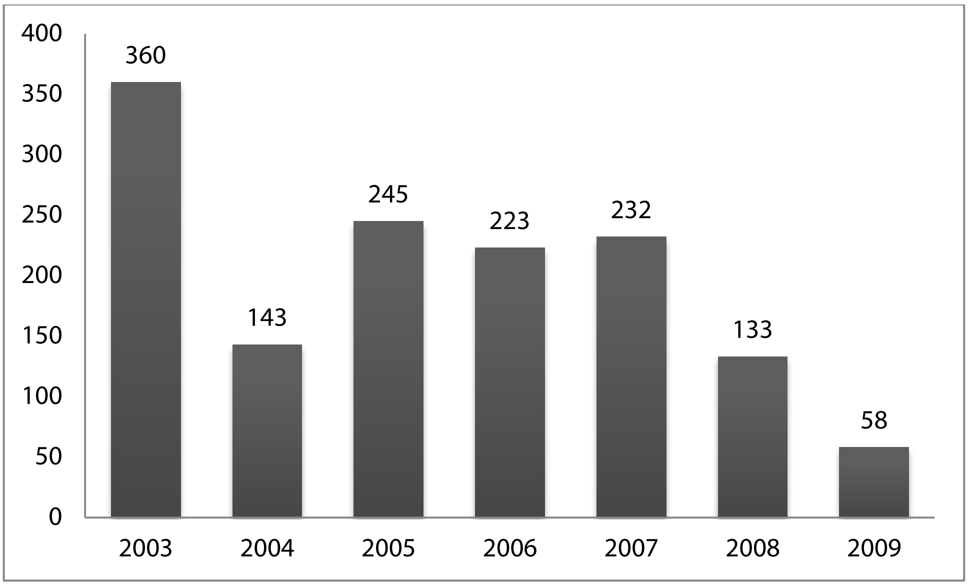


Figure 3.3.2.3.4 Number of flights between the two domestic airports, 2003–2009

Emissions of indirect GHG gases from the civil aviation sector are negligible and there is thus no need for further elaboration.

Road Transport

Although Road Transport is identified as a key source of GHG emissions in the period 2003–2009, the Tier 1 approach has been used to calculate such emissions due to a lack of data essential for the development of higher Tier estimation methodology.

Table 3.3.2.3.3 Fuel consumption from the Road Transport Subsector, 2003–2009, [TJ]

Fuel Consumption [TJ]	Gasoline	Gas / Diesel	LPG	Natural Gas
2003	6,606.02	9,075.88	527.80	NO
2004	5,427.37	7,825.19	806.70	NO
2005	5,116.40	7,805.74	1,267.55	NO
2006	4,686.12	7,954.59	1,510.05	5.99
2007	4,985.10	9,213.10	2,022.89	6.41
2008	5,160.94	9,433.70	2,137.24	10.38
2009	5,429.27	10,511.05	2,078.03	10.22

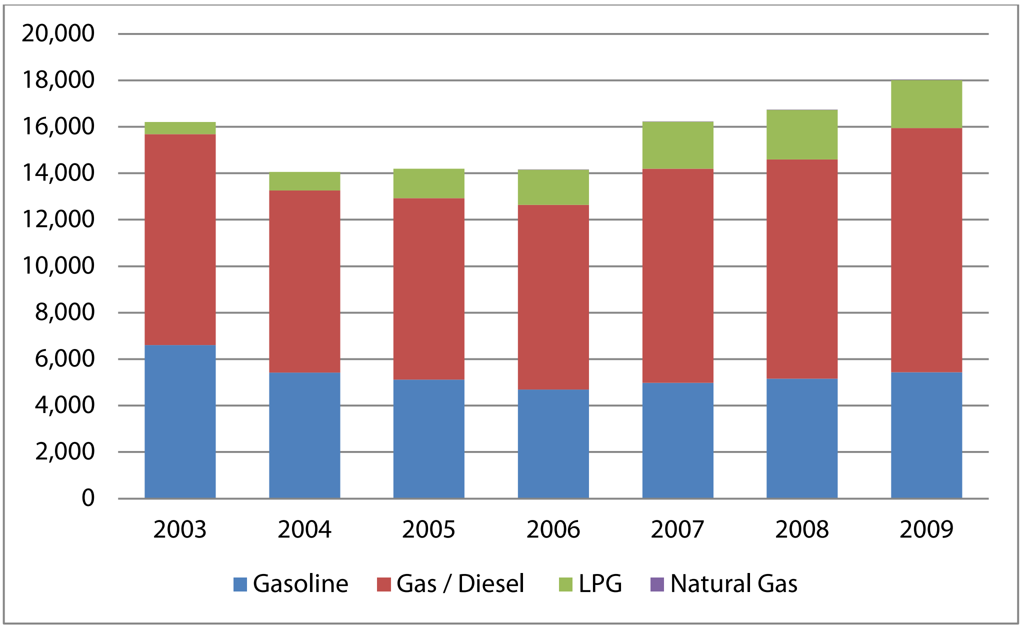


Figure 3.3.2.3.5 Fuel consumption from the Road Transport Subsector, 2003–2009, [TJ]

As can be seen, CO_2 emissions from Road Transport increased slightly in the last three years and this trend continued in the period after 2009. This was caused by a continuous decline in the price of vehicles and the increased transport needs in the country. The decrease in the price of vehicles was caused by a change in governmental policy for vehicle import and an improved tax policy for imported vehicles.

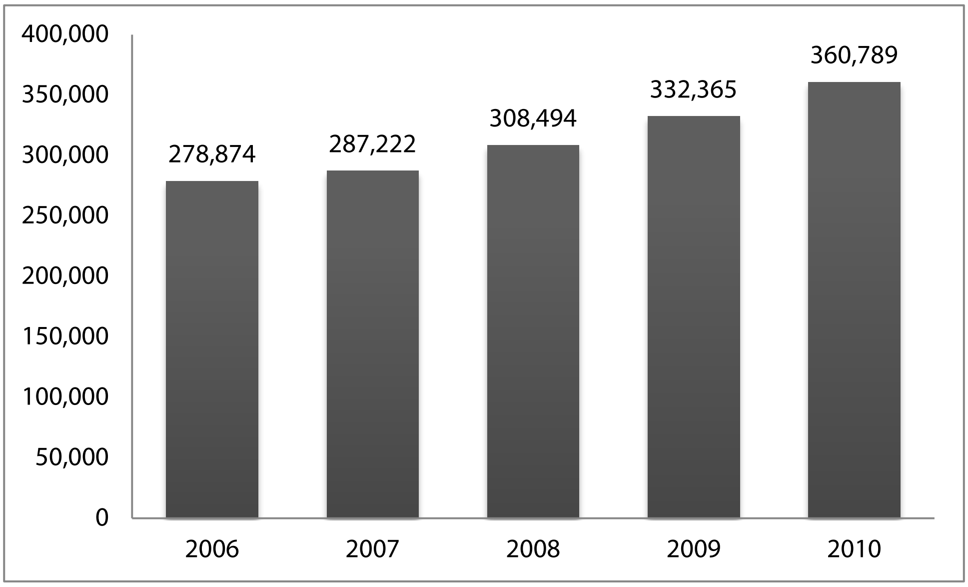


Figure 3.3.2.3.6 Total Number of Vehicles Registered in the Country, 2006–2010. (Source: State Statistical Office)

Road Transportation is the main contributor to overall emissions from the transport sector. In the inventory period 2003–2009, road transport was responsible for an average of 99.04% of overall emissions from the transport sector, or an average of 12.41% of overall emissions from the Energy Sector.

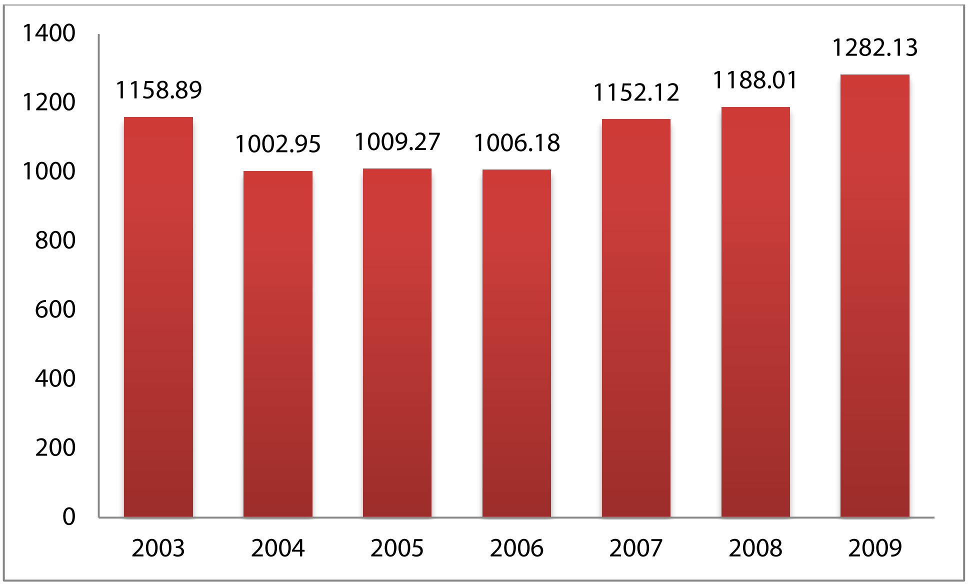


Figure 3.3.2.3.7 CO_2 eq. emissions from the Road Transport subsector [kt]

Non-CO_2 emissions from the Road Transport subsector are of considerable magnitude for the entire Energy sector. These values are dependent on the technology used for combustion, the type of fuel used, the operating parameters, and the equipment used for vehicle emission control.

The development of an electronic database of the country's vehicle fleet is essential for improving the quality of the road transport inventory and is an essential tool for assessment and monitoring high level road transport emissions.

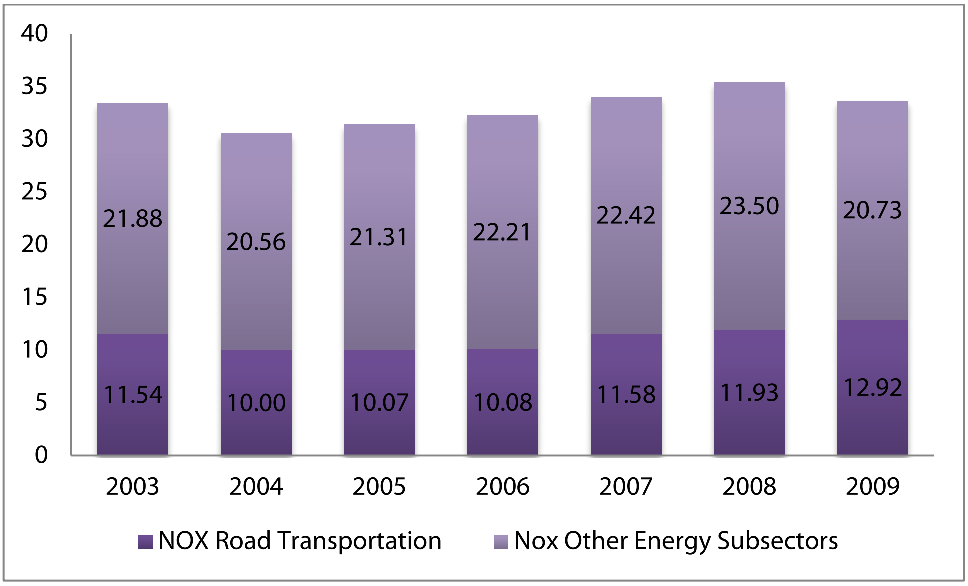


Figure 3.3.2.3.8 NOx emissions from Road Transportation and overall NOx emissions from the Energy Sector [kt]

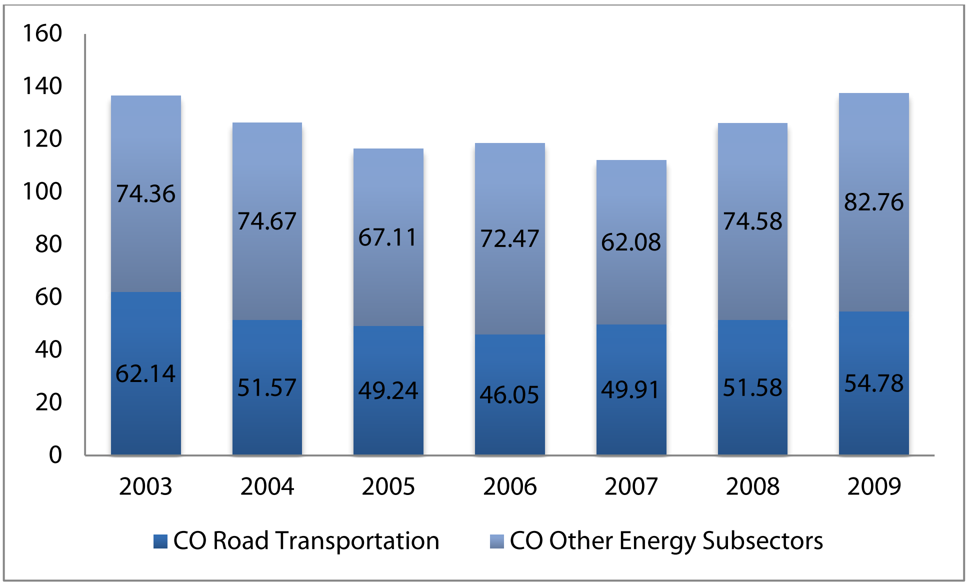


Figure 3.3.2.3.9 CO emissions from Road Transport and overall CO emissions from the Energy Sector [kt]

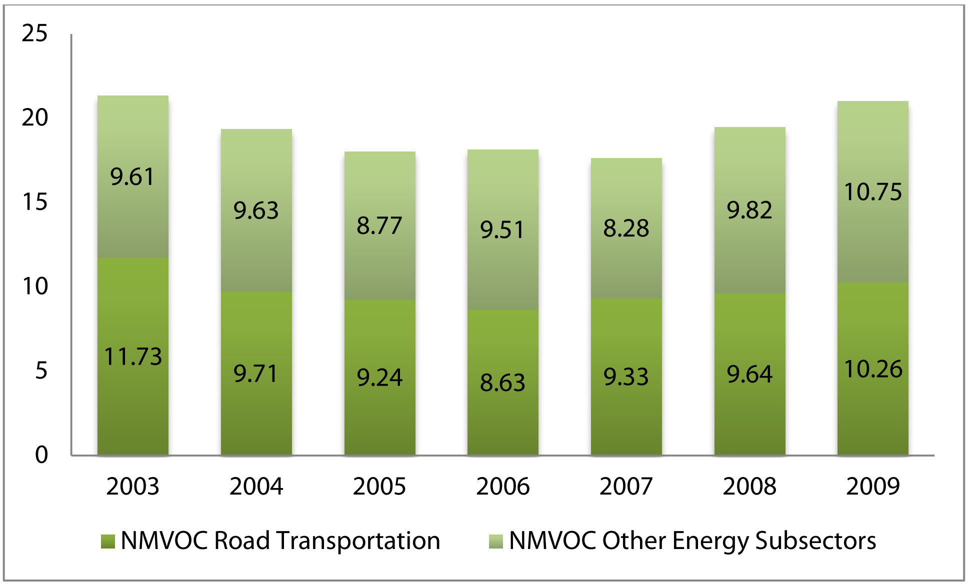


Figure 3.3.2.3.10 - NMVOC emissions from Road Transport and overall NMVOC emissions from the Energy Sector [kt]

Railways

Rail transport is unpopular and infrequently used in Macedonia. The high operating cost involved in rail transport, the need for large-scale investment to establish new corridors and improve existing ones, together with the need to replace old and inefficient railway vehicles, have all held back the development of this subsector.

Table 3.3.2.3.4 - Fuel consumption from the Railway Subsector, 2003– 2009, [TJ]

Fuel Consumption [TJ]	Gas / Diesel Oil
2003	114.58
2004	114.87
2005	111.75
2006	154.07
2007	160.23
2008	159.06
2009	156.80

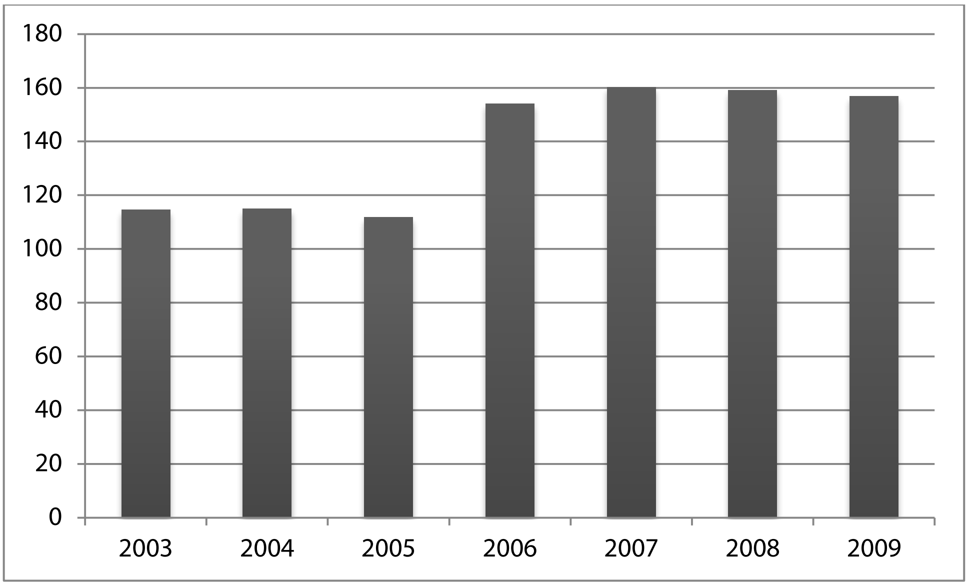


Figure 3.3.2.3.11Fuel consumption of the Railway Subsector, 2003– 2009, [TJ]

Table 3.3.2.3.5 Railway activity data, period 2003– 2009. (Source: State Statistical Office)

Railway activity	2003	2004	2005	2006	2007	2008	2009
Passengers carried, in '000	902	917	903	1011	1104	1448	1523

Passenger-km, in '000	91941	94345	93904	105,111	109399	147965	154500
Goods carried, in '000 tonnes	2390	2641	3129	3,800	4686	4206	2929
Net tonne-kilometres, in '000	372759	426344	530044	614,424	778581	742917	496719

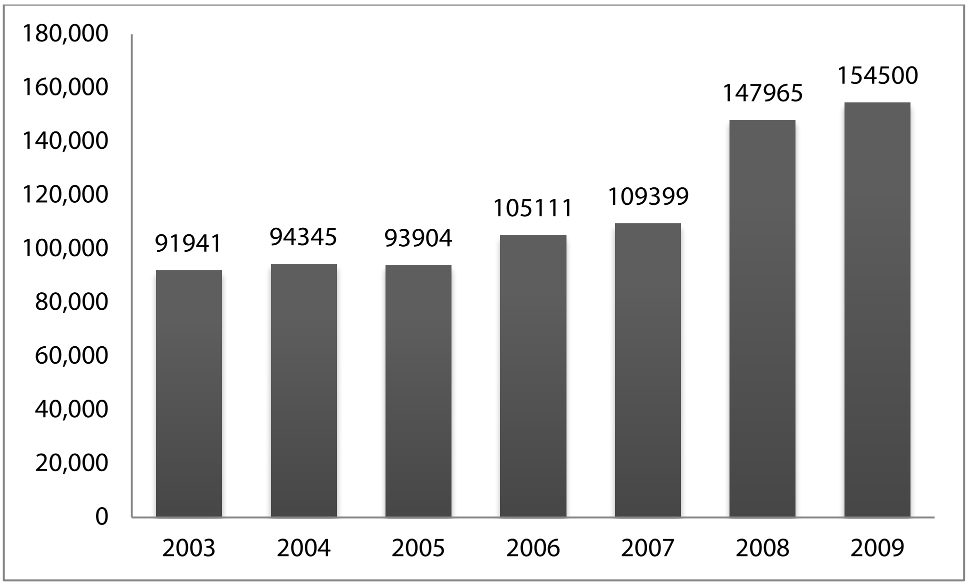


Figure 3.3.2.3.12 Passenger-km, in '000, 2003– 2009. (Source: State Statistical Office)

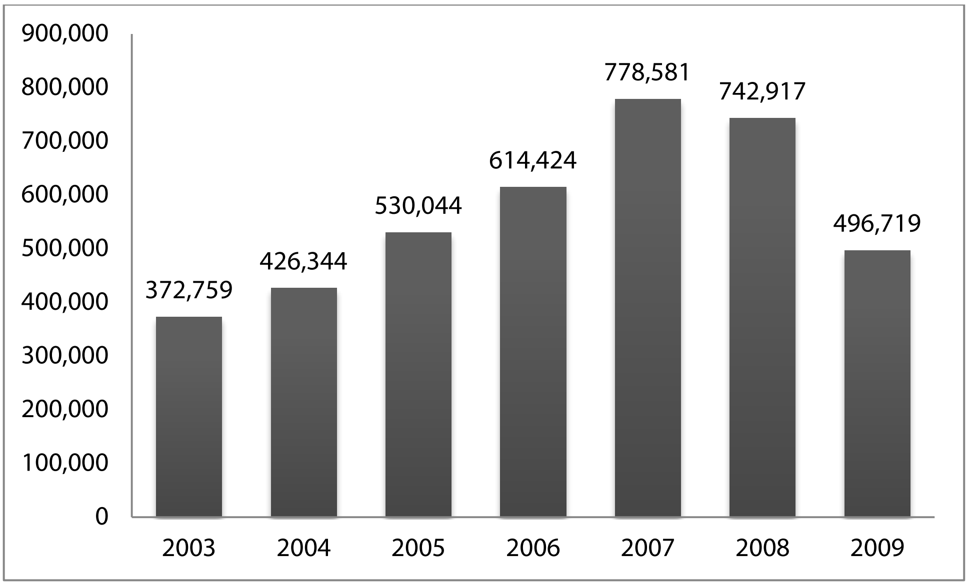


Figure 3.3.2.3.13 Net tonne-kilometres in '000, 2003– 2009. (Source: State Statistical Office)

The Railways subsector accounts for an average of 0.91% of overall emissions from the Transport sector.

Non-CO_2 emissions from this sector are relatively high in relation to the Activity Data of this sector. This is due to old and inefficient locomotives and outdated infrastructure.

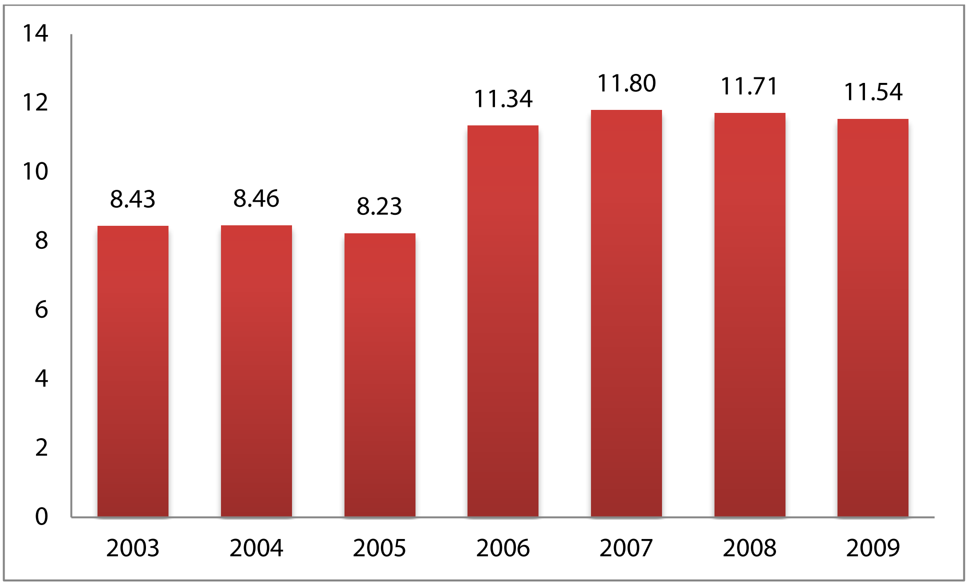


Figure 3.3.2.3.14 CO_2 eq. emissions from the Rail subsector [kt]

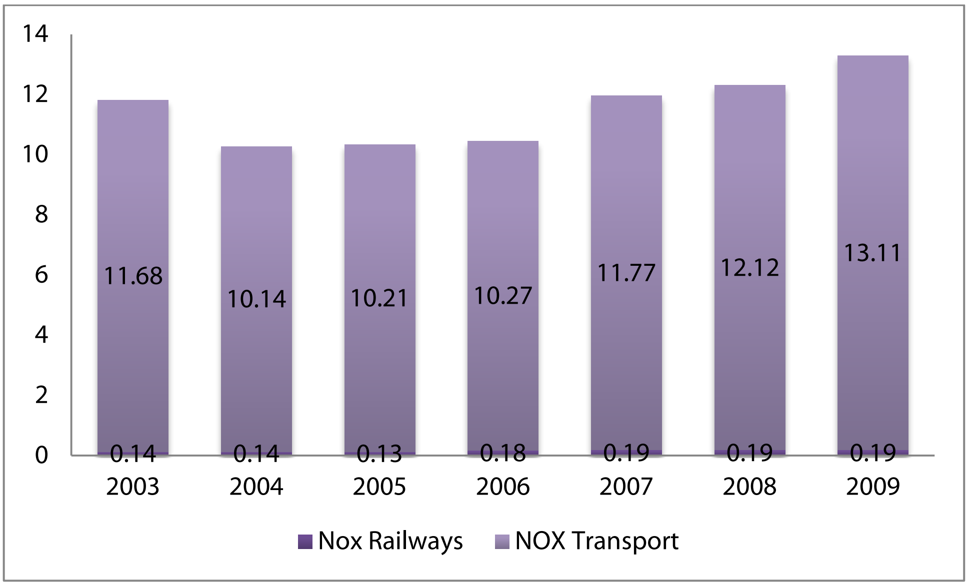


Figure 3.3.2.3.15 NOx emissions from Railways and overall NOx emissions from the Transport Sector [kt]

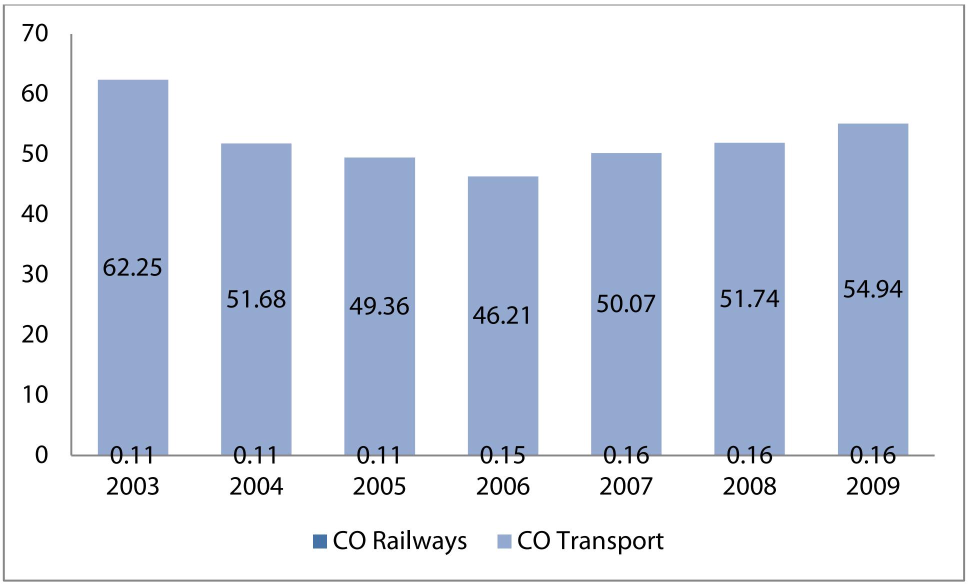


Figure 3.3.2.3.16 CO emissions from Railways and overall CO emissions from the Transport Sector [kt]

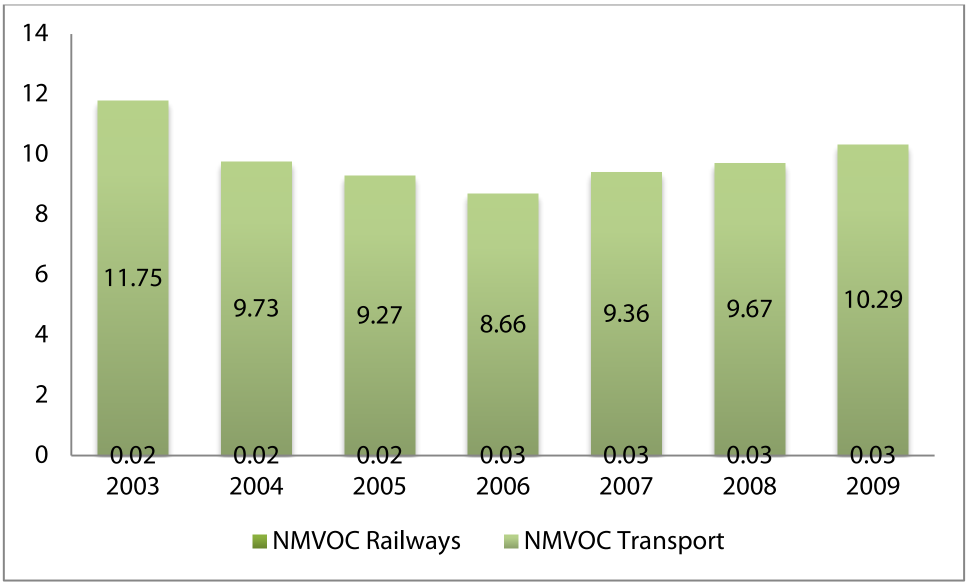


Figure 3.3.2.3.17 - NMVOC emissions from Railways and overall NMVOC emissions from the Transport Sector [kt]

3.3.2.4. Commercial / Institutional / Residential sector / Agriculture / Forestry / Fishing

The commercial / institutional / residential sector / agriculture / forestry / fishing subsectors accounted for an average of 3.48% of overall emissions of direct GHGs from the Energy sector in the period 2003–2009.

Non-CO_2 emissions from this sector are significant, resulting from the fact that the main emissions from this sector arise from the heating needs of the general population. Small boilers and personal usage of fuels produces significantly more non-CO_2 emissions due to the lack of control mechanisms and advanced combustion technology.

Table 3.3.2.4.1- Fuel consumption from Commercial/Institutional/Residential Sector/ Agriculture/Forestry/ Fishing, 2003– 2009, [TJ]

Fuel Consumption [TJ]	Gasoline	Gas / Diesel	Residual	LPG	Lignite
2003	0.00	1644.22	812.13	161.28	467.65
2004	0.00	1420.51	909.23	246.51	538.20
2005	16.45	1398.77	933.70	387.32	253.76
2006	25.96	1420.75	772.17	392.05	306.39
2007	14.19	1517.30	497.22	420.52	229.23
2008	14.28	1431.97	533.98	403.44	131.30
2009	14.78	1550.31	335.32	388.17	85.58

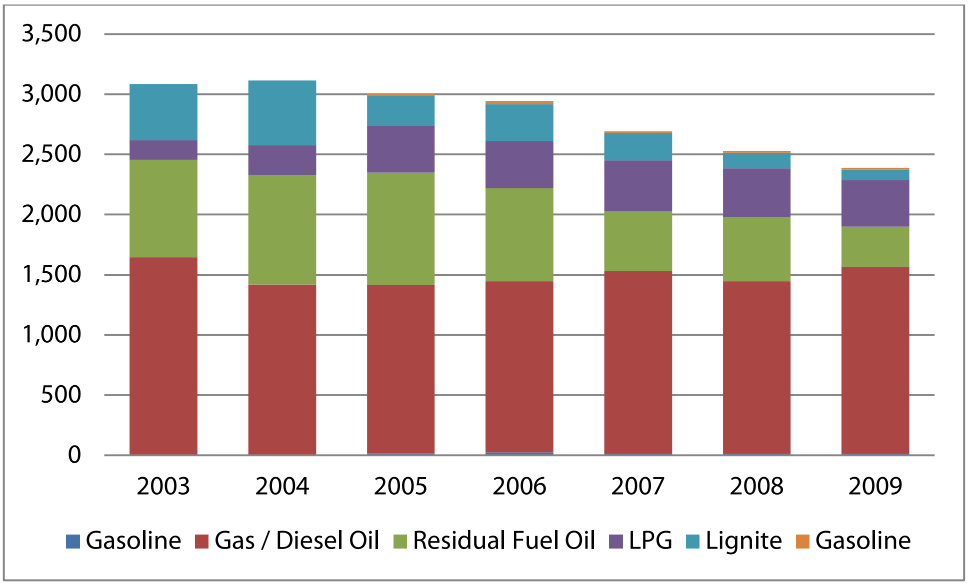


Figure 3.3.2.4.1 Fuel consumption from Commercial/Institutional/Residential Sector/ Agriculture/Forestry/ Fishing, 2003– 2009, [TJ]

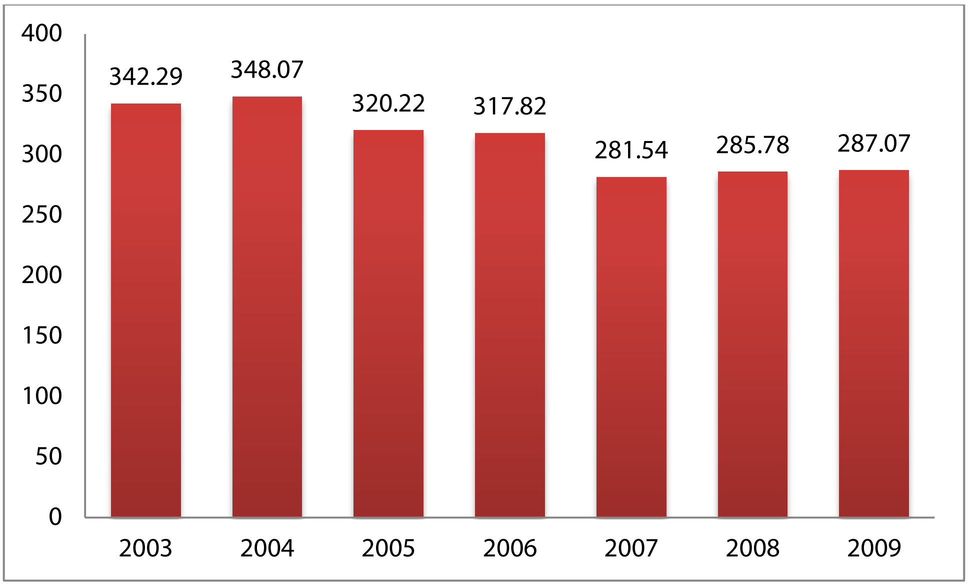


Figure 3.3.2.4.2 - CO_2 eq. emissions from commercial / institutional / residential sector / agriculture / forestry / fishing subsectors, 2003– 2009 [kt]

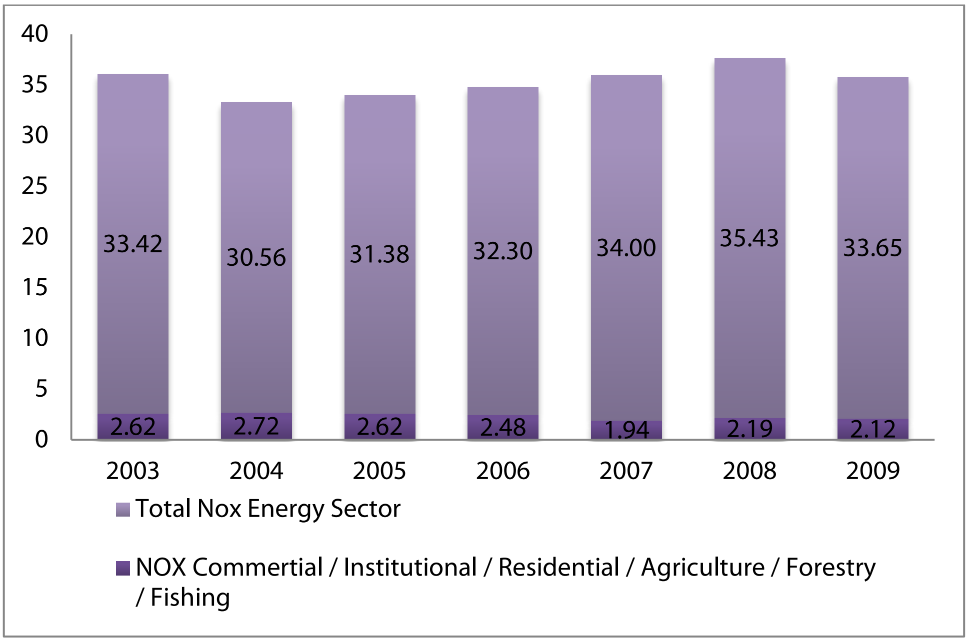


Figure 3.3.2.4.3 NOx emissions from commercial / institutional / residential sector / agriculture / forestry / fishing subsectors, and overall NOx emissions from the Energy Sector [kt]

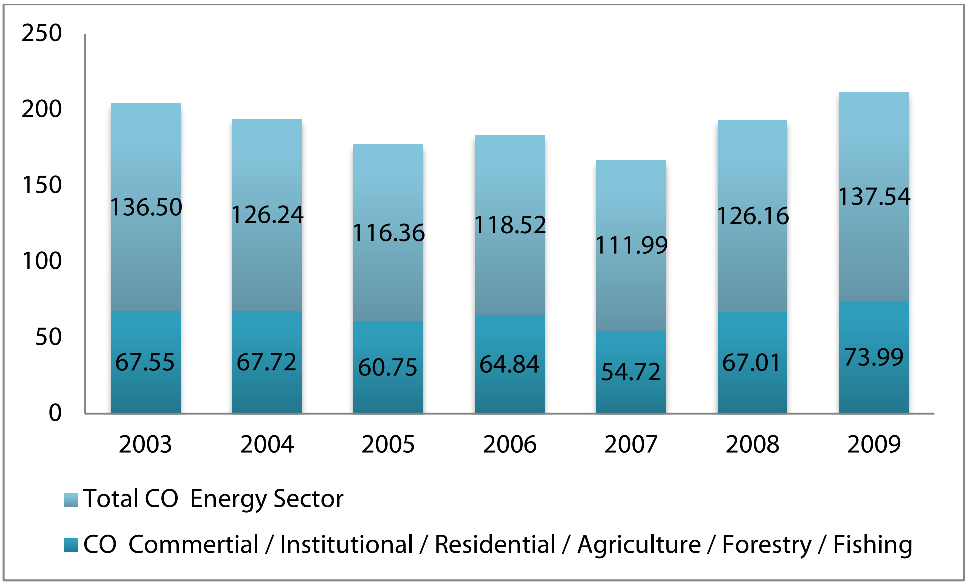


Figure 3.3.2.4.4 CO emissions from commercial / institutional / residential sector / agriculture / forestry / fishing subsectors, and overall CO emissions from the Energy Sector [kt]

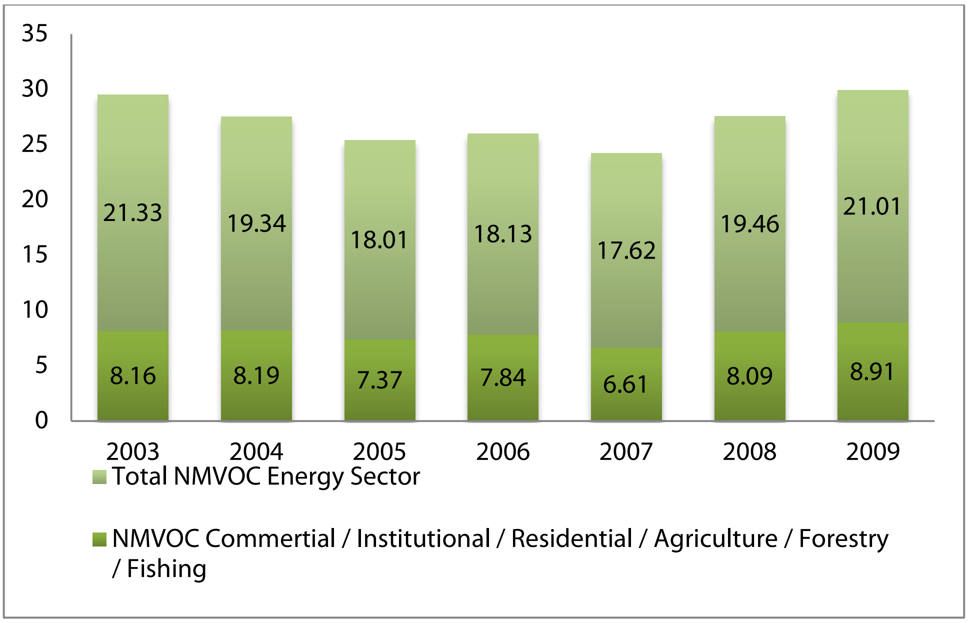


Figure 3.3.2.4.5 NMVOC emissions from commercial / institutional / residential sector / agriculture / forestry / fishing subsectors, and overall NMVOC emissions from the Energy Sector [kt]

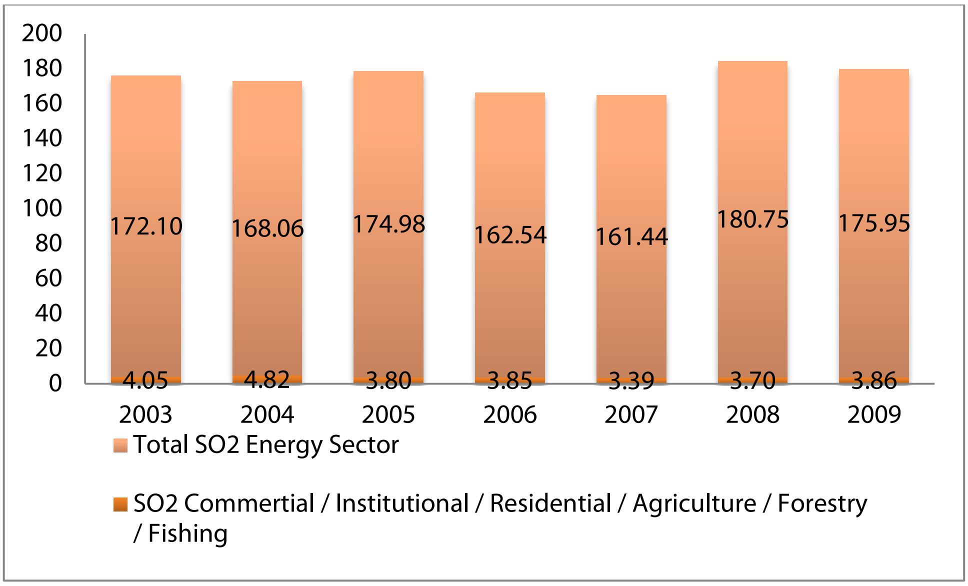


Figure 3.3.2.4.6 SO_2 emissions from commercial / institutional / residential sector / agriculture / forestry / fishing subsectors, and overall SO_2 emissions from the Energy Sector [kt]

3.3.2.5. *OTHER SECTORS*

The fuel combustion activities of 'other sectors' cover those emissions that are not specifically determined elsewhere, such as, for example, the level of fuel consumed by the military. Emissions from other sectors account for an average of 3.89% of overall direct GHG emissions from the Energy sector.

Table 3.3.2.5.1 Fuel consumption from Other Sectors, 2003– 2009, [TJ]

Fuel Consumption [TJ]	Gas / Diesel	Residual	LPG	Lignite	Natural Gas
2003	4,457.31	855.84	71.83	467.65	0.00
2004	3,850.86	958.17	109.79	538.20	0.00
2005	3,791.86	983.94	172.50	308.40	22.11
2006	3,630.96	122.21	207.50	358.64	24.41
2007	3,326.29	103.16	285.62	323.01	30.40
2008	2,618.30	28.18	305.34	74.86	25.67
2009	3,256.70	14.40	294.83	71.30	33.16

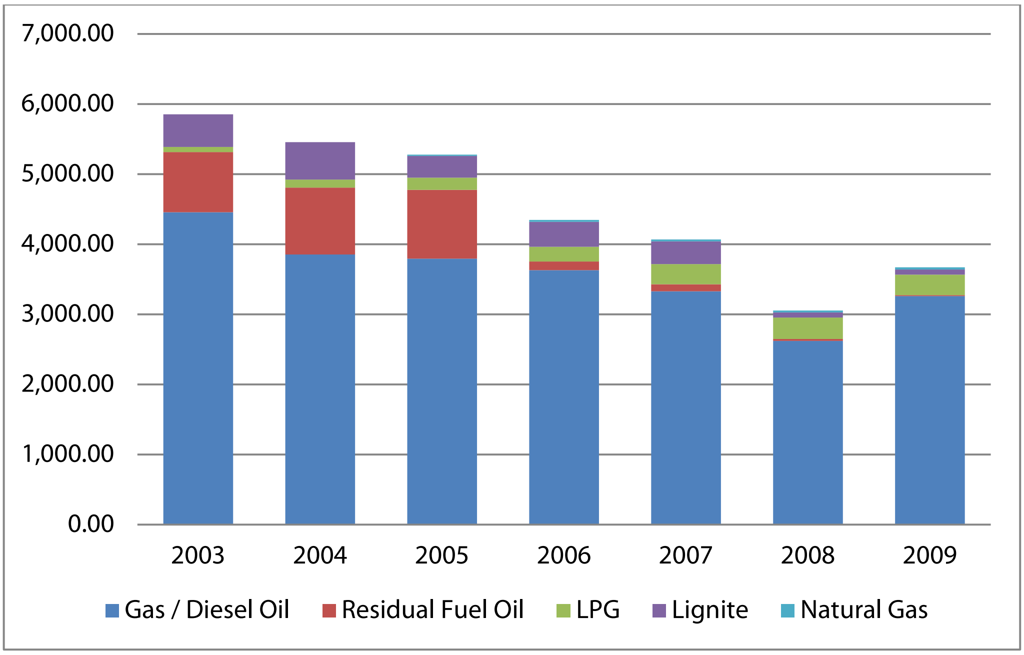


Figure 3.3.2.5.1 Fuel consumption of 'Other Sectors', 2003– 2009, [TJ]

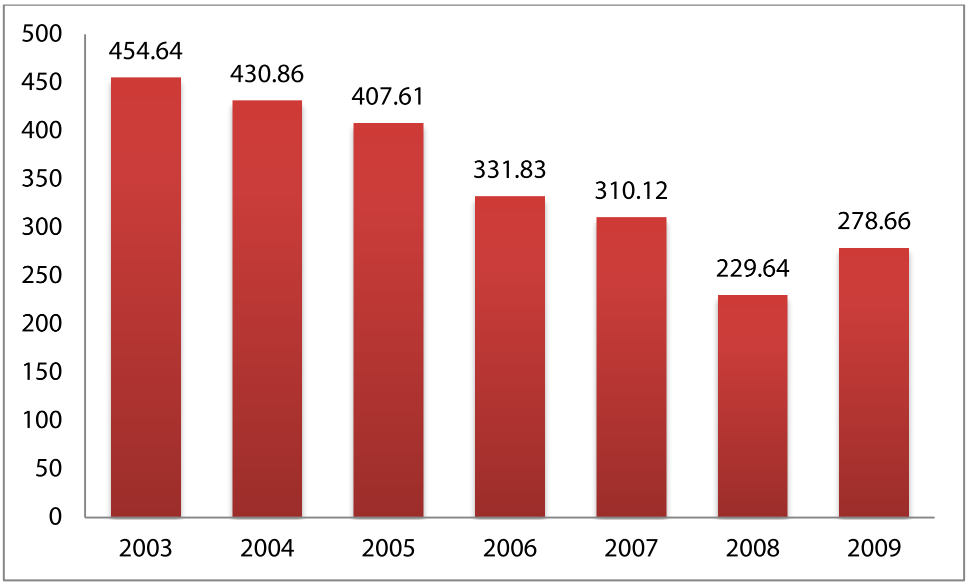


Table 3.3.2.5.2 GHG emissions from the subsector 'Other Sectors' in CO_2 eq. [kt]

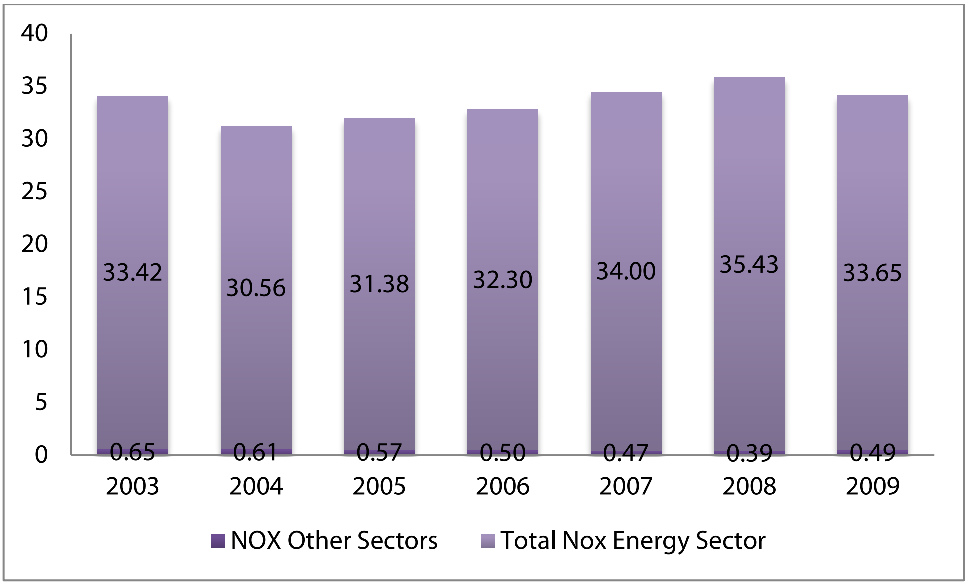


Figure 3.3.2.5.2 NOx emissions from the subsector 'Other Sectors' and overall NOx emissions from the Energy Sector [kt]

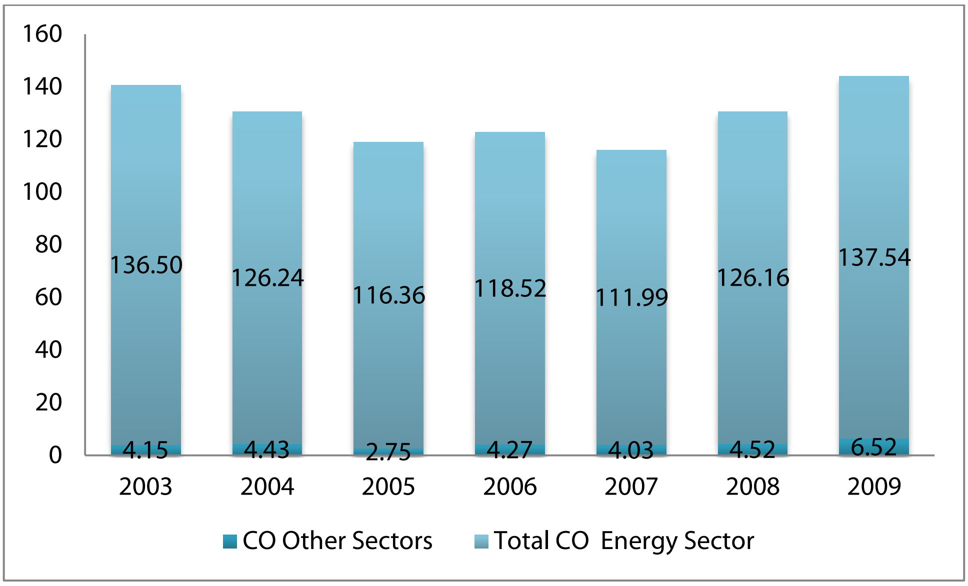


Figure 3.3.2.5.3 CO emissions from the subsector 'Other Sectors' and overall CO emissions from the Energy Sector [kt]

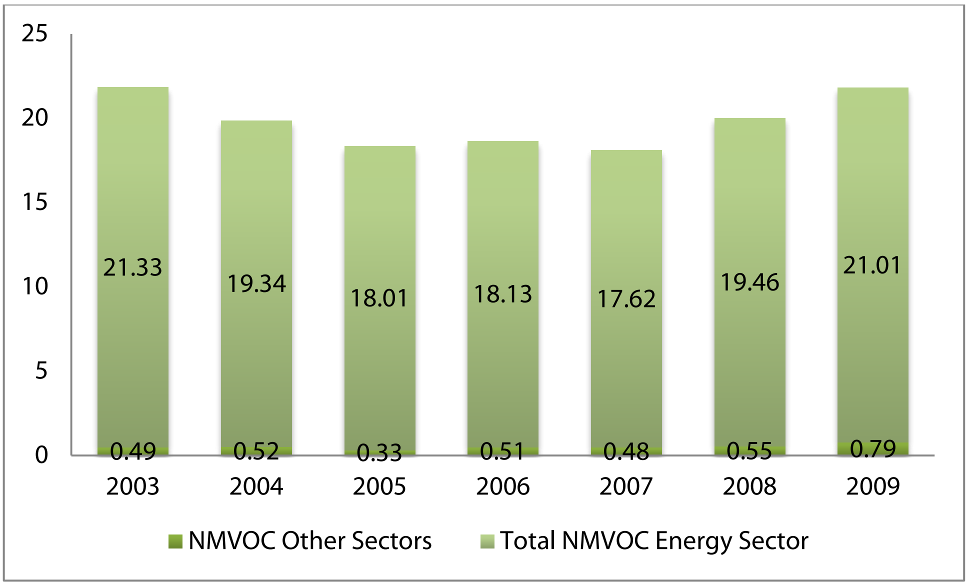


Figure 3.3.2.5.4 NMVOC emissions from the subsector 'Other Sectors' and overall NMVOC emissions from the Energy Sector [kt]

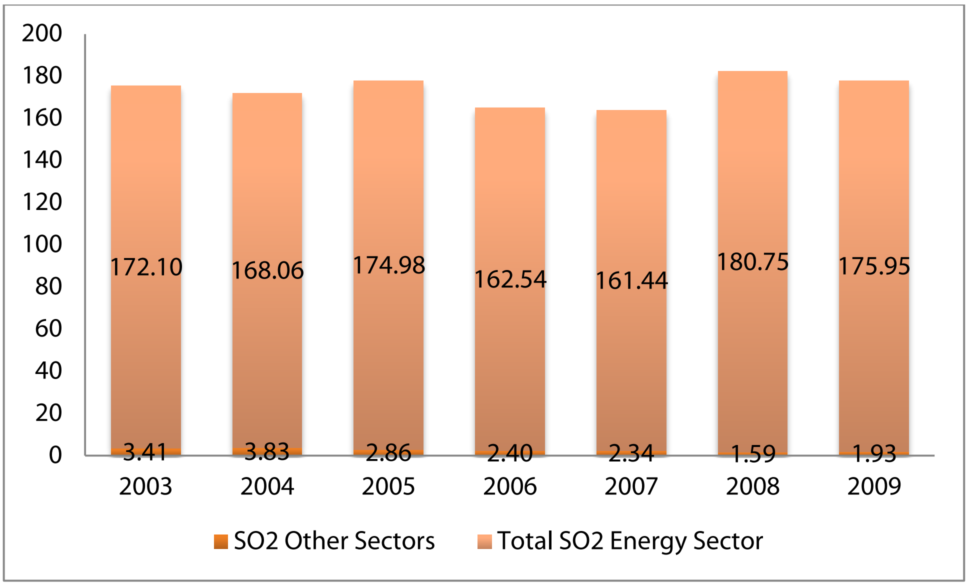


Figure 3.3.2.5.5 SO_2 emissions from the subsector 'Other Sectors' and overall SO_2 emissions from the Energy Sector [kt]

3.3.2.6. FUGITIVE EMISSIONS FROM FUELS

Fugitive emissions from fuels account for an average of 2% of overall emissions from the Energy sector. Fugitive emissions originate from coal mining and handling, as well as the production, refining and distribution of products of the petroleum industry.

There is no domestic production of oil or natural gas in Macedonia, nor any extensively developed pipeline network, and therefore the main source of fugitive emissions from fuels is coal mining and handling.

Direct GHG emissions arising from fugitive emissions from fuels are actually CH_4 emissions, mainly from coal expropriations and coal mining and handling. Emissions from coal mining and handling are dependent of the type of coal that is expropriated and the depth of the mine. Macedonia has surface mines, which have a lower emission factor and emissions potential. The Country-Specific CH_4 Emissions Factor from coal mining and handling for domestic coal lignite is estimated at 1.5m3/m3.

Emissions from coal mining and handling are estimated by using the Tier 1 Global Average Method for surface mines, multiplying surface coal production by an emission factor which in this case is considered a Country-Specific Emissions Factor.

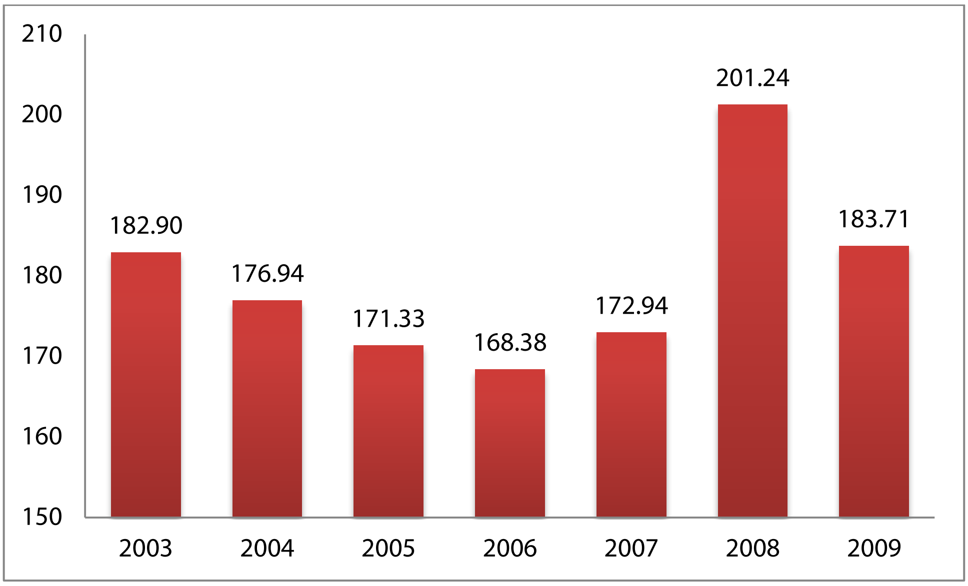


Figure 3.3.2.6.1 CH_4 emissions from fugitive emissions from fuels, expressed in CO_2 eq, 2003–2009 [kt]

Of indirect GHGs emissions, SO_2 has the most significant share because of the high amount of sulphur contained in crude oil and released in the refining process, followed by NMVOC, CO and NOx emissions.

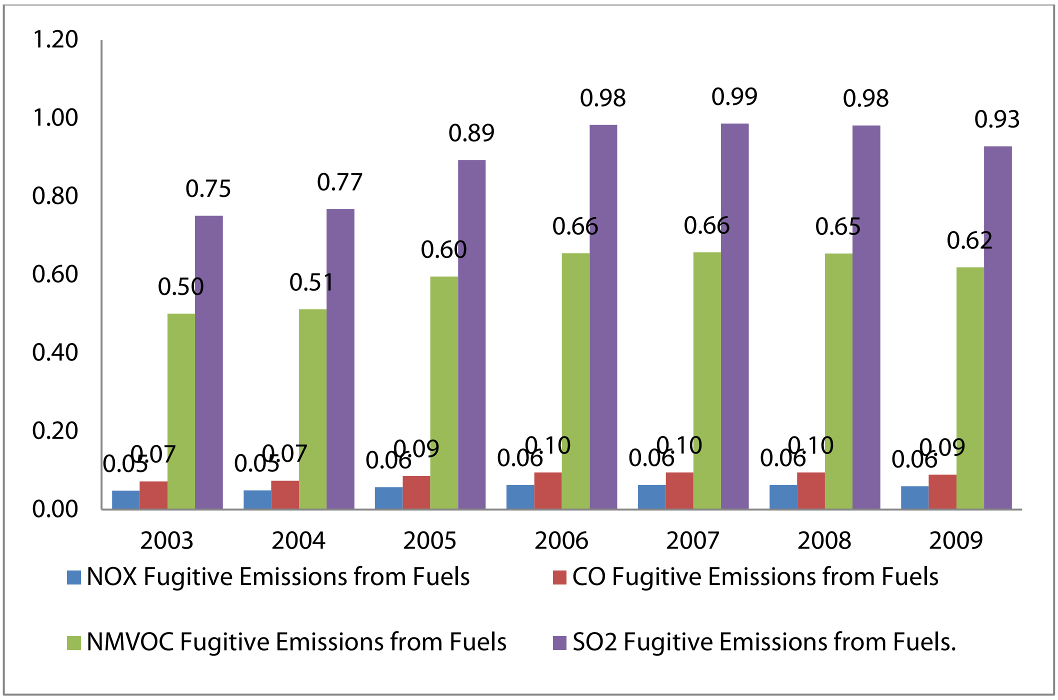


Figure 3.3.2.6.2 Indirect GHG emissions from Fugitive Emissions from Fuels, 2003– 2009 [kt]

3.3.2.7. Memo Items

International Bunkers – Aviation

Emissions from International Aviation were estimated using a detailed Tier 2 methodology based on actual activity data taken from the Macedonian Air Navigation Services Provider.

The fuel used for international aviation was calculated in accordance with the IPCC Good Practice guidelines for GHG Inventories, i.e., by calculating the difference between the total amount of fuel sold for the aviation subsector and the fuel consumed by domestic aviation.

As can be seen from the Tables and Figures below, the level of fuel consumption and the actual number of international flight from Macedonian airports is highly changeable. This is preconditioned by the demand for transport of goods and passengers, which is a main indicator of the economic situation in the region and in the country. An important factor that determines the amount of international traffic in domestic airports is the amount of network connections available at the airport and the most economical and efficient determination of the travel routes.

The sharp decrease in the volume of international aviation in recent years is due to the global economic crisis and decreased demand for international transportation of goods and passengers.

Table 3.3.2.7.1 Fuel Combustion by International Aviation, Tier 2 Approach, 2003– 2009 [TJ]

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Fuel Consumption [TJ]	537.94	523.88	267.48	195.34	288.49	267.70	117.61

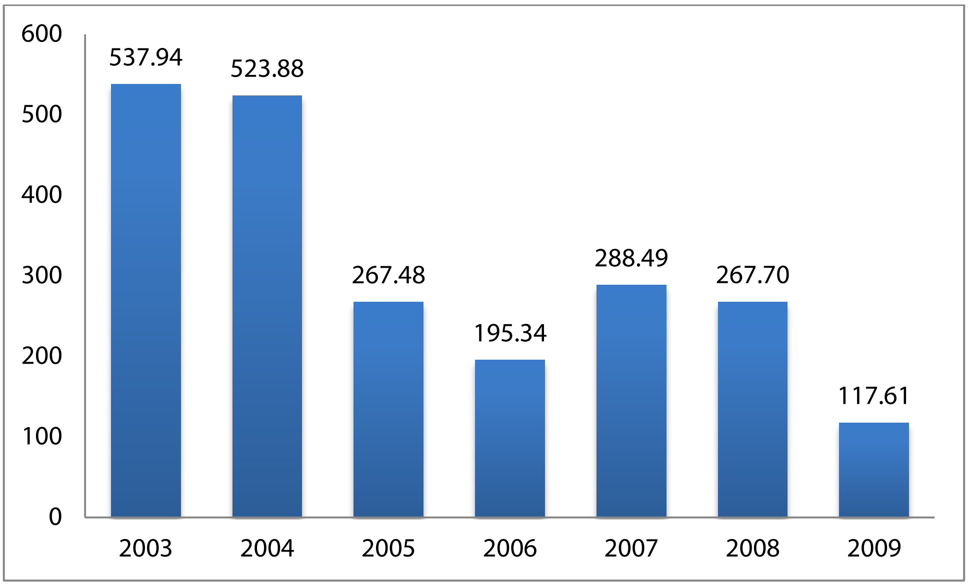


Figure 3.3.2.7.1 Fuel Combustion by International Aviation, Tier 2 Approach, 2003– 2009 [TJ]

Table 3.3.2.7.2 GHG emissions from International Aviation, Tier 2 approach, 2003– 2009 [kt]

Year	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**	**SO_2**
2003	38.77	0.01	0.00	0.19	0.40	0.11	0.01
2004	37.66	0.01	0.00	0.19	0.37	0.10	0.01
2005	19.70	0.00	0.00	0.09	0.39	0.10	0.01
2006	14.44	0.01	0.00	0.06	0.39	0.09	0.00
2007	21.20	0.02	0.00	0.10	0.42	0.10	0.01
2008	19.08	0.02	0.00	0.09	0.41	0.10	0.01
2009	8.77	0.01	0.00	0.04	0.01	0.01	0.00

The amount of CO_2 and non-CO_2 greenhouse gases released by the aviation sector is highly dependent on aircraft technology, the age of the fleet and operating performance. Macedonia lies within a region that is not generally highly economically developed and consequently its own aircraft fleet and those of surrounding countries which operate on Macedonian territory do not incorporate the latest technologies for low cost and low pollution operating performances.

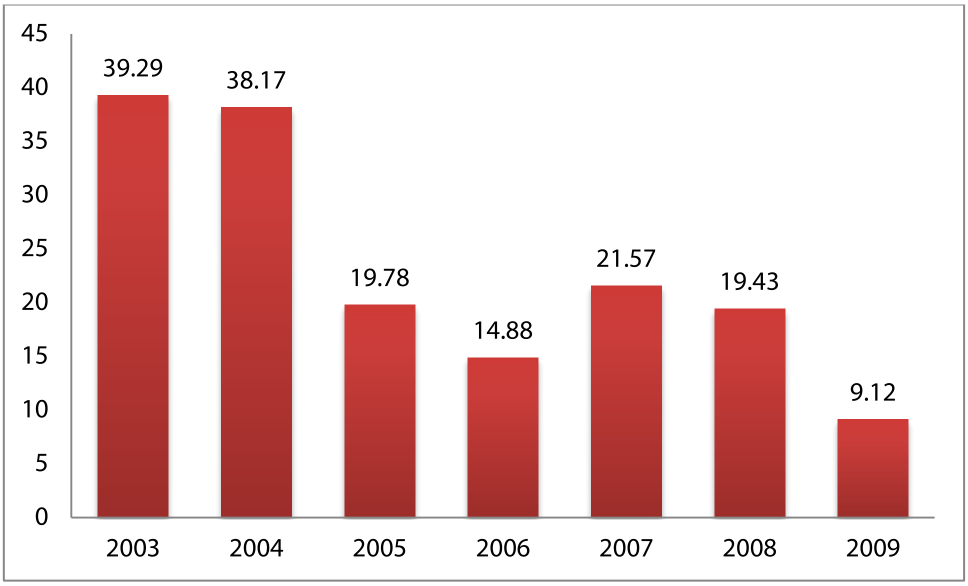


Figure 3.3.2.7.2 GHG emissions from International Aviation in CO_2 eq., Tier 2 approach, 2003– 2009, [kt]

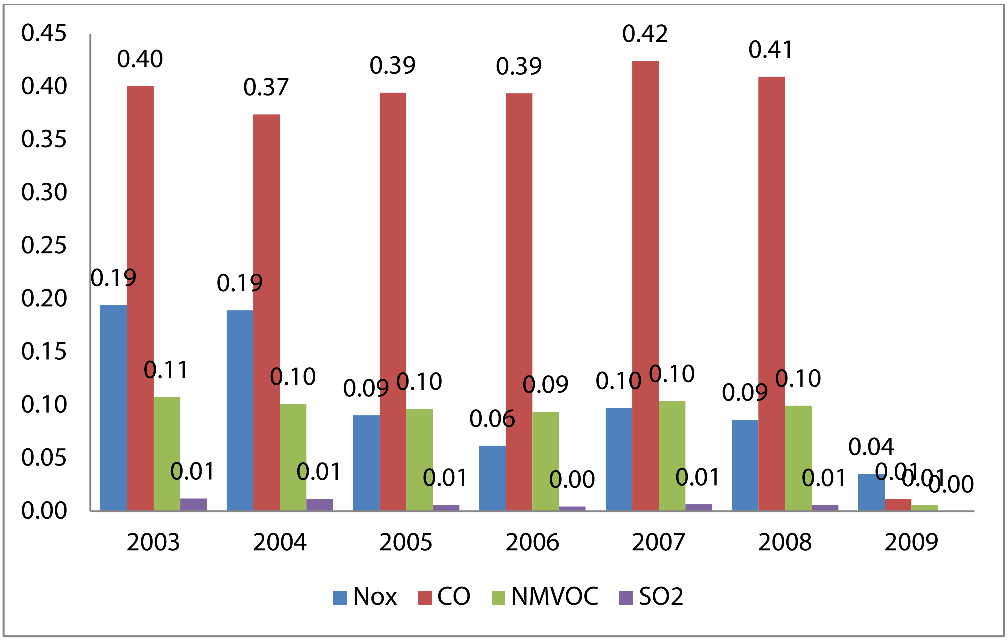


Figure 3.3.2.7.3 Indirect GHG emissions from International Aviation, Tier 2 approach, 2003– 2009 [kt]

CO_2 emissions from biomass

CO_2 emissions from biomass in Macedonia are represented by the combustion of wood biomass. This energy source is generally used by households and the quantity of usage is very difficult to estimate precisely because of illegal wood felling, especially in the rural areas.

The official data on biomass usage were obtained by the State Statistical Office.

Non-CO_2 emissions from biomass usage are considered within the overall estimations for GHG emissions from the general energy sector .

Table 3.3.2.7.3 Total Biomass Consumption by Energy Sector, 2003– 2009 [TJ]

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Biomass Consumption [TJ]	7,159.39	7,153.27	6,465.63	6,933.55	5,878.90	7,193.51	8,072.86

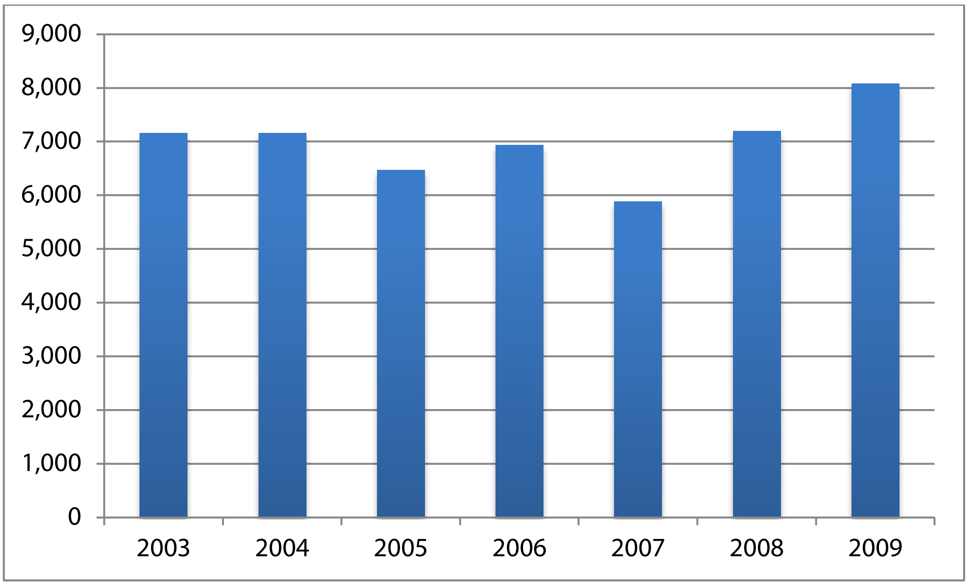


Figure 3.3.2.7.4 Total Biomass Consumption by Energy Sector, 2003–2009 [TJ]

Table 3.3.2.7.4 CO_2 emissions from total biomass consumption by the Energy Sector, 2003–2009 [TJ]

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
CO_2 emissions [kt]	769.21	768.55	672.85	744.95	631.63	772.88	867.43

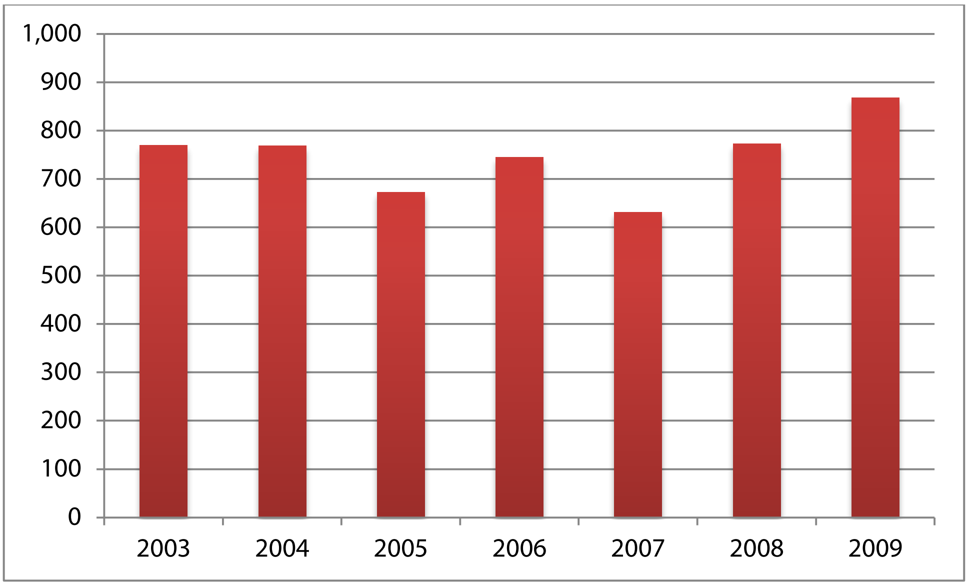


Figure 3.3.2.7.5 CO_2 emissions from total biomass consumption by Energy Sector, 2003–2009 [TJ]

As can be seen from the tables and figures above, the general usage of biomass in the country has been increasing slightly in recent years, and this is due to a continuous increase in the price of other energy sources and increased energy demand.

Consequently, CO_2 emissions from the use of biomass as an energy source have also increased in recent years in the inventory, and this trend is expected to continue in the coming period due to the high costs of electricity and other fuels.

Table 3.3.2.7.5 Biomass Consumption by Energy Subsectors, 2003– 2009 [TJ]

Biomass Consumption [TJ]	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Energy Industries	235.63	187.07	156.29	116.18	90.73	96.92	69.12
Manufacturing Industries and Construction	45.43	78.92	189.33	134.73	88.63	50.03	32.82
Residential Sector	6,525.92	6,508.55	5,851.64	6,275.18	5,311.96	6,534.09	7,300.14
Agriculture / Forestry / Fishing	41.66	53.51	65.23	60.37	56.44	81.60	40.24
Other subsectors	310.74	325.23	203.14	347.09	331.13	430.86	630.53

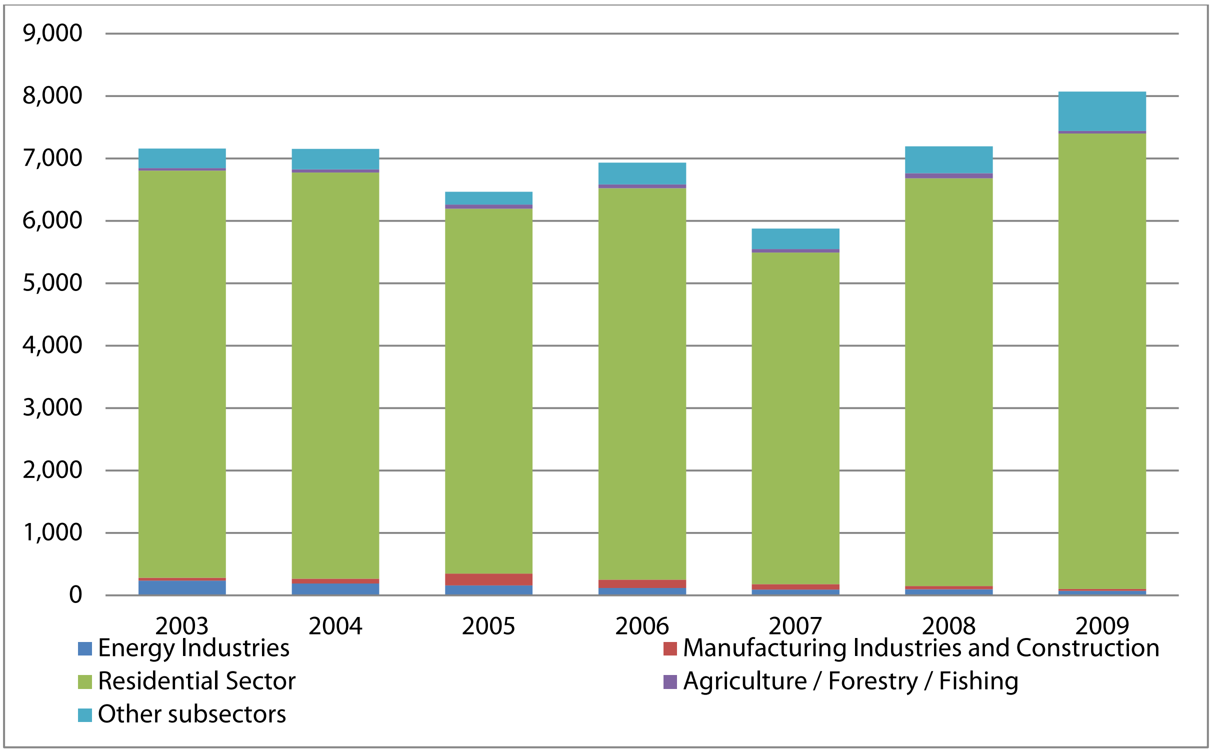


Figure 3.3.2.7.6 Biomass Consumption by Energy Subsectors, 2003– 2009 [TJ]

Table 3.3.2.7.6 CO_2 emissions from Biomass Consumption by Energy Subsectors, 2003– 2009, [kt]

CO_2 emissions [kt]	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Energy Industries	25.32	20.10	16.79	12.48	9.75	10.41	7.50
Manufacturing Industries and Construction	4.88	8.48	20.34	14.48	9.52	5.38	3.53
Residential Sector	701.15	699.28	628.70	674.21	570.72	702.03	784.33
Agriculture / Forestry / Fishing	4.48	5.75	7.01	6.49	6.06	8.77	4.32
Other subsectors	33.39	34.94	0.00	37.29	35.58	46.29	67.74

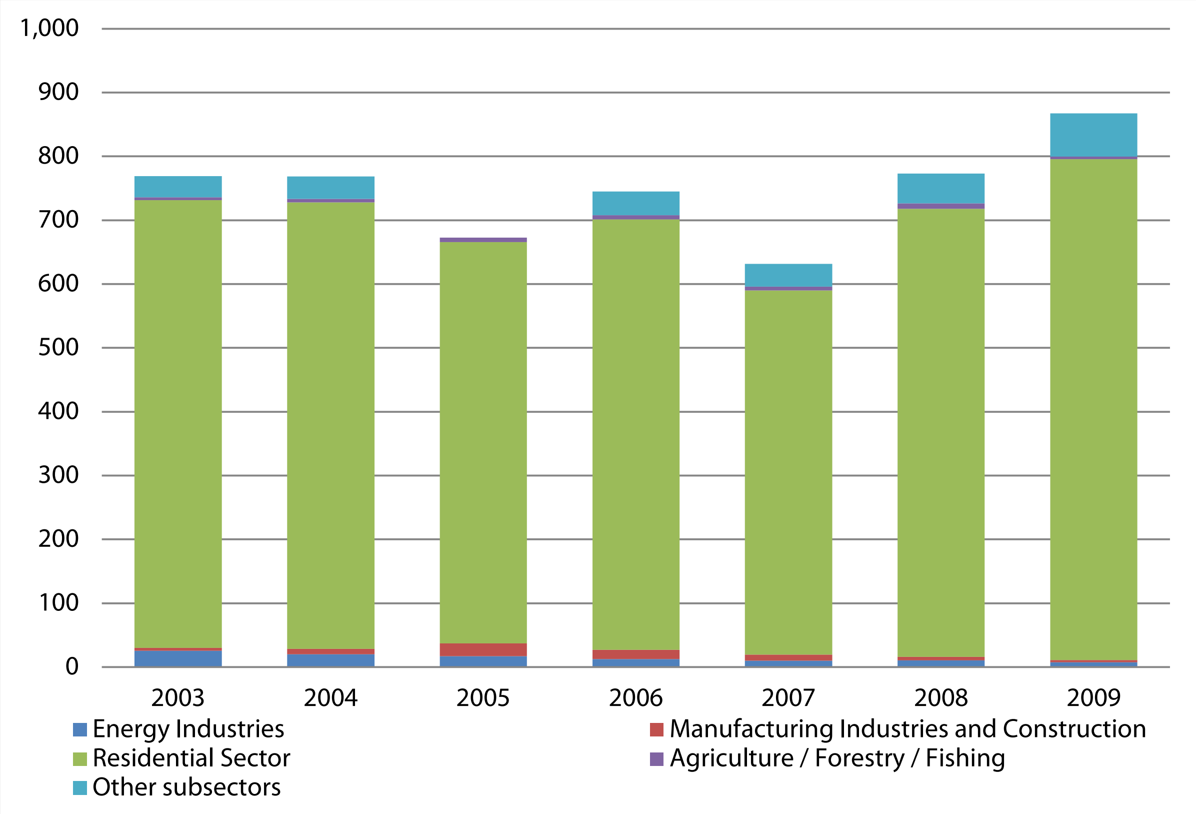


Figure 3.3.2.7.7 CO_2 emissions from Biomass Consumption by Energy Subsectors, 2003–2009 [kt]

3.4. CONCLUSION

The GHG Inventory for the period 2003–2009 clearly shows that the Energy Sector is the main contributor of GHG emissions in Macedonia, accounting for an average of 73.4% of overall GHG emissions for the inventory period 2003–2009.

The Energy Industries subsector is the main contributor to overall emissions from the energy sector, accounting for an average of 49.41% of the country’s total GHG emissions. The use of lignite as fuel for power plants is inefficient in terms of energy delivery, has an extremely negative impact on the environment and is not a sustainable solution for energy production, especially for a country with limited resources of lignite.

A strategic plan for the development of the energy sector and investments in renewable energies and energy efficiency are vital to address the environmental impact of using fossil fuels and the continuous rise in energy prices energy and demand for energy.

The Road Transportation subsector is the second biggest emitter of GHGs in the country, accounting for an average of 9.15% of overall GHG emissions in the country. The emissions from Road Transportation are significant for human health and represent a major ecological problem, especially in densely populated cities.

There is a wide range of mitigation measures for reducing GHG emissions from Road Transportation, starting from the introduction of low carbon fuels, increased control of fuel quality, legal changes for limiting maximum emissions, as well as continuous control of vehicle exhaust emissions.

The third biggest contributor to GHG emissions from the Energy Sector is the subsector of Manufacturing Industries and Construction. This sector is also the fifth biggest emitter of key source GHGs in the country, with an average contribution of 7.97%.

The implementation of greener technologies and increased energy efficiency in the Industrial sector is a vital strategic step to reduce emissions and reduce the cost of energy use in the Manufacturing Industries and Construction. At the same time it is an important step towards achieving the country’s EU aspirations and its inclusion in the EU Emission Trading Scheme.

4. INDUSTRIAL PROCESSES

4.1. INTRODUCTION

Greenhouse gas emissions are generated by a wide variety of industrial activities. The main emission sources are those industrial processes that chemically or physically transform material. Examples include blast furnacing in the iron and steel industry, while ammonia and other chemical products manufactured from fossil fuels used as chemical feedstock and the cement industry are notable examples of industrial processes that release a significant amount of CO_2. During these processes, many different greenhouse gases can be produced, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N2O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). In addition, greenhouse gases often are used in products such as refrigerators, foams or aerosol cans. For example, HFCs are used as alternatives to ozone-depleting substances (ODS) in various types of product applications. Similarly, sulphur hexafluoride (SF_6) and N2O are used in a number of products in industry (e.g., SF_6 is used in electrical equipment, N2O is used as a propellant in aerosol products, primarily in the food industry) or by end-consumers (e.g., SF_6 used in running-shoes, N2O used in anaesthesia). A notable feature of these product uses is that, in almost all cases, significant time can elapse between the manufacture of the product and the release of the greenhouse gas. The delay can vary from a few weeks (e.g., for aerosol cans) to several decades, as in the case of rigid foams. In some applications (e.g., refrigeration), a fraction of the greenhouse gases used in the products can be recovered at the end of the product's life and either be recycled or destroyed. In addition, several other fluorinated greenhouse gases may be used in special processes, as for example in semiconductor manufacture:

- nitrogen trifluoride (NF_3);
- trifluoromethyl sulphur pentafluoride (SF_5CF_3);
- halogenated ethers (e.g.,$C4F_9OC_2H_5$,$CHF_2OCF_2OC_2F_4OCHF_2$, $CHF_2OCF_2OCHF_2$);

and other halocarbons not covered by the Montreal Protocol, including CF_3I, CH_2Br_2, $CHCl_3$, CH_3Cl, CH_2Cl_2.

4.1.1. GHG INVENTORY UP TO 2002

For the purpose of the Second National Communication on Climate Change, an inventory of emissions of greenhouse gases for the period 1999–2002 has been made in accordance with IPCC methodology. 2000 was taken as the base year and more detailed information has been provided for that particular year. In the process of creating the inventory for the Industry sector, a revision was made to the GHG Inventory prepared for the First National Communication on Climate Change. The reported inventory contained data on emissions of 8 gases from the industrial sector: CO_2, CH_4, HFC, SF_6, CO, SO_2, NOx and NMVOC.

The period covered by the Second National Communication was most turbulent in terms of industrial activities. During the process of restructuring and privatization, many companies ceased to operate or reduced their production rate to a minimum. Some companies reduced their production rate to 10% of the design capacity. Very few industrial activities remained steady over the period 1999–2002. Some of these either further reduced production rates or were shut down after 2002.

Due to the disintegration of some of the biggest companies into several smaller firms, notably in iron and steel production and manufacturing, a divergence occurs between production and manufacture and GHG emissions. Most of the data for the inventory for the period 1999–2002 was drawn from relevant editions of the State Statistical Office reports or, in some rare cases, data were received directly from the operators, while the calculation methodologies used the 1996 IPCC Guidelines for National Greenhouse Gas Inventories. All of the emissions in the inventory for the Second National Communication were calculated according to Tier 1. The produced data is given in the tables below.

Table 4.1.1.1. Greenhouse gas emissions from the industrial sector in the period 1990–2002 [kt]

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
kt	**Mineral Industry**	350.80	327.14	285.90	273.03	258.18	277.11	254.65	311.10	234.14	290.39	411.54	304.53	367.66
	Metal Industry	538.49	581.56	671.87	558.21	458.27	516.00	565.01	599.14	659.12	452.04	448.95	504.02	385.67
	Chemical Industry	0.00	0.00	0.00	0.21	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Food and Drinks	0	0	0	0	0	0	0	0	0	0	0	0	0
	Use of HFC & SF_6										8.35	33.57	128.84	39.04
	Total	**889.29**	**908.70**	**957.77**	**831.46**	**716.66**	**793.32**	**819.66**	**910.24**	**893.26**	**750.79**	**894.06**	**937.39**	**792.37**
%	**Mineral Industry**	39.45	36.00	29.85	32.84	36.02	34.93	31.07	34.18	26.21	38.68	46.03	32.49	46.40
	Metal Industry	60.55	64.00	70.15	67.14	63.95	65.04	68.93	65.82	73.79	60.21	50.21	53.77	48.67
	Chemical Industry	0.00	0.00	0.00	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Food and Drinks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Use of HFC & SF_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	3.75	13.74	4.93

Table 4.1.1.2. Contribution of individual GHGs to the total CO_2-eq emissions from the Industrial sector in the period 1990–2002

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CO_2	818.5	838.8	886.8	766.5	664.13	738.1	745.6	835.8	819.91	676.0	780.6	733.1	679.02
CH_4	-	0.19	-	0.12	0.11	0.17	0.05	0.05	0.05	-	0.01	-	-
CO	70.70	69.89	70.89	64.71	52.32	54.93	74.04	74.39	73.35	66.43	79.84	75.41	74.31

HFC & SF_6	-	-	-	-	-	-	-	-	-	8.33	33.53	128.8	39.04
Total	**889.2**	**908.8**	**957.7**	**831.3**	**716.5**	**793.2**	**819.7**	**910.3**	**893.2**	**750.7**	**894.0**	**937.3**	**792.3**
CO_2	92.05	92.29	92.60	92.20	92.68	93.05	91.07	91.82	91.86	90.04	87.32	78.21	86.02
CH_4	-	0.02	-	0.01	0.02	0.02	0.01	0.01	0.01	-	0.00	-	-
CO	7.95	7.69	7.40	7.78	7.30	6.92	8.92	8.17	8.13	8.85	8.93	8.05	9.41
HFC & SF_6	-	-	-	-	-	-	-	-	-	1.11	3.75	13.74	4.57
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

4.2. INDUSTRIAL PROCESSES INVENTORY 2003–2009

4.2.1. DATA SOURCES

Industry has one of the most important roles to play in the development of the Macedonian economy. Rapid industrial development of is one of the most important drivers of economic growth, with the potential to have a transformative effect on socio-economic relationships and standards and manners of living, as well as encouraging, increased interest in technical progress.

This development of industry and its major socio-economic influences imposed the need for more complex monitoring and analysis of this sector. Since 1952, the index of industrial production and natural data of production has been calculated regularly by the State Statistical Office, thereby obtaining an optimal amount of data needed for producing the GHG Inventory for the Industry and Product Use Sector.

The State Statistical Office covers the following three sections in the Industry Sector: **B - Mining and quarrying; C – Manufacturing;** and **D - Electricity, gas, steam and air-conditioning supply** (divisions 05 to 35 from the **National Classification of Activities (NKD Rev 2)**).

According to the value added data for 2005, industrial production in general was dominated by the following divisions: 10 - Manufacture of food products (11.47%); 35 - Electricity, gas, steam and air conditioning supply (12.43%); 24 - Manufacture of basic metals (11.47%); 14 - Manufacture of wearing apparel (11.32%); 23 - Manufacture of other non-metallic products (7.46%); 12 - Manufacture of tobacco products (5.81%); 11 - Manufacture of beverages (4.91%); and 19 - Manufacture of coke and refined petroleum products (4.53%).

In addition to the data provided by the State Statistical Office, other international data sources were used, such as UN industrial production statistics that give the data (in physical units) by commodity and country for all years and almost all commodities relevant for emission inventories (http://unstats.un.org/unsd/industry/commoditylist2.asp?Lg=1&S=3) and Eurostat PRODCOM data (Eurostat, 2005) for many European countries.

An added value from preparing a more comprehensive inventory within the Third National Communication is that of enhanced cooperation with relevant installations and institutions (such as the Chamber of Commerce) in identifying data which are collected but which are used only internally for the needs of the institution.

Emission factors and other parameters with background documentation or technical references were derived from the IPCC Emission Factor Database (EFDB), which contains the IPCC default data, IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, and data from peer-reviewed papers and other publications, including National Inventory Reports (NIRs). The emission factors were compared to those used in the Second National Communication. Furthermore, country-specific emission factors were calculated for the sub-categories of Cement Production, Steel Production and Ferro-alloy Production. These emission factors are given in the publication entitled 'National C_2O and non-C_2O emission factors for key sectors under IPCC and CORINAIR methodologies'.

4.2.2. METHODOLOGY FOR DATA IDENTIFICATION

Allocating emissions from the use of fossil fuels between the Energy sector and the Industrial processes sector can be difficult. Feedstock and reductant uses of fuels frequently produce gases that may be combusted to provide energy for the process. Part of the feedstock may be combusted directly for heat, for example. And this can lead to uncertainty and ambiguity in reporting. To help overcome this problem, the IPCC Inventory Guidelines were used to allocate CO_2 emissions released from the combustion of fuel to the subcategory of fuel combustion within the energy source category or to the industrial process source category.

Emissions from the combustion processes (*i.e., the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus*) are reported in the Energy sector, while emissions from non-energy use of fuels are reposted in the IPPU sector. These types of use can be classed as feedstock and reductant or non-energy products.

The IPCC Guidelines do not cover methodologies for estimating emissions of precursors (NOx, NMVOC, CO, SO_2 and NH3). Emissions of these gases were estimated using the EMEP/CORINAIR Emission Inventory Guidebook (EEA, 2005). This guidebook has been developed for emission inventories of substances regulated under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP) and covers all source sectors; it should therefore be considered as the primary source of information for the estimation of these emissions. Table 7.1 from the Inventory Excel sheets provides a link between the IPCC source categories and the corresponding methodology chapters in the EMEP/CORINAIR Emission Inventory Guidebook. This table provides information on the specific EMEP/CORINAIR chapter in which methodological guidance can be found on NOx, CO, NMVOC and SO_2.

4.2.3. INVENTORY

For the purposes of the Third National Communication, country-specific emission factors were developed in close collaboration with the industrial plants. A leap forward was made in the used of methodology, especially in the Metal Production sub-category where emissions were calculated according to Tier 2 and the exact amount of feedstock used and its carbonate content data were taken into account. The plant-specific data for Iron and Steel Production was taken from the A integrated environmental permit and the data for ferro-alloys production was gathered directly from the industrial plants. Country-specific emission factors were also developed for the cement industry, with data collected directly from the only cement production plant in the country, Usje Titan. Data on annual clinker production were not available for the period 2003–2009 and so clinker production was calculated from the cement production data. This implies that the GHG emissions from cement production are calculated according to Tier 1 methodology.

Table 4.2.3.1. Production of industrial goods in the period 2003–2009 [kt]

Categories	ACTIVITY RATE [kt]						
	2003	2004	2005	2006	2007	2008	2009
2 - Industrial Processes and Product Use							
2. A - Mineral Industry							
Cement production	768.00	752.00	854.95	867.00	902.13	861.90	854.95
Lime production	6.19	9.03	2.71	11.18	5.33	0.00	2.71
Limestone and Dolomite Use	25.11	26.94	2.36	30.88	31.87	22.12	23.56
Soda Ash (Production and Use)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Road Paving	249.91	650.56	197.91	172.94	104.74	216.35	197.91
Glass Production	0.00	0.00	0.11	0.00	0.17	0.10	0.11
Concrete Pumice Stone	167.16	123.04	59.72	190.19	69.22	56.45	59.72
2.B - Chemical Industry							
Polyvinyl chloride	15.77	12.30	4.55	7.69	3.18	5.51	4.55
2.C - Metal Industry							
Iron and Steel Production	583.87	626.60	547.92	718.13	741.06	514.37	547.92
Ferroalloy Production	55.53	72.08	19.66	69.97	120.01	112.63	19.66
Aluminium production	3.79	0.19	0.38	0.23	0.07	0.02	0.38
2.H - Other							
Pulp and Paper Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Food Industry	208.67	200.32	375.24	179.82	299.81	316.54	375.24
Beverages Industry [hl]	1,678.21	1,528.16	1,514.18	1,384.49	1,626.25	1,541.43	1,514.18

Industrial production in the period 2003-2009 was stable in some sectors but fluctuated in others. Cement Production and Commodities Production were stable throughout the whole time series. The highest fluctuations occurred in the Metal Production category. Ferroalloy production increased in 2007 and 2008 due to the production of Ferro-silico-manganese, which was absent the previous year and then experienced a sudden downturn as a result of the world economic crisis. Iron and steel production also increased until 2007 before declining as a result of the global crisis. Limestone use was calculated on the basis of steel production data.

As can be seen from Tables 4.2.3.1. and 4.2.3.2., emissions from the Industrial Processes category mainly derive from Cement production and Metal Production. In the Key category analysis, Cement Production and Ferro-alloy Production were identified as key categories. Also, the HFCs consumption in refrigeration and air-conditioning is identified as a key category in the period of 2004–2008 because of the high GWP of the HFCs. This category does not appear as a key category in 2003 and 2009 due to a lack of data.

Emissions of indirect GHGs are calculated for each subcategory (Table 4.2.3.4.). From the displayed results it can be seen that the highest emitters of SO_2 are the Mineral Industry and the Metal Industry, while NMVOCs are mostly emitted during the road-paving process and the production of food and beverages. In accordance with the IPCC Good Practice Guidance, emissions of indirect GHGs are not included in the calculation of total CO_2-eq emissions.

Table 4.2.3.2. Greenhouse gas emissions from the industrial sector in the period 2003–2009 [kt]

Categories	CO_2**-eq [kt]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Industrial Processes and Product Use	599.55	971.68	1,075.91	784.67	943.66	974.96	443.98
Mineral Industry	286.51	283.92	314.81	327.87	336.05	313.38	313.71
Cement production	270.57	264.93	291.35	305.44	317.82	303.65	301.20
Lime production	4.89	7.13	11.21	8.84	4.21	0.00	2.14
Limestone and Dolomite Use	11.05	11.86	12.24	13.59	14.02	9.73	10.37
Soda Ash Production and Use	NE	NE	NE	NE	NE	NE	NE
Chemical Industry							
Ammonia Production	NO	NO	NO	NO	NO	NO	NO
Nitric Acid Production	NO	NO	NO	NO	NO	NO	NO
Adipic Acid Production	NO	NO	NO	NO	NO	NO	NO
Carbide Production	NO	NO	NO	NO	NO	NO	NO
Metal Industry	290.55	357.24	388.91	355.71	380.76	387.28	130.27
Iron and Steel Production	52.72	56.59	58.49	64.75	66.83	46.42	49.42
Ferroalloy Production	231.12	300.31	330.38	290.55	313.80	340.83	80.18
Aluminium production	6.72	0.34	0.04	0.41	0.13	0.03	0.66
SF_6 Used in Aluminium and Magnesium Foundries	NA	NA	NA	NA	NA	NA	NA
Production of Halocarbons and Sulphur Hexafluoride	NO	NO	NO	NO	NO	NO	NO

Consumption of halocarbons and sulphur hexafluoride	22.49	330.53	372.19	101.09	226.85	274.30	0.00

Table 4.2.3.3. Contribution of individual subsectors to the total CO_2-eq emissions from the Industrial sector in the period 2003-2009

Categories	CO_2**-eq [kt]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Industrial Processes and Product Use							
Mineral Industry	47.79%	29.22%	29.26%	41.78%	35.61%	32.14%	70.66%
Metal Industry	48.46%	36.77%	36.15%	45.33%	40.35%	39.72%	29.34%
Consumption of halocarbons and sulphur hexafluoride	3.75%	34.02%	34.59%	12.88%	24.04%	28.13%	0.00%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

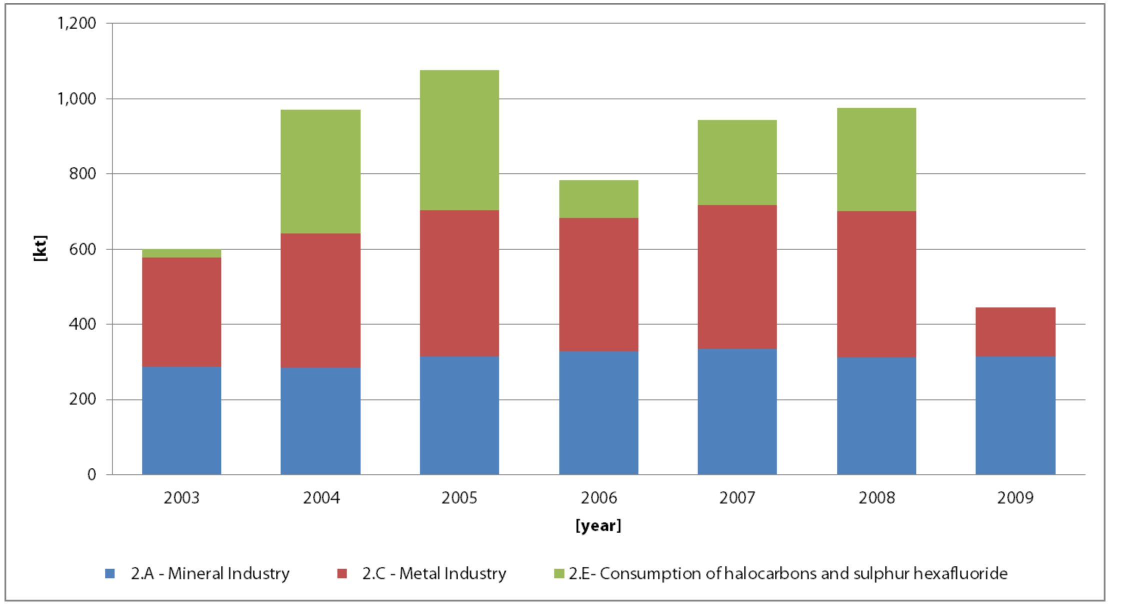


Figure 4.2.3.1. Greenhouse gas emissions from the industrial sector in the period 2003–2009 year [kt CO_2-eq]

Table 4.2.3.4. Emissions from indirect greenhouse gasses in the period 2003–2009 [t]

Industrial Processes	[t]						
	2003	2004	2005	2006	2007	2008	2009
A Mineral Products							
NOx	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO_2	313.98	287.12	319.91	355,20	305,25	286,79	286,34
CO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOCs	79,970.12	208,178.19	162,672.91	55,341.28	33,519.13	69,232.20	63,332.08
B Chemical Industry							
NOx	1,432.28	1,116.57	707.97	698.43	288.83	499.85	412.87
SO_2	121.74	0.14	0.09	0.09	0.04	0.06	0.05
CO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NMVOCs	121.74	94.91	60.18	59.37	24.55	42.49	35.09
C Metal Production							
NOx	26.73	21.21	27.66	13.55	15.16	13.97	12.78
SO_2	74.76	26.14	31.35	17.95	17.90	15.90	18.80
CO	512.52	26.71	3.39	31.38	10.10	2.37	50.92
NMVOCs	13.93	15.59	20.71	9.79	11.25	10.45	8.98
D Other Production							
NOx	0,00	0,00	0,00	0,00	0,00	0,00	0,00
SO_2	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CO	0,00	0,00	0,00	0,00	0,00	0,00	0,00
NMVOCs	1,090.29	1,116.84	1,216.71	1,020.03	1,310.12	1,465.10	1,313.81

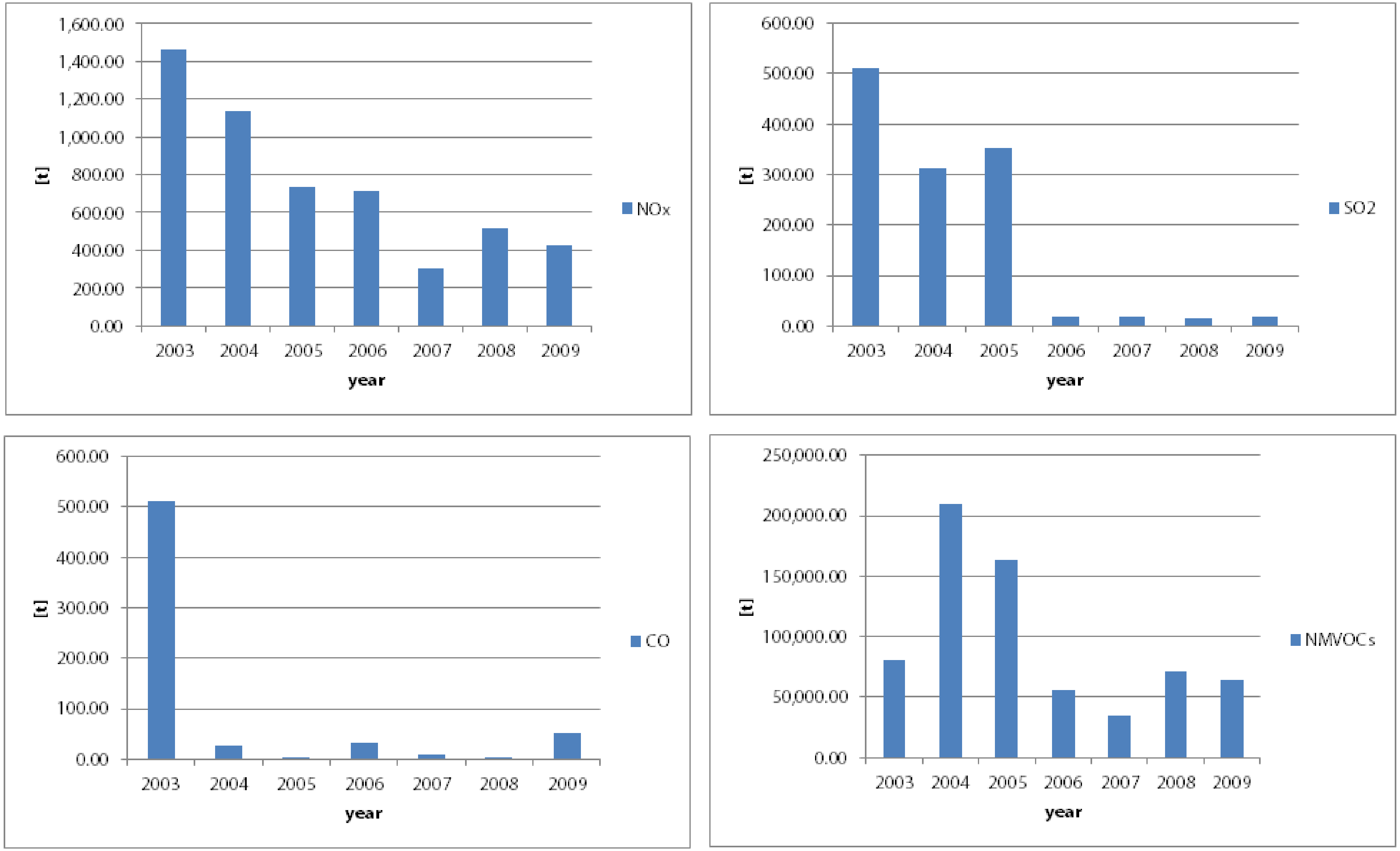


Figure 4.2.3.2. Emissions from indirect greenhouse gasses in the period 2003–2009 [t]

MINERAL PRODUCTS

Carbon dioxide (CO_2) emissions result from the use of carbonate raw materials in the production and use of a variety of mineral industry products. There are two broad pathways for the release of CO_2 from carbonates: calcination and the acid-induced release of CO_2. In the Mineral industry the emissions result from the calcination of carbonate materials. Although the principal process by which calcination-related emissions are released is similar among the source categories in the mineral industry in Macedonia, the Cement industry is a source category and also contributes the most to overall CO_2 emissions in the country.

Table 4.2.3.5. Greenhouse gas emissions from the mineral industry sector [kt CO_2-eq]

Categories	CO_2-eq [kt]						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Mineral Industry	**286.51**	**283.92**	**314.81**	**327.87**	**336.05**	**313.38**	**313.71**
Cement production	270.57	264.93	291.35	305.44	317.82	303.65	301.20
Lime production	4.89	7.13	11.21	8.84	4.21	0.00	2.14
Limestone and Dolomite Use	11.05	11.86	12.24	13.59	14.02	9.73	10.37

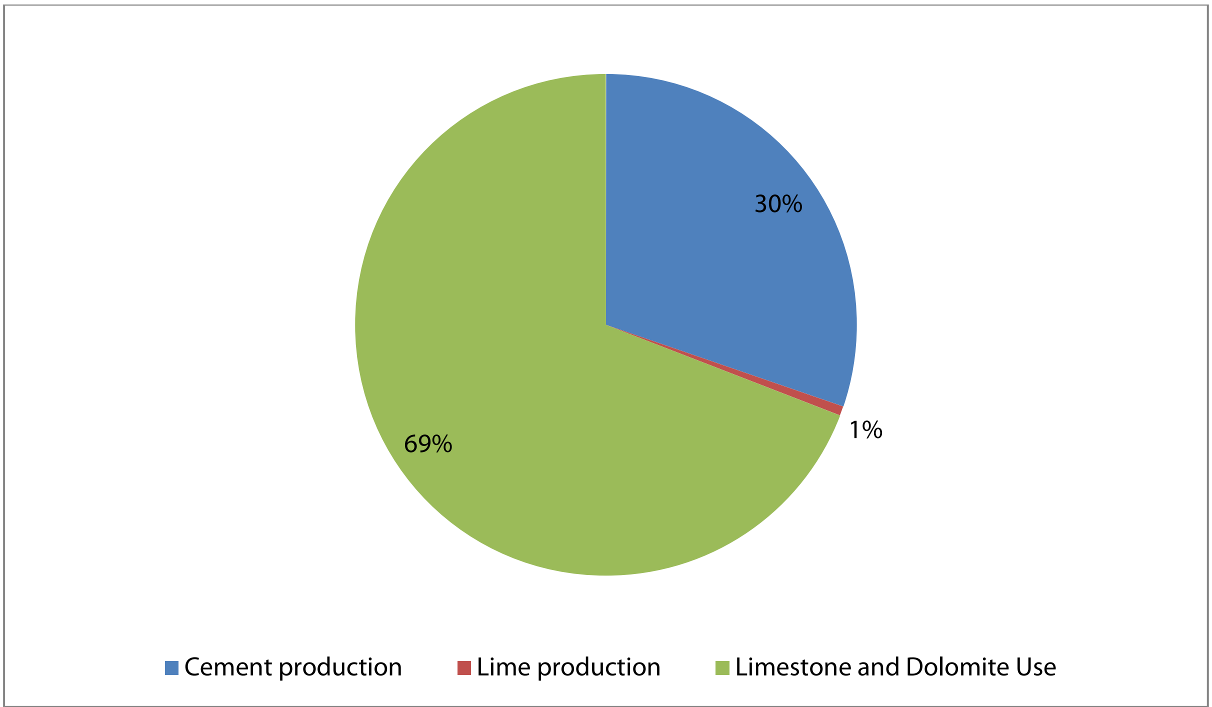


Figure 4.2.3.3. Share of emissions by subsectors in the mineral industry (average values) [%]

Cement production

In cement manufacture, CO_2 is produced during the production of clinker, a nodular intermediate product that is then finely ground, along with a small proportion of calcium sulfate (gypsum or anhydrite), into hydraulic (typically Portland) cement. There is one cement production factory in the country: Titan Cementarnica Usje A.D. Skopje. Marlstone is used as basic mineral raw material and is obtained from the Usje open-cast mine that located within the factory. Marlstone, as a non-metallic mineral raw material, is a basic component in the production of clinker, i.e., cement. Other components are used, apart from marlstone, in order to form fly ash, from which the semi-finished product, i.e., clinker, is obtained. Firstly, the emissions in the inventory were calculated based on the Tier 1 method in which estimates for clinker production are inferred from cement production data, correcting for imports and exports of clinker. The estimation of emissions directly from cement production (i.e., applying an emission factor directly to cement production without first estimating clinker production) is not considered a good practice method because it does not account for clinker imports and exports., The State Statistical Office does not publish data on clinker production and therefore this data had to be collected directly from the Cement production installation. In the beginning, there were no available data for clinker production in Macedonia. However, it was known that the average fraction of clinker in cement in Macedonia was 0.65 and therefore the assumption was made that all the clinker used in the cement process was produced in the country. And because clinker is produced in a closed circular process, no cement kiln dust (CKD) correction factor was considered because cement kiln dust is returned back into the raw material. More precise data was obtained from the only industrial plant for cement production: Titan Cementarnica Usje Skopje. According to the data received from Titan Cementarnica Usje Skopje, the (CaO share in clinker amounts to 0.65, and the MgO share in clinker amounts to 0.029. A relevant value for the CO_2 emission factor, which amounts to 0.54215 (tonnes of CO_2/ tonnes of clinker), was thus obtained.

Cement and clinker production and GHG emissions over the period 2003–2009 are given in the tables below with corresponding graphical representation.

Table 4.2.3.6. Production of cement and clinker in the period 2003–2009 [kt]

ACTIVITY RATE	[kt]						
	2003	2004	2005	2006	2007	2008	2009
Cement production	768	752	827	867	902	862	855
Clinker production	499	489	538	564	586	560	556

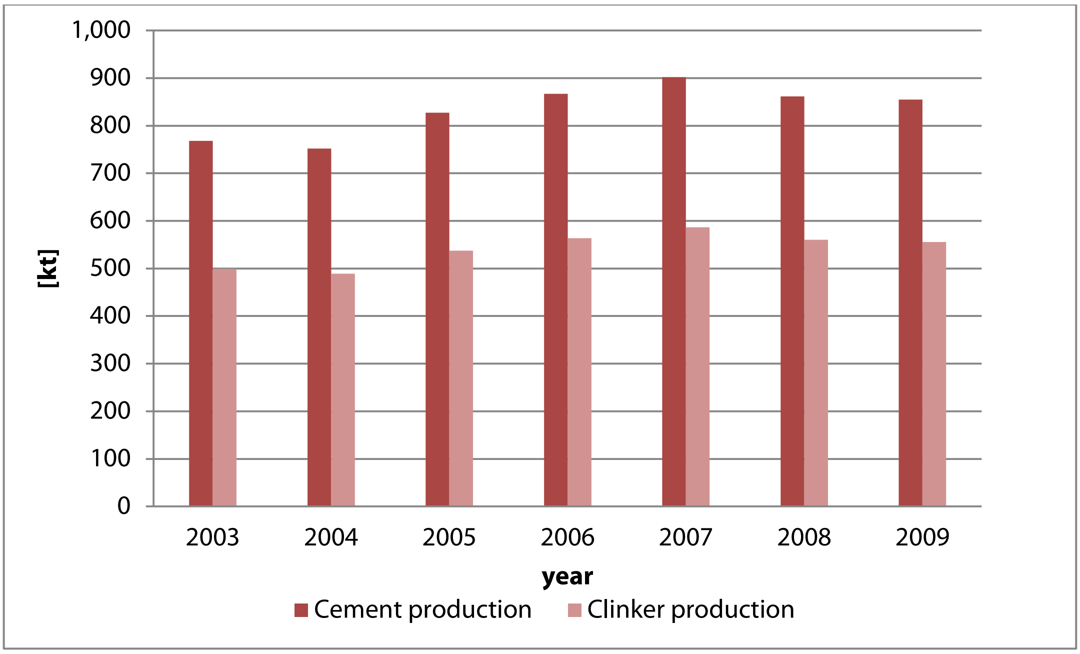


Figure 4.2.3.4. Production of cement and clinker in the period 2003–2009 [kt]

Table 4.2.3.7. Emissions of CO_2-eq in the cement production subsector [kt]

Emissions	CO_2**-eq [kt]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Cement production	270.57	264.93	291.35	305.44	317.82	303.65	301.20

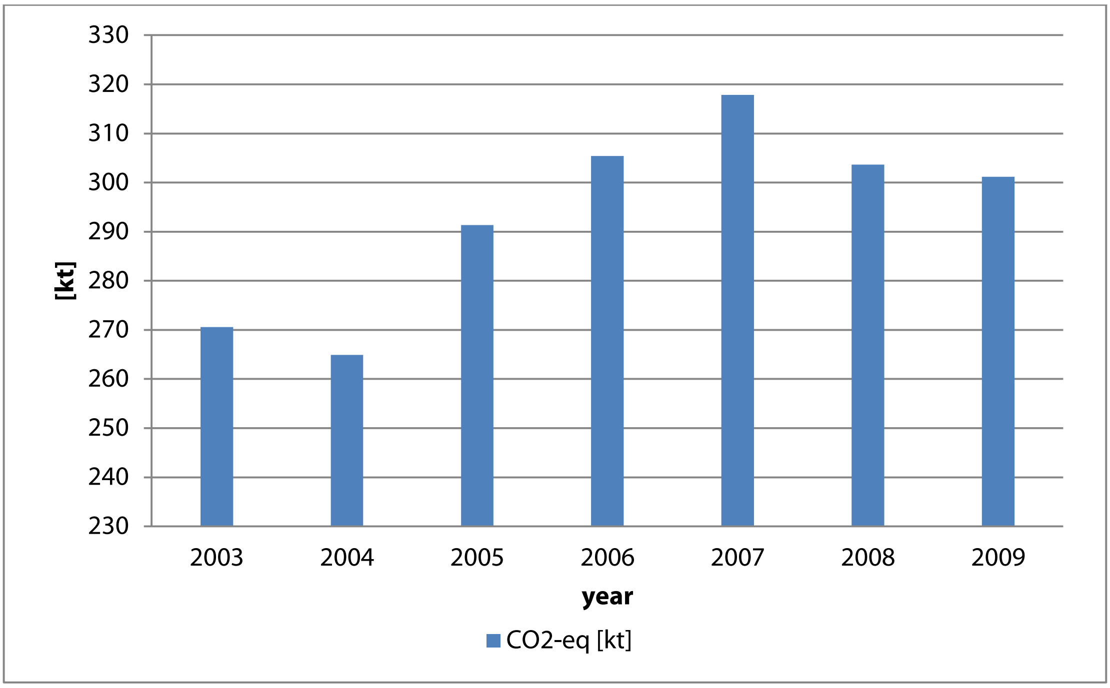


Figure 4.2.3.5. Emissions of CO_2-eq in the cement production subsector [kt CO_2-eq]

Lime production

Calcium oxide (CaO or quicklime) is formed by heating limestone to decompose the carbonates. This is usually done in shaft or rotary kilns at high temperatures and the process releases CO_2. CO_2 during the calcination step in lime production. Calcium carbonate (CaCO3) in limestone and calcium/ magnesium carbonates in dolomite rock (CaCO3•MgCO3) are decomposed to form CO_2 and quicklime (CaO) or dolomite quicklime (CaOMgO) respectively. In the 2003–2009 Inventory, an output-based approach using default values (Tier 1) was adopted. The default emission factors were multiplied to the national level of lime production according to data provided by the State Statistical Office. In accordance with good practice, this data was segregated by lime type: Quicklime, Slaked lime and Hydraulic lime. There was no lime production reported in the year 2008.

Table 4.2.3.8. Lime production in the period 2003–2009, [kt]

ACTIVITY RATE	[kt]						
	2003	2004	2005	2006	2007	2008	2009
Lime production	6.19	9.03	2.71	11.18	5.33	0.00	2.71

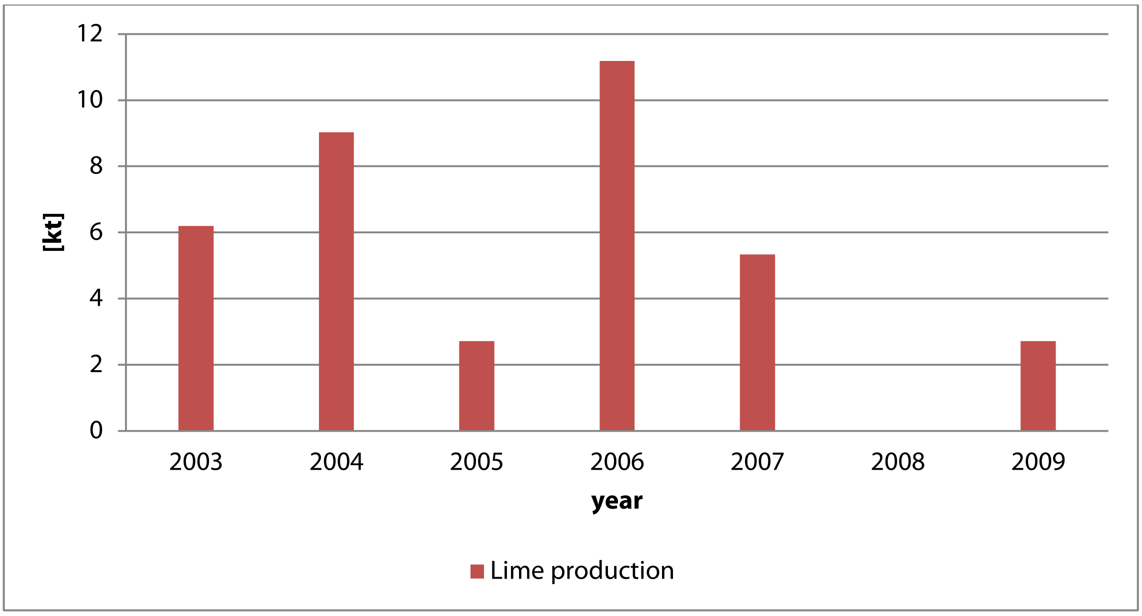


Figure 4.2.3.6. Lime production in the period 2003–2009, [kt]

Table 4.2.3.9. Emissions of CO_2-eq in the lime production subsector, [kt]

Emissions	CO_2-eq [kt]						
	2003	2004	2005	2006	2007	2008	2009
Lime production	4.89	7.13	2.14	8.84	4.21	0.00	2.14

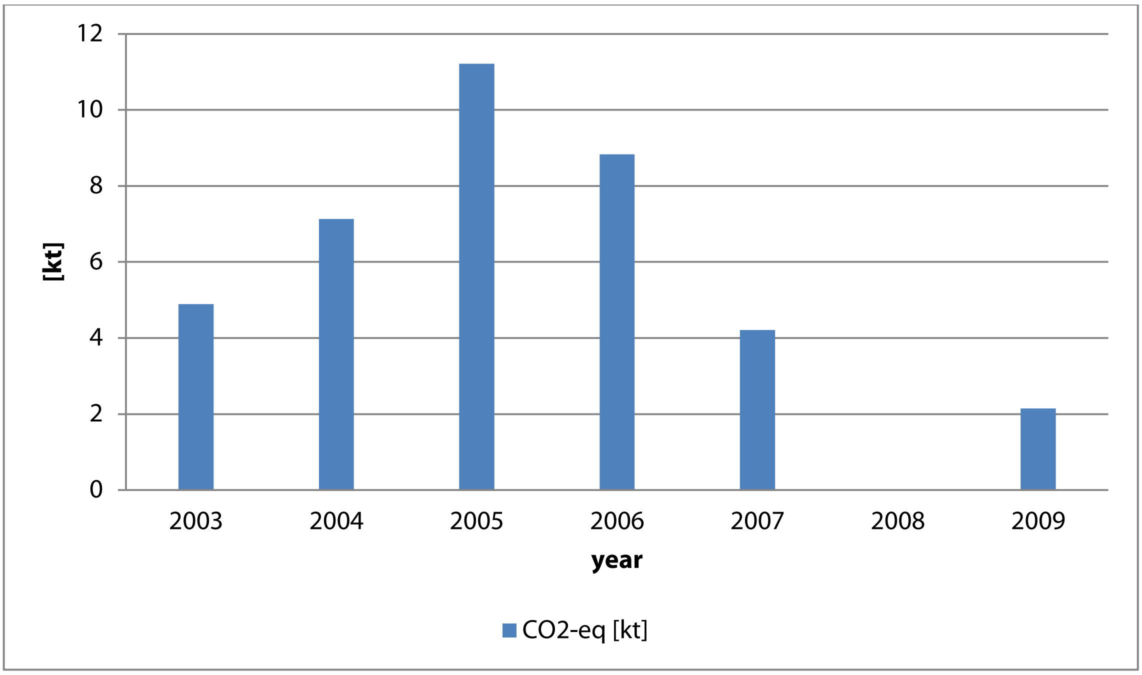


Figure 4.2.3.7. Emissions of CO_2-eq in the lime production subsector [kt]

Limestone and dolomite use

Limestone (CaCO3) and dolomite (CaCO3.MgCO3) are basic raw materials with commercial applications in a number of industries including metallurgy (e.g., iron and steel), glass manufacture, agriculture, construction and environmental pollution control.

In industrial applications involving the heating of limestone or dolomite at high temperatures, CO_2 is generated. Limestone and dolomite used in cement and lime production should be reported under that industry sector and not under the sector of Limestone and Dolomite Use. Under this section are inventoried all other uses of limestone and dolomite which produce CO_2 emissions. Since there is no available data provided by an official source of information on limestone and dolomite use (e.g. the State Statistical Office of Republic of Macedonia) the assumption was made that most usage is in the Iron and Steel sector for producing crude iron. Because the metal industry relies mainly on electricity, the consumption of limestone was calculated taking into account the assumption that metal is produced in the electric furnaces. The electric arc furnace (EAF) route uses primarily recycled steels and/or direct reduced iron (DRI) and electricity. On average, the recycled steel-EAF route uses 880 kg of recycled steel, 150 kg of coal and 43 kg of limestone to produce a tonne of crude steel.

Table 4.2.3.10. Limestone and dolomite use in the period of 2003–2009 [kt]

ACTIVITY RATE	[kt]						
	2003	2004	2005	2006	2007	2008	2009

Limestone and Dolomite Use	25.11	26.94	27.82	30.88	31.87	22.12	23.56

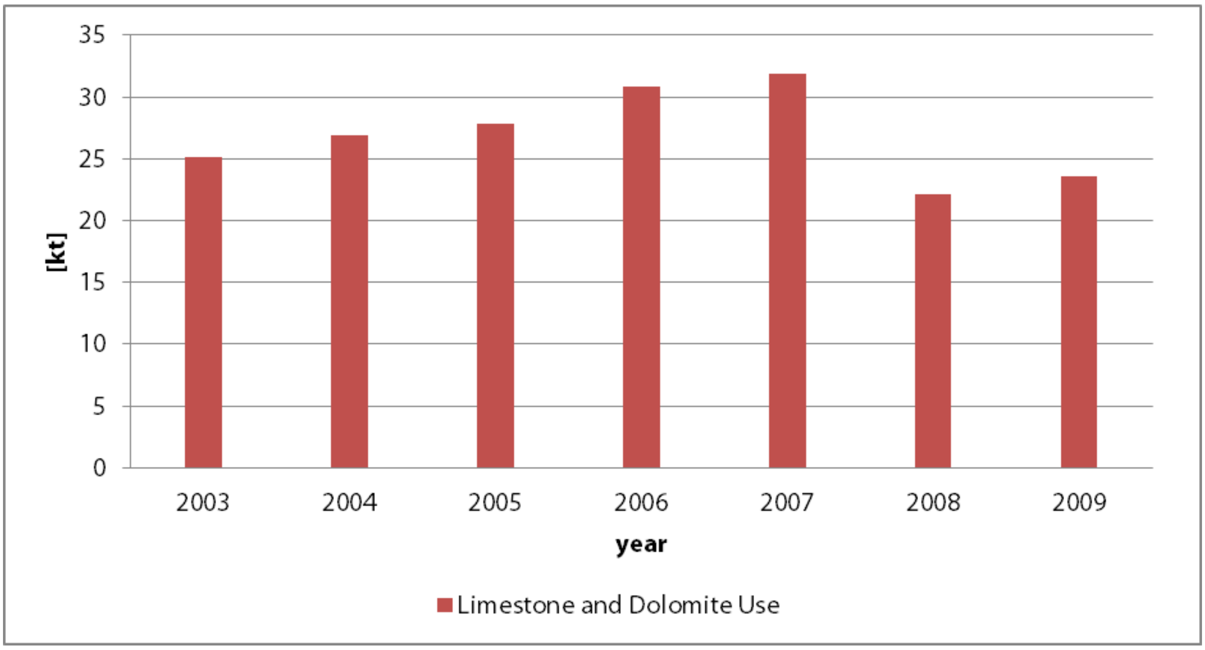


Figure 4.2.3.8. Limestone and dolomite use in the period 2003–2009, [kt]

Table 4.2.3.11. Emissions of CO_2-eq from limestone and dolomite use [kt]

Emissions	CO_2**-eq [kt]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Limestone and Dolomite Use	11.05	11.86	12.24	13.59	14.02	9.73	10.37

This activity depends on steel production data. As can be seen from the tables and figures, this category is not very influential on overall emissions since steel production is performed in an electric furnace, a process with lower CO_2 emissions compared to other metal production processes.

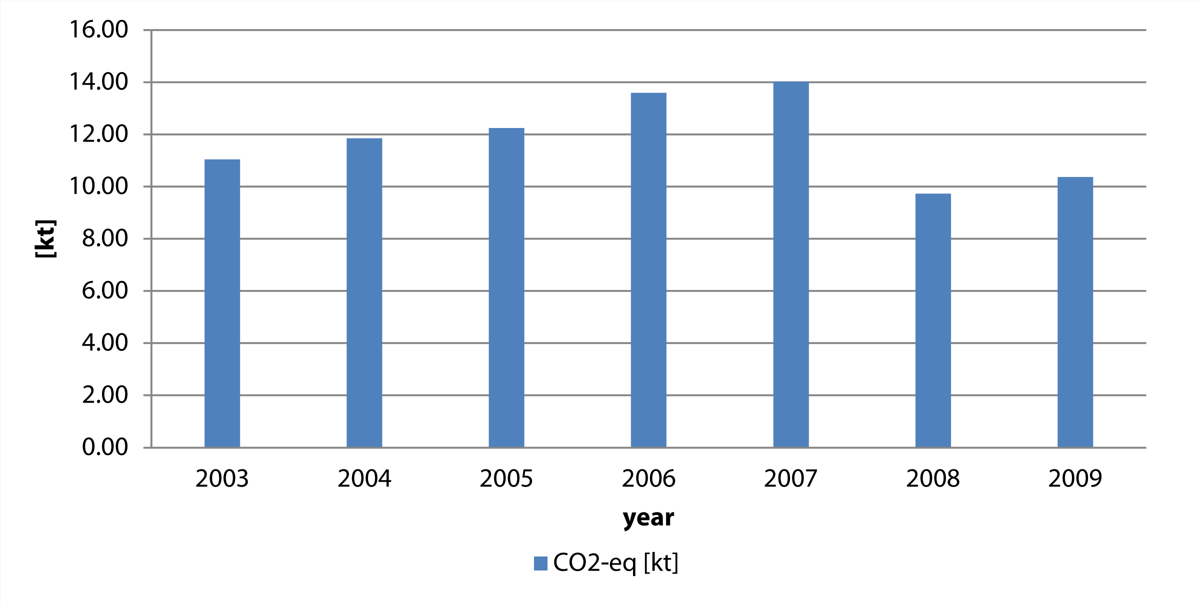


Figure 4.2.3.9. Emissions of CO_2-eq from limestone and dolomite use [kt]

Road Paving

Asphalt road surfaces are composed of compacted aggregate and asphalt binder. Gases are emitted from the asphalt plant, the road surfacing operations, and from the subsequent road surface. Emissions of NMVOC depend on the type of asphalt (slow, medium or rapid cure) and the amount of diluent. For the calculations, default emission factors were used under the assumptions given in the EMEP/CORINAIR Guidebook (SNAP 40611). The amount of diluent used is usually lower in warm countries than in colder climates, and hence lower emission factors may be expected in warm countries. Asphalt quantity was calculated based on data provided by the State Statistical Office for the length of highways and roads, since there is no data about the quantity of asphalt used in the road paving process per year. There is no available data on the thickness of the asphalt roads or the density of the asphalt mix. These data were taken as a global average: 0,1524 m for asphalt thickness and 2,4 t/m^3 for average asphalt hot mix density. The quantity of road paving material was calculated as the sum of the surfaces of the highways, streets and roads, multiplied by the asphalt thickness and the asphalt density.

Table 4.2.3.12. Surface of road covered with asphalt [m^2] and road paving material used [kt]

ACTIVITY RATE	2003	2004	2005	2006	2007	2008	2009
Highways, [m^2]	1,081,185.00	1,081,185.00	1,079,803.00	129,122.00	0.00	41,473.00	242,503.00
Streets and Roads, [m^2]	697,459.00	697,459.00	310,049.00	343,701.00	286,376.00	550,033.00	298,593.00
Quantity of Road Paving material	650.56	650.56	508.35	172.94	104.74	216.35	197.91

used, [kt]							

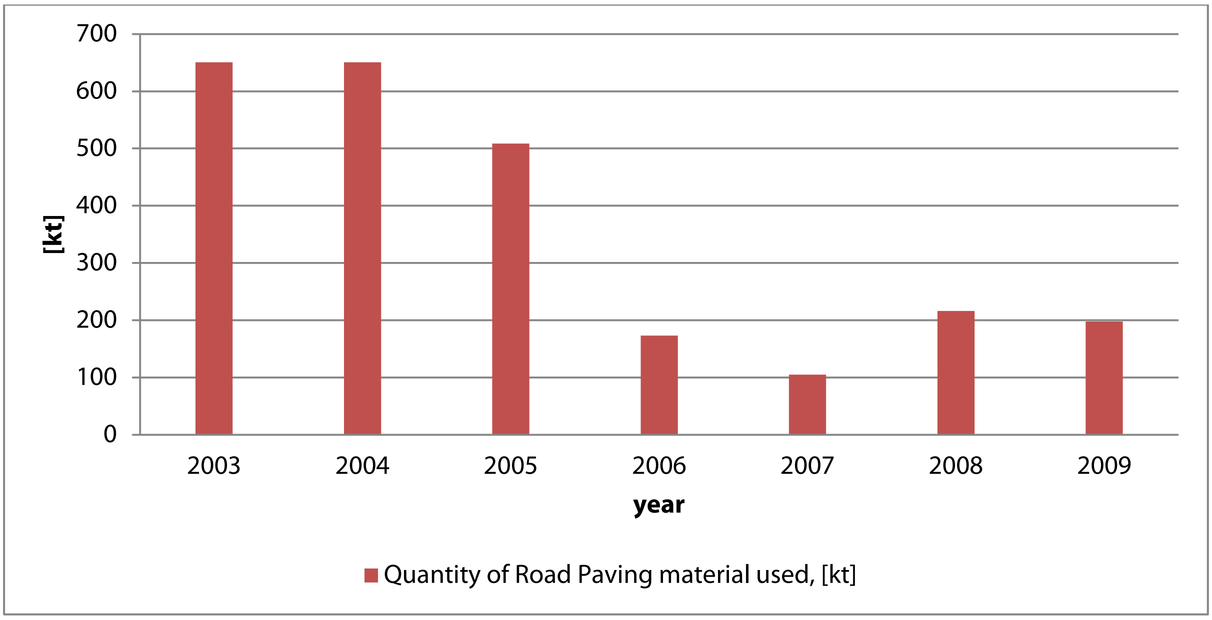


Figure 4.2.3.10. Road paving material used [kt]

The data in the tables shows that the highest rates of construction activities occurred in 2003-2004 due to major reconstruction of the road infrastructure. This implies higher emissions of NMVOCs in the air.

Table 4.2.3.13. NMVOCs emissions [kt] and CO_2-eq emissions

Emissions	**[kt]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Road Paving, NMVOC	208.18	208.18	162.67	55.34	33.52	69.23	63.33

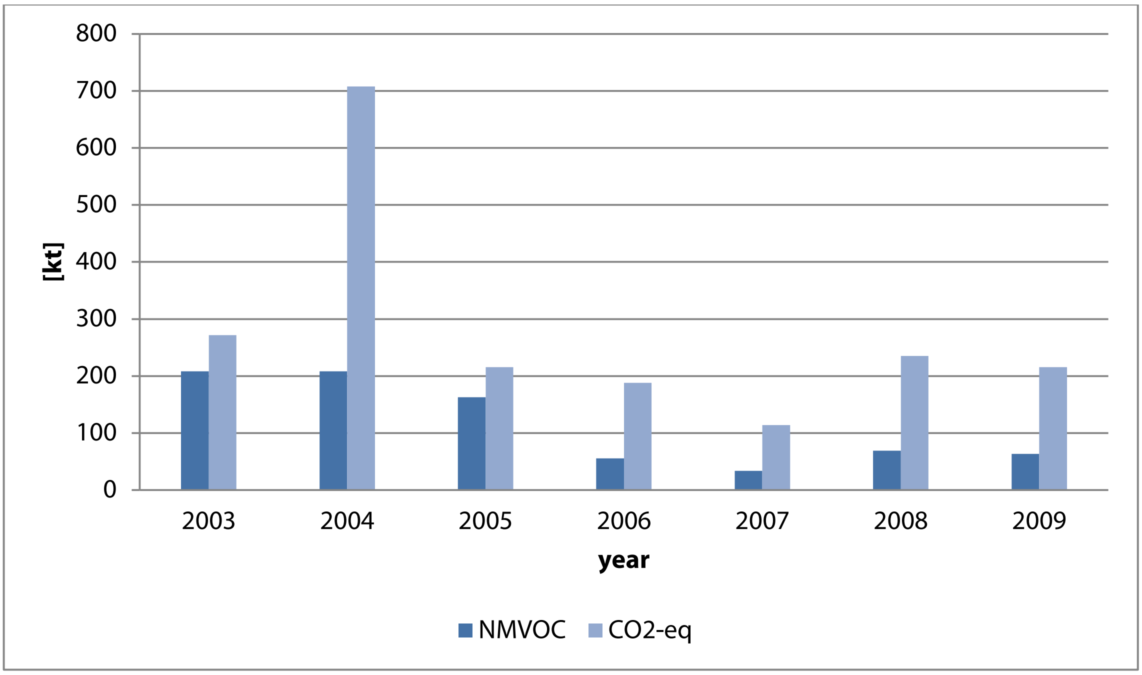


Figure 4.2.3.11. Emissions of NMVOCs [kt] and CO_2-eq emissions

Glass production

The major glass raw materials which emit CO_2 during the melting process are limestone, dolomite and soda ash. Where these materials are mined as carbonate minerals for their use in the glass industry they represent primary CO_2 production and should be included in emissions estimates. The action of these carbonates in the fusion of glass is a complex high-temperature chemical reaction and is not to be directly compared to the calcination of carbonates to produce quicklime or burnt dolomitic lime. Nevertheless, this has the same net effect in terms of CO_2 emissions. In practice, glass-makers do not produce glass only from raw materials, but use a certain amount of recycled glass. Most operations will use as much cullet as they can obtain, sometimes with restrictions for glass quality requirements. In Macedonia there is only a small quantity of glass produced per year since most installations of this type were closed or worked with reduced activity during the period under consideration, meaning that the glass production sector is not so important in the Macedonian GHG inventory. There are no relevant data from an official source on the fraction of cullet used in glass production in the country.

Table 4.2.3.14. Glass production in the period 2003–2009 [t]

ACTIVITY RATE	[t]						
	2003	2004	2005	2006	2007	2008	2009
Glass Production	0	0	106	0	170	98	106

Figure 4.2.3.12. Glass production in the period 2003–2009 [t]

Table 4.2.3.15. NMVOCs emission from the glass production subsector [kg]

Emissions	NMVOCs [kg]						
	2003	2004	2005	2006	2007	2008	2009

Glass Production	0.00	0.00	477.00	0.00	765.00	441.00	477.00

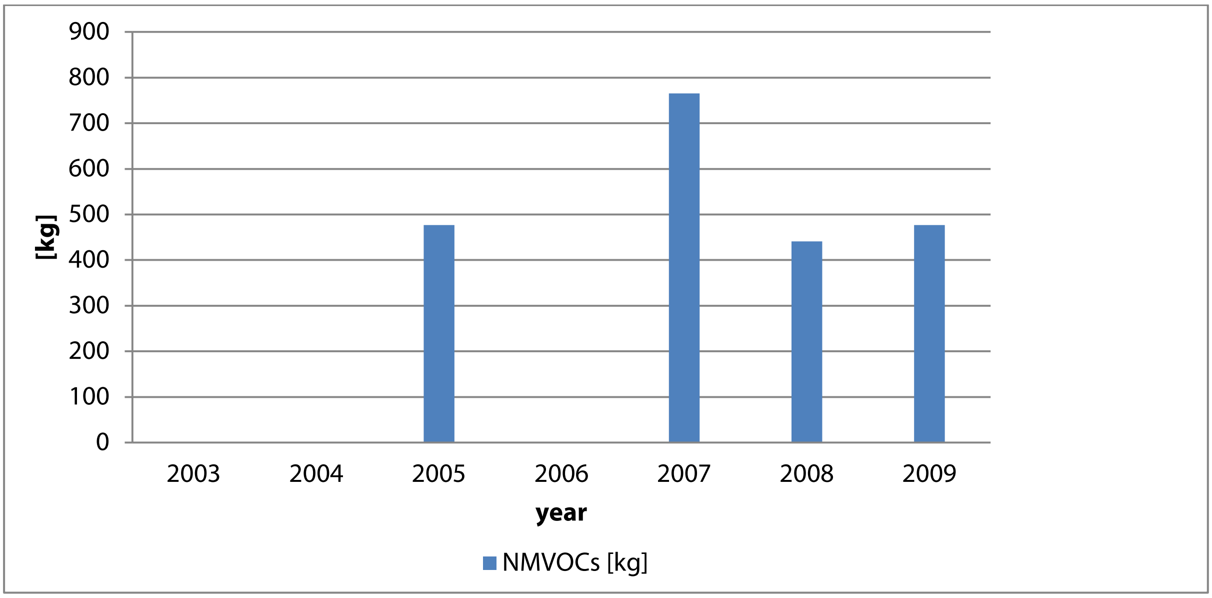


Figure 4.2.3.13. NMVOCs emission from the glass production subsector [kg]

Concrete

Concrete is the most widely used construction material. The production of concrete is similar to cement production in that SO_2 emissions originate from fuel use and the sulphur in clay. About 45 per cent of the SO_2 generated in the process will be sequestered in the product. The data for concrete production is derived from the State Statistical Office reviews and is displayed in Table 4.2.3.16.

Table 4.2.3.16. Concrete production in the period 2003–2009 [kt]

ACTIVITY RATE	[kt]						
	2003	2004	2005	2006	2007	2008	2009
Concrete	167.16	123.04	59.72	190.19	69.22	56.45	59.72

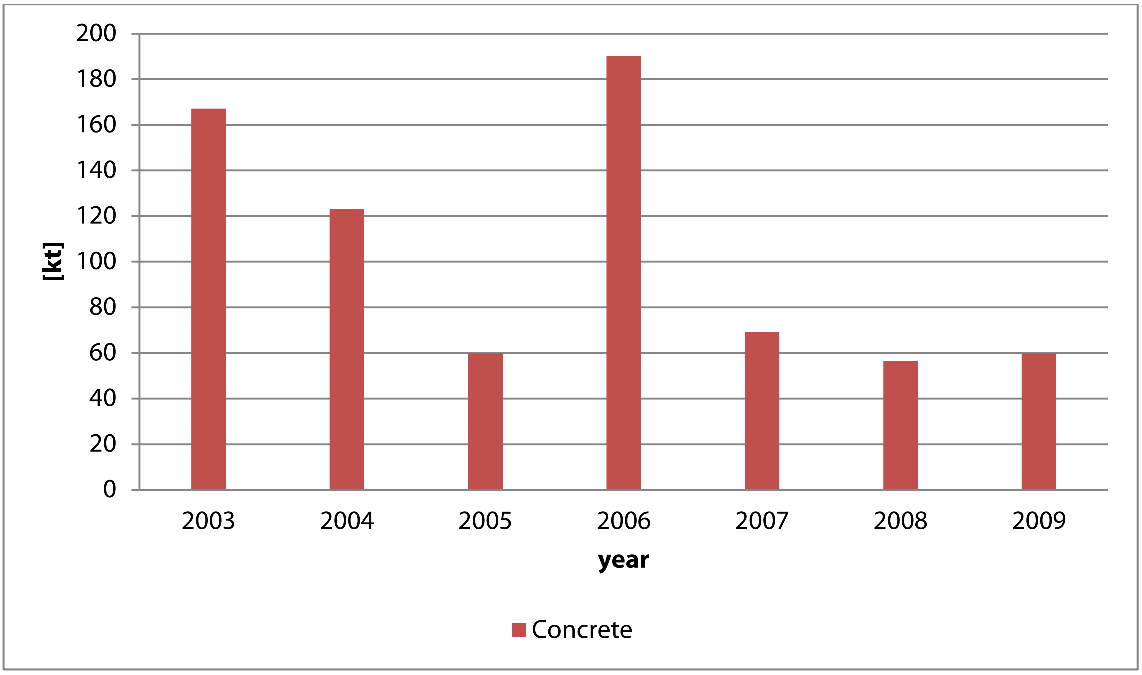


Figure 4.2.3.14. Concrete production in the period 2003–2009 [kt]

Table 4.2.3.17. SO_2 emissions from the concrete production subsector [kt]

Emissions	SO_2 [t]						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Concrete	83.58	61.52	71.81	95.10	34.61	28.22	29.86

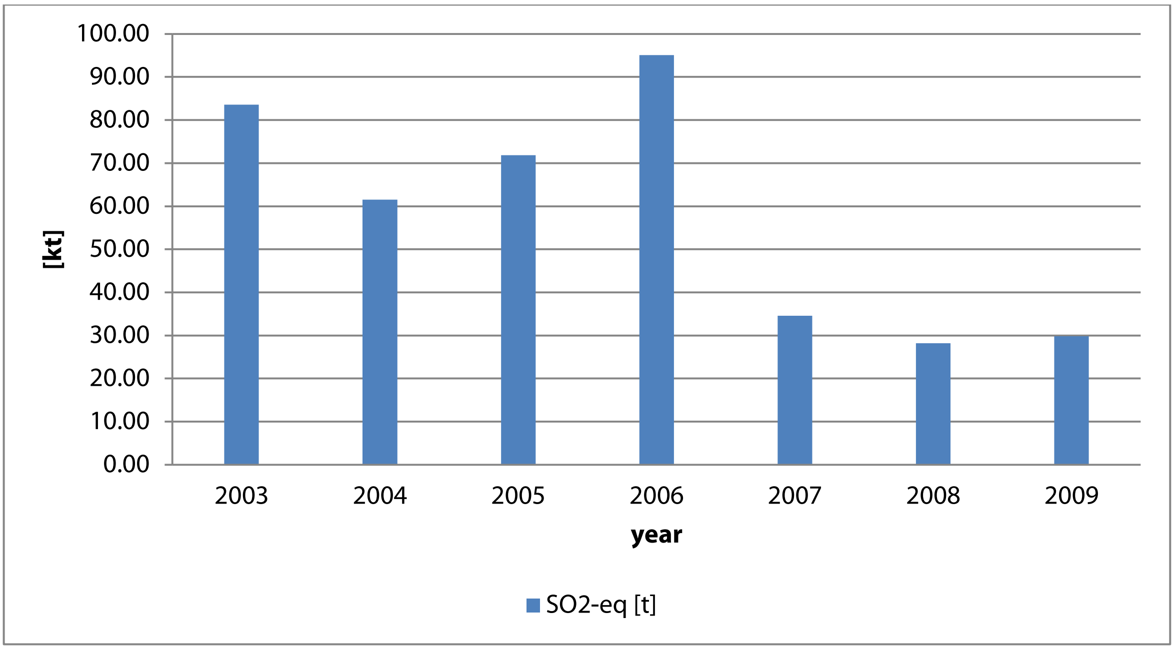


Figure 4.2.3.15. SO_2-eq emission from the concrete production subsector [kt]

THE CHEMICAL INDUSTRY

Polyvinyl chloride

Polyvinyl chloride, better known as PVC or vinyl, is an inexpensive plastic so versatile that it has become pervasive in modern society. The list of products made from PVC is exhaustive and the ones produced in Macedonia are given in Table 4.2.3.18. There are no direct GHG emissions from PVC production. Indirect GHG emissions were calculated in previous inventories were also calculated for the period 2003–2009 in order to provide a consistent time series.

Table 4.2.3.18. Polyvinyl chloride production by type [t]

PVC	2003	2004	2005	2006	2007	2008	2009
Polyvinyl chloride; suspensioned, not mixed with any other substances; in primary forms	3,932	2,561	1,006	0	645	1,975	1,731
Non-plasticised polyvinyl chloride, mixed, in primary forms	110	131	113	117	0	0	0
Plasticised polyvinyl chloride, mixed, in primary forms	5,836	5,166	3,216	1,332	645	1,975	1,731
Rigid tubes; pipes and hoses of polymers of vinyl chloride	2,546	1,888	1,281	4,567	665	560	461
Cellular plates; sheets; film; foil and strip of polymers of vinyl chloride	741	710	712	618	399	399	326
Strips, of polymers of vinyl chloride, in rolls width <= 20 cm	259	160	47	10	0	0	0
Mono filament with any cross-sectional dimension > 1 mm; rods; sticks and profile shapes of polymers of vinyl chloride	2,350	1,681	1,422	1,048	827	596	298
TOTAL	15,774	12,297	7,797	7,692	3,181	5,505	4,547

Table 4.2.3.19. Polyvinyl chloride production in the period 2003–2009 [kt]

ACTIVITY RATE	**[kt]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Polyvinyl chloride	15.77	12.30	4.55	7.69	3.18	5.51	4.55

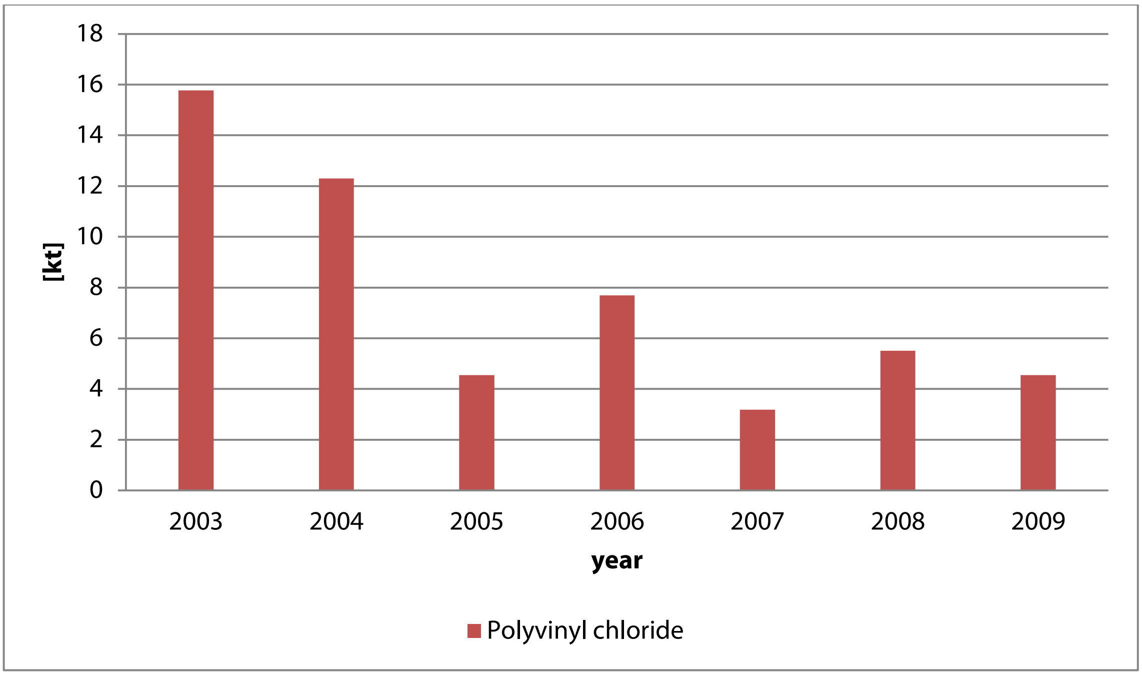


Figure 4.2.3.16. Polyvinyl chloride production in the period 2003–2009 [kt]

Table 4.2.3.20. Indirect GHG emissions from PVC production [t]

Emissions	**[t]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
NOx	1432.28	1116.57	707.97	698.43	288.83	499.85	412.87
NMVOC	121.74	94.91	60.18	59.37	24.55	42.49	35.09
SO_2, **kg**	0.18	0.14	0.09	0.09	0.04	0.06	0.05

Metal Production

With a few exceptions, commercial production of metals from ores requires the use of carbon as a reducing agent. If the ore contains carbonate, CO_2 originating from the ore will also be emitted during production. On the other hand, carbon may also be sequestered in the metal. The metal may be reduced by using coal, coke, prebaked anodes and coal electrodes. Coke is produced from coal or refinery residuals (petrol coke). Prebaked anodes and electrodes are produced from coal. By-product fuel (coke oven gas and blast furnace gas) are produced in some of the processes. These fuels may be sold or used within the plant. As iron occurs only as iron oxides in the earth's crust, the ores must be converted, or 'reduced', using carbon. The primary source of this carbon is coking coal. Coal is a key raw material in steel production. Coal is primarily used as a solid fuel to produce electricity and heat through combustion. Coke, made by carburizing coal (i.e. heating in the absence of oxygen at high temperatures), is the primary reducing agent of iron ore. Coke reduces iron ore to molten iron saturated with carbon. There are two ways of calculating emissions from the metal industry, according to what we take as the activity rate: whether that be the quantity of reducing agent or the quantity of metal produced. In Macedonia there is no official data about the usage of reducing agent per process, so the statistical data on metal production was used for this inventory.

Table 4.2.3.21. Metal production in the period 2003–2009 [kt]

Categories	ACTIVITY RATE [kt]						
	2003	2004	2005	2006	2007	2008	2009
Metal Industry	643.20	698.88	567.95	788.33	861.14	627.02	567.95
Iron and Steel Production	583.87	626.60	547.92	718.13	741.06	514.37	547.92
Ferroalloy Production	55.53	72.08	19.66	69.97	120.01	112.63	19.66
Aluminium production	3.79	0.19	0.38	0.23	0.07	0.02	0.38

Table 4.2.3.22. CO_2-eq emissions from the metal production sector [kt]

Categories	CO_2-eq [kt]						
	2003	2004	2005	2006	2007	2008	2009
Metal Industry	290.55	357.24	388.91	355.71	380.76	387.28	130.27
Iron and Steel Production	52.72	56.59	58.49	64.75	66.83	46.42	49.42
Ferroalloy Production	231.12	300.31	330.38	290.55	313.80	340.83	80.18
Aluminium production	6.72	0.34	0.04	0.41	0.13	0.03	0.66

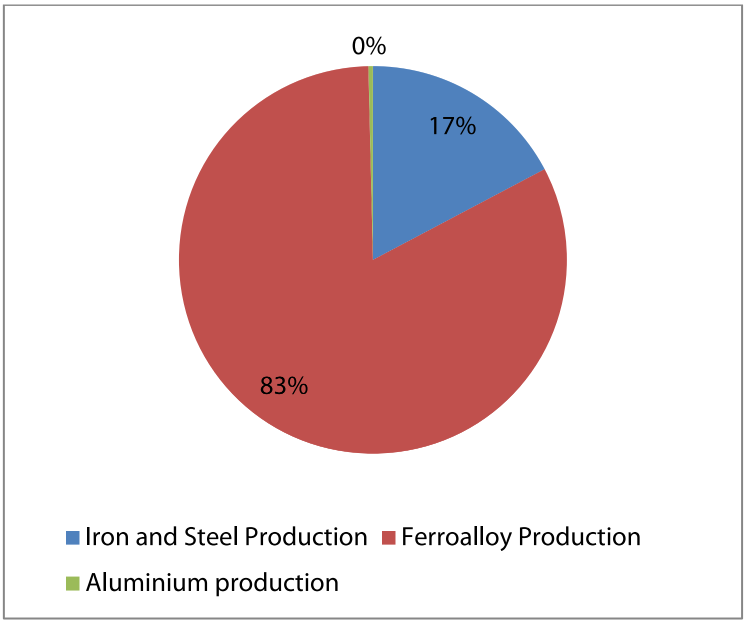


Figure 4.2.3.17. Share of emissions in the metal production sector [%].

The production of most metals may generate emissions of SO_2, CO, NOx and NMVOC. Emissions of SO_2 originate from sulphur in the reducing agents and in the ores. The emissions will also depend on control technologies and the extent to which sulphur is sequestered in the products. NOx is produced primarily by the high temperate oxidisation of nitrogen in air. In metal production, most NOx emissions usually occur as a result of fuel combustion. However, high temperature metal production processes (such as roasting and reduction), which occur in the presence of air, will also produce nitrogen oxides. These NOx emissions are in principle included in this section, but are often impossible to distinguish from the fuel NOx. CO is formed due to incomplete oxidation of the reducing carbon. This CO may in many plants be used as a fuel, and double counting of emissions already counted as energy must be avoided. In addition, small amounts of NMVOCs may be emitted during parts of some of the processes, especially those involving coal.

Table 4.2.3.23. Emissions of indirect greenhouse gasses from the metal industry sector [t]

Categories	[t]						
	2003	2004	2005	2006	2007	2008	2009
Iron and Steel Production							
NOx	18.58	20.79	11.97	13.05	15.00	13.94	11.97
CO	0.46	0.52	0.30	0.33	0.38	0.35	0.30
NMVOCs	13.93	15.59	8.98	9.79	11.25	10.45	8.98
SO_2	20.90	23.39	13.47	14.68	16.88	15.68	13.47
Aluminium production							
NOx	8.15	0.42	0.81	0.49	0.15	0.03	0.81
CO	512.06	26.19	50.63	31.05	9.72	2.03	50.63
SO_2	53.86	2.75	5.33	3.27	1.02	0.21	5.33

It can be noticed that most of the emissions in the metal production sector come from ferro-alloy production due to the high carbonate content in the feedstock. Ferro-alloy production is also identified as a key category in the overall inventory.

Iron and Steel

Iron and steel production in Macedonia mainly relies on electricity. Nationally, iron and steel are produced in the factory Makstil AD Skopje. The economic activity of this factory covers steel and hot rolled plate production. The basic raw material in the technological process of steel production is scrap iron. Iron ore is not used. The production process takes place in two plants: the production of steel in slabs takes place at the Steel Mill while the production of hot rolled plates takes place at the Rolling Mill for thick plates.

The production process of the Steel Mill involves the preparation and processing of scrap iron which is melted in an electric arc furnace, thus producing liquid steel. This liquid steel is then further processed in a ladle furnace (which is an electric furnace) and afterwards continuously cast into slabs. The process in the Rolling Mill for thick plates includes the heating of slabs in pre-heating furnace and the hot rolling of slabs in rolling mills. In the process of the production of slabs, apart from scrap iron as the main input raw material, other materials are used which act as reducing agents, melting agents and electrodes for the electric furnaces (anthracite, coke, lime, dolomite, electrode mass).

Steel production in electrical furnaces typically occurs by charging 100 per cent recycled steel scrap, which is melted using electrical energy imparted to the charge through carbon electrodes and then refined and alloyed to produce the desired grade of steel. Although electrical furnaces may be located in integrated plants, typically they are stand-alone operations because of their fundamental reliance on scrap and not iron as a raw material. Since the electrical furnaces process is mainly one of melting scrap and not reducing oxides, carbon's role is not so dominant and CO_2 emissions are mainly associated with the consumption of carbon electrodes. For the activity rate, data was taken from the Statistical Yearbooks of the State Statistical Office and the emission factor was adopted from the previous national reports.

Additional indirect GHGs are released during the processes of steel rolling. The emissions from rolling mills are a significant part of primary iron and steel production. Long products such as sections and concrete reinforcing rods can be produced by hot-rolling steel ingots. The huge reduction in thickness is accompanied by changes in structure and recrystallization, leading to a material with a very fine crystal structure. This is necessary for the requirements of strength and deformability. Gradual heating and cooling gives emissions of nitrogen oxides and carbon monoxide.

Table 4.2.3.24. Production of iron and steel by type in the period 2003–2009 [kt]

ACTIVITY RATE	[kt]						
	2003	2004	2005	2006	2007	2008	2009
Crude Steel	583.87	626.60	547.92	718.13	741.06	514.37	547.92
Flat-rolled products of iron or non-alloy steel, of a width = 600 mm, simply hot-rolled, not clad, plated or coated, in coils/t	NA	NA	20.78	6.23	4.69	3.63	0.03
Flat-rolled products, of iron or non-alloy steel, of a width = 600 mm (excluding "wide flats"), not in coils, simply hot-rolled, not clad, plated or coated, without patterns in relief; flat-rolled products of iron or steel, of a width = 600 mm,	306.64	319.87	321.17	326.48	370.32	344.87	299.33
Hot rolled flat products in coil for rerolling of a width of less than 600 mm, of stainless steel/t	49.11	62.20	172.59	159.34	267.42	205.76	27.14
Uncoated cold rolled sheet, plate and strip of a width = 600 mm, of steel other than stainless steel/t	51.34	65.91	79.22	90.63	119.76	68.93	36.55

The production rate is given in Table 4.2.3.24. Crude Iron production remained generally stable over the whole time series, with an increase in 2006 and 2007, but rolled metal products fluctuate over the time series.

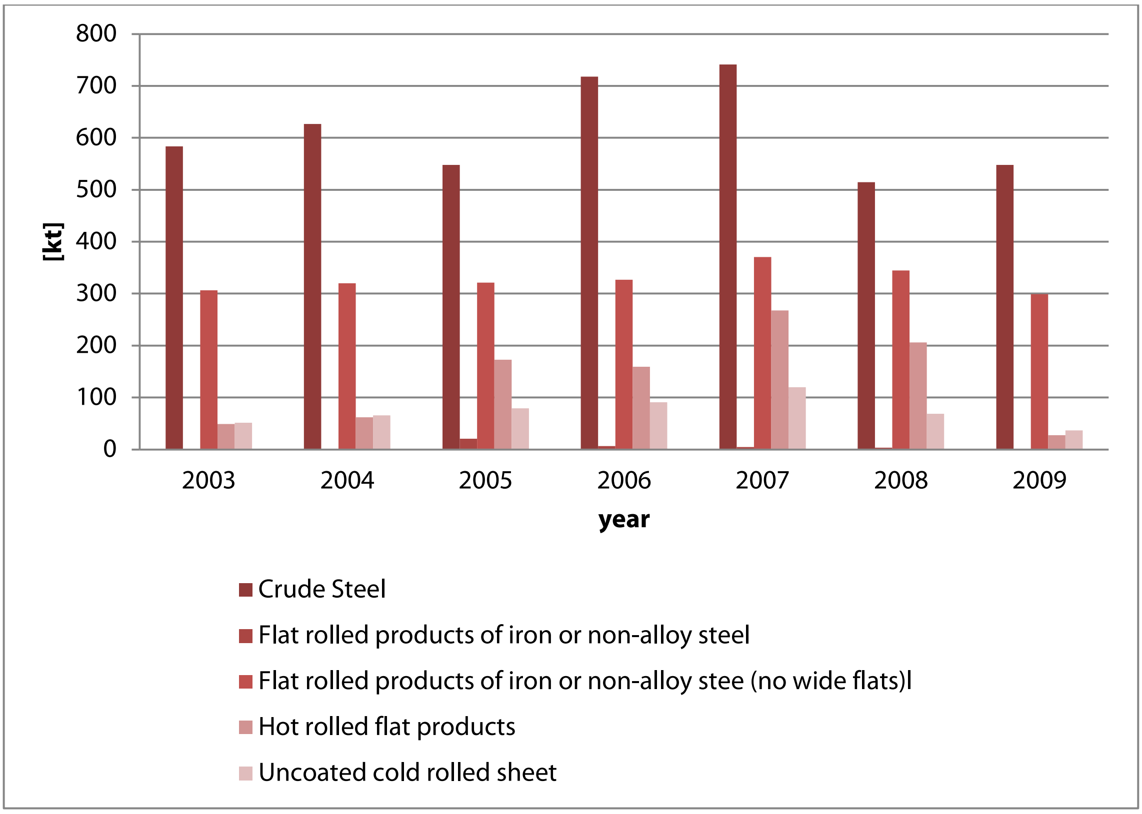


Figure 4.2.3..18. Production of iron and steel by type in the period 2003-2009 [kt]

Table 4.2.3.25. CO_2 emissions from the Iron and Steel production subsector [kt]

Emissions	[kt]						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
CO_2	52.72	56.59	58.49	64.75	52.72	52.72	52.72

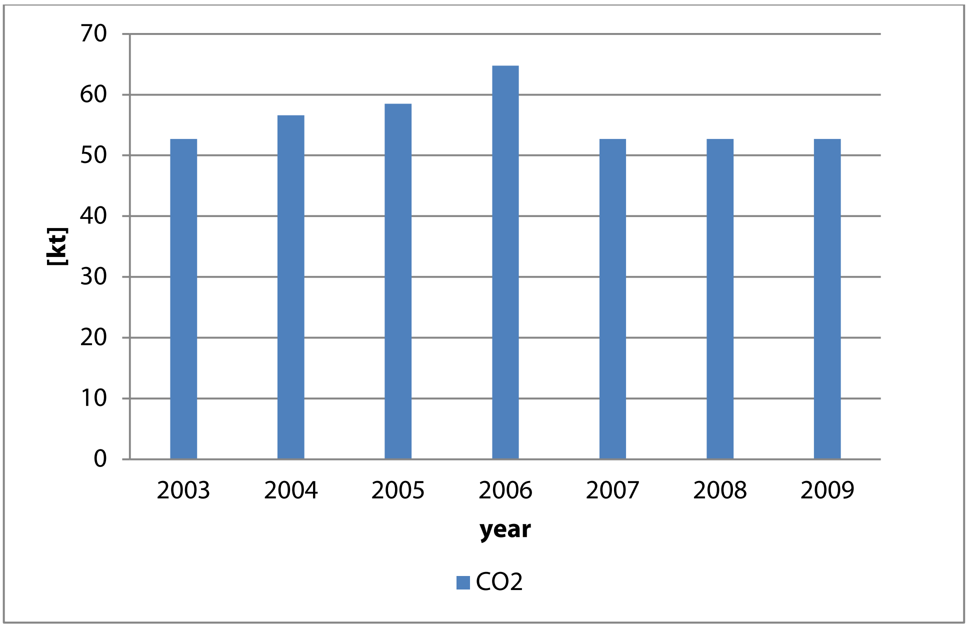


Figure 4.2.3.19. CO_2 emissions from the Iron and Steel production subsector [kt]

The emission calculation mainly depends on the quantity of the feedstock used and the amount of final product produced. Thus it is obvious that the emission trend will follow the trend of the production rate, as shown in Figure 4.2.3.19.

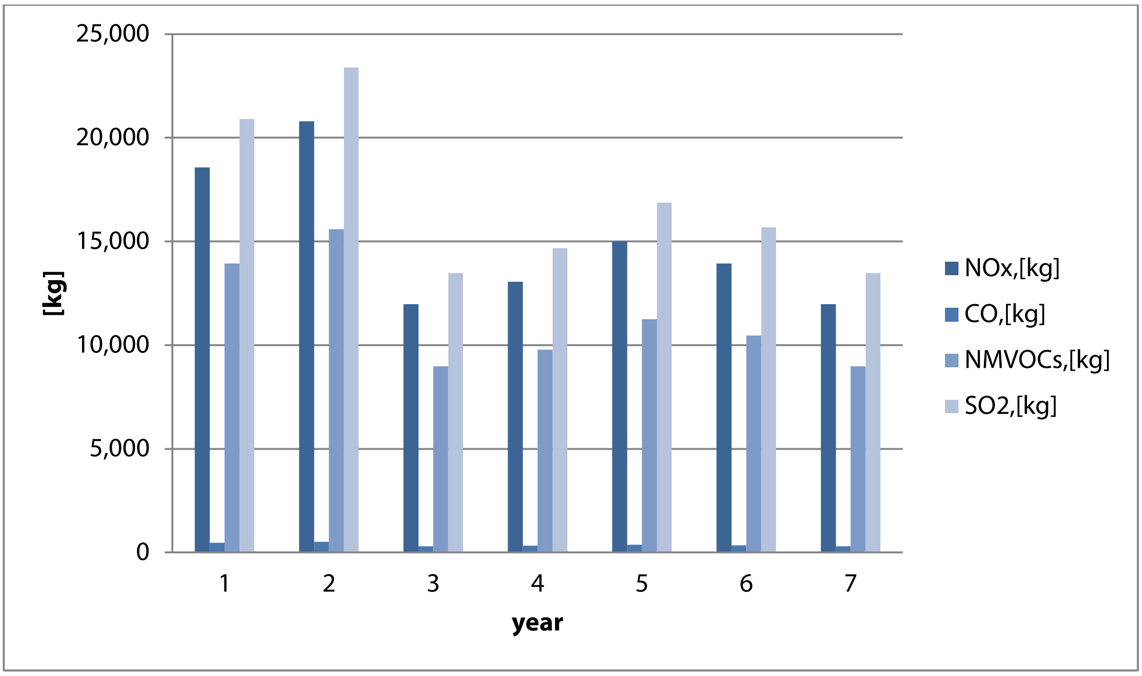


Figure 4.2.3.20. Emissions of indirect greenhouse gasses [kg]

Ferroalloys

In ferroalloy production, raw ore, carbon materials and slag forming materials are mixed and heated to high temperatures for reduction and smelting. The carbonaceous reductants are usually coal and coke. In Macedonia, electricity is mainly used for the production of ferro-alloy. In the electric furnaces, heating is accomplished by passing current through graphite electrodes suspended in a cup-shaped, refractory-lined steel shell. Carbon reduction of the metallic oxides occurs as both coke and graphite electrodes are consumed.

The State Statistical Office provides segregated data for ferroalloy production by ferroalloy type. There is no additional data on the type or quantity of reducing agent. Because the available data on national ferroalloy production statistics is divided by ferroalloy type, it is good practice to use default emission factors. However, because of widely disparate factors depending on the type of ferroalloy production, it is necessary to determine how much tonnage is produced by which method and then to sum the product of the factors. In the inventory tables provided by IPCC, the emission factor value used corresponds to the median value of the emission factor combined with the activity rate.

Table 4.2.3.26. Production of ferroalloy by type in the period 2003–2009 [kt]

ACTIVITY RATE	[kt]						
	2003	2004	2005	2006	2007	2008	2009
Ferro-nickel	5.63	5.31	8.14	10.94	15.32	15.03	12.00
Ferro-silicon	49.91	66.77	71.25	59.02	34.22	42.67	7.66
Ferro-silico-manganese	NA	NA	NA	NA	70.47	54.93	0.00
Ferro-manganese	NA	NA	NA	NA	0.00	12.62	0.00
TOTAL	55.53	72.08	79.39	69.97	120.01	125.25	19.66

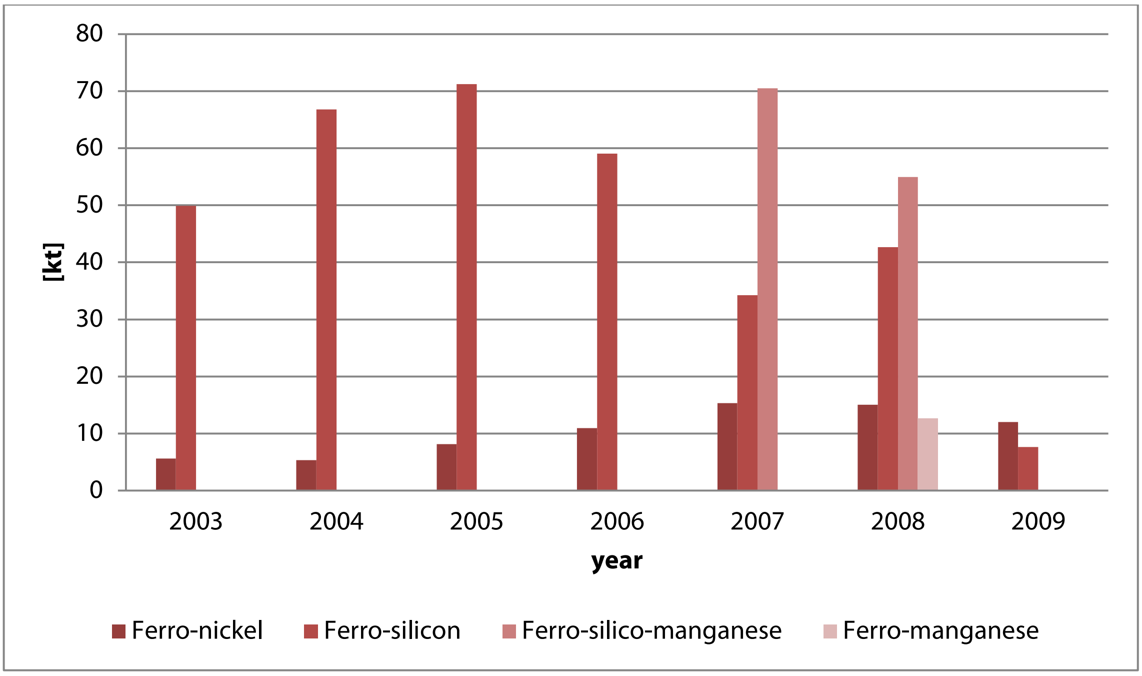


Figure 4.2.3.21. Production of ferroalloy by type in the period 2003–2009 [kt]

Table 4.2.3.27. CO_2-eq emissions from the ferroalloy production subsector [kt.

Emissions	[kt]						
	2003	2004	2005	2006	2007	2008	2009
Ferro-alloy	231.12	300.31	330.38	290.55	313.80	340.83	80.18

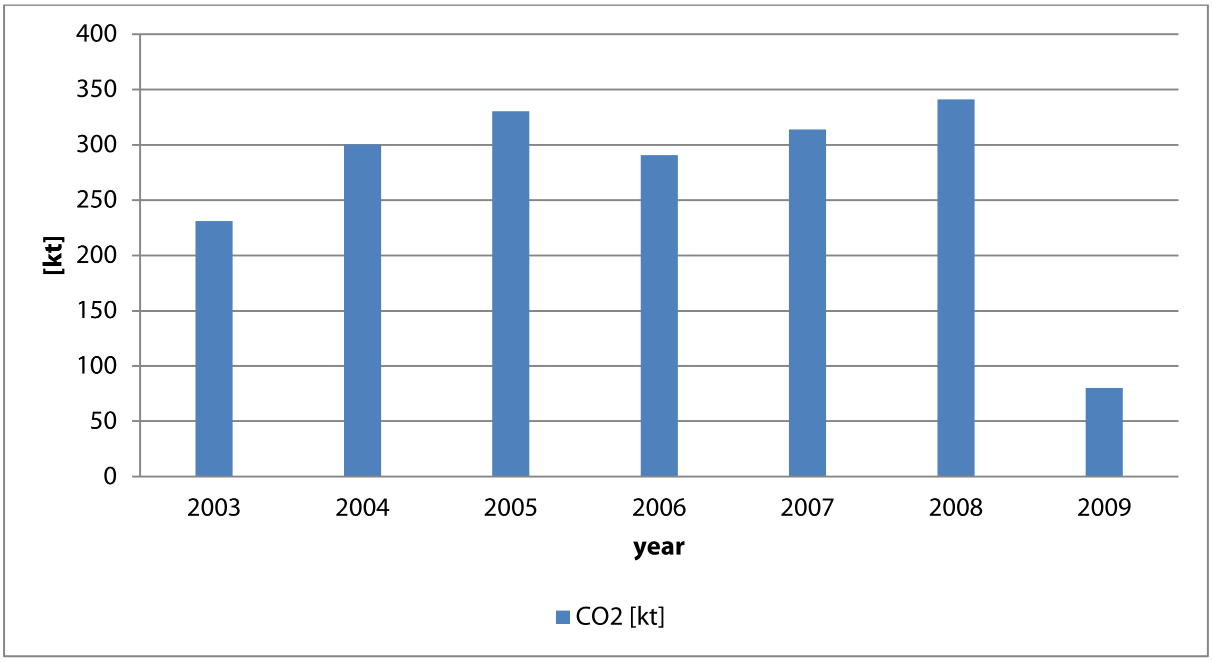


Figure4.2.3.22. CO_2-eq emissions from the ferroalloy production subsector [kt]

Aluminium

In the aluminium production process the alumina is electrically reduced to aluminium by smelting in large pots. Most carbon dioxide is evolved from the reaction of the carbon anode with alumina, but some is formed as the anode reacts with other sources of oxygen (especially air). CO_2 emissions may be calculated on the basis of the amount of reducing agents used or the amount of aluminium produced. Emissions factors for CO_2 are based on SINTEF 1991b and ORTECH 1994. The production and use of carbon anodes for aluminium smelting is a very well established process. There is little variation in CO_2 emissions from plants using similar technologies. It is very likely that use of the appropriate emission factor, along with the correct activity data, will produce accurate estimates. In Macedonia, Alumina AD Skopje was the only company that had a complete process for the production of aluminium alloys, profiles, pipes and structures. In 1998, Alumina was transformed from a state-owned enterprise into a joint stock company with a majority of private shares. This company became bankrupt in 2003 and was sold, with the result that aluminium production in the country was drastically reduced, leading to lower emissions in this sector. The quantity of produced aluminium is given in the table below.

Table 4.2.3.28. Production of ferroalloy by type in the period 2003–2009 [t]

ACTIVITY RATE	[t]						
	2003	2004	2005	2006	2007	2008	2009
Aluminium	3793	194	375	230	72	15	375

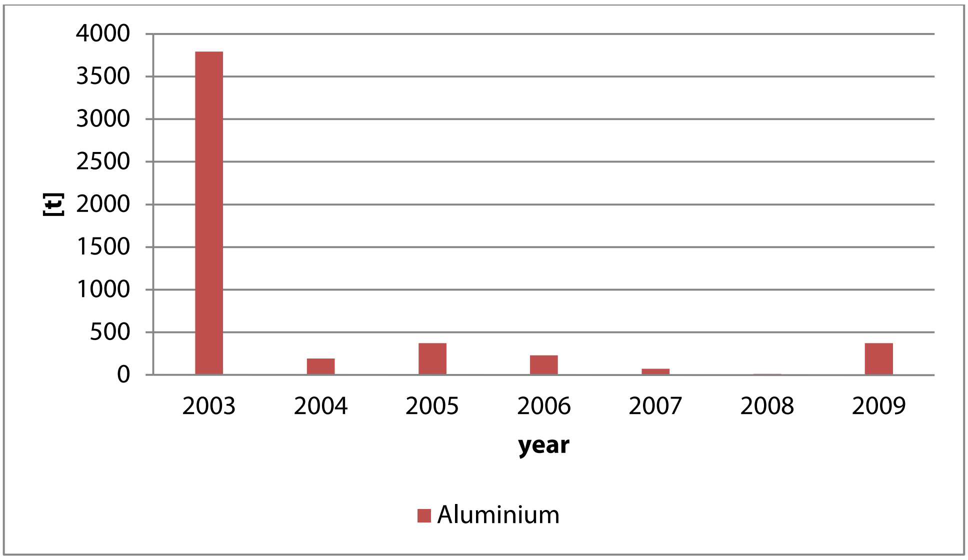


Figure 4.2.3.23. Emissions from the aluminium production subsector [kt]

Table 4.2.3.29. Emissions of CO_2-eq [kt] from the aluminium production subsector and emissions of indirect greenhouse gasses [kg].

EMISSIONS	2003	2004	2005	2006	2007	2008	2009
CO_2-eq [kt]	6.72	0.34	0.66	0.41	0.13	0.03	0.66
NOx [kg]	8,154.95	417.10	806.25	494.50	154.80	32.25	806.25
CO [kg]	512,055.00	26,190.00	50,625.00	31,050.00	9,720.00	2,025.00	50,625.00
SO_2 [kg]	53,860.60	2,754.80	5,325.00	3,266.00	1,022.40	213.00	5,325.00

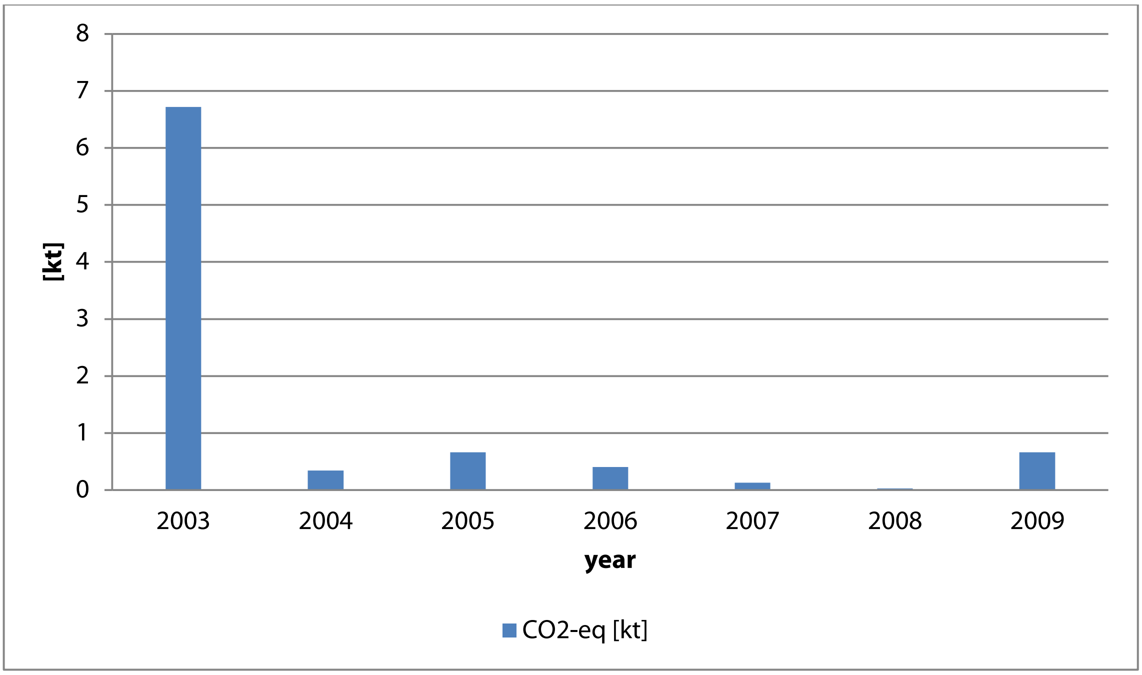


Figure4.2.3.24. Emissions of CO_2-eq from the aluminium production subsector [kt]

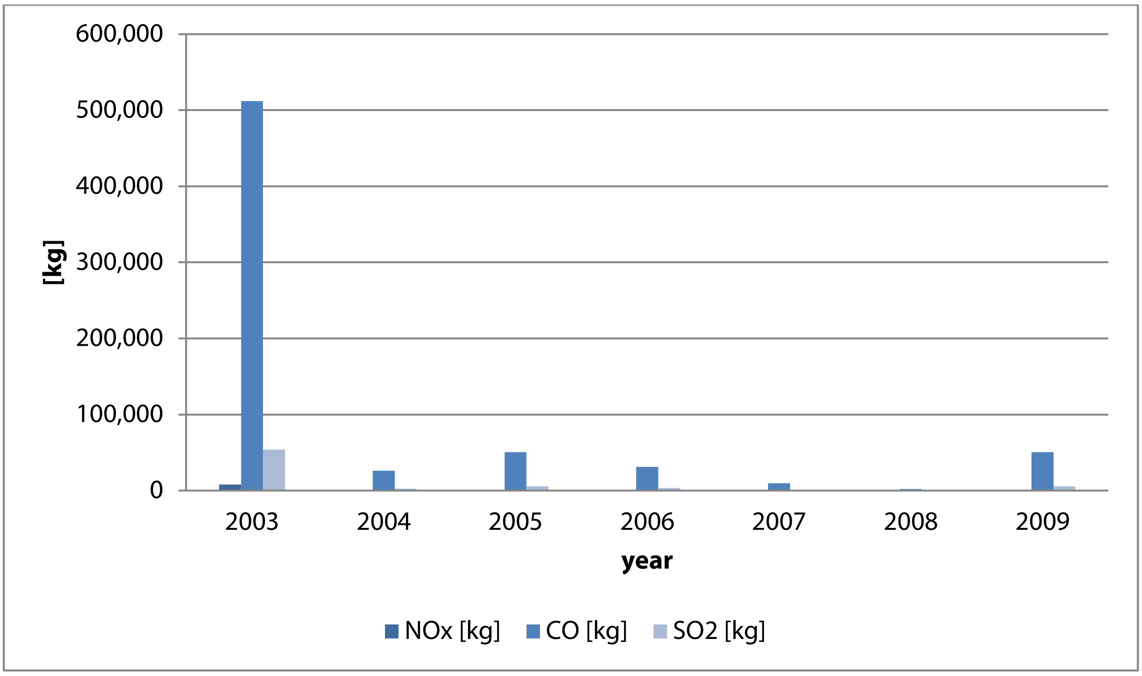


Figure 4.2.3.25. Emissions of indirect greenhouse gasses [kg]

Emissions of carbon monoxide, nitrogen oxide and sulphur dioxide can be estimated from the amount of aluminium produced. Emissions may originate from the production process and the baking of anodes. The suggested emission factors from the EMEP/CORINAIR Guidebook (SNAP 40301) were used with no distinction between the processes of production. No information about the degree of control was used.

COMMODITIES
Beverages

When making any alcoholic beverage, sugar is converted into ethanol by yeast. This is fermentation. The sugar comes from fruit, cereals or other vegetables. These materials may need to be processed before fermentation. For example, in the manufacture of beer, cereals are allowed to germinate, then roasted and boiled before fermentation. To make spirits, the fermented liquid is then distilled. Alcoholic beverages, particularly spirits and wine, may be stored for a number of years before consumption.

Emissions may occur during any of the four stages which may be needed in the production of an alcoholic beverage. During the preparation of feedstock, the most important emissions appear to occur during the roasting of cereals and the drying of solid residues. During fermentation, alcohol and other NMVOCs are carried out with the carbon dioxide as it escapes into the atmosphere. In some cases, the carbon dioxide may be recovered, reducing the emission of NMVOC as a result. During the distillation of fermentation products, emissions are to be expected, but very little data is available. During maturation, NMVOCs evaporate from the stored beverage. The mass of emission will be proportional to the length of the maturation period. Few if any control technologies are known.

In Macedonia there are number of factories that produce alcoholic beverages. The State Statistical Office keeps a good record of the type of beverage produced, as shown in the table below.

Table 4.2.3.30. Production of beverage by type in the period 2003–2009 [hl]

ACTIVITY RATE		[hl]						
Beverage		2003	2004	2005	2006	2007	2008	2009
Brandy	Natural strong alcohol from grape wine or grape marc (grape brandy, cognac, brandy, etc.)/hl	7,826	12,318	10,548	11,831	11,237	7,929	6,652
White wine	White wine in specified regions (v.q.p.r.d.), in bulk/hl	180,643	124,676	209,284	168,968	179,683	239,526	214,823
	White wine in specified regions (v.q.p.r.d.), in bottles/hl	17,589	16,006	16,233	15,579	26,030	27,998	49,530
	White wine (other), not v.q.p.r.d., in bulk/hl	243,595	227,758	174,847	83,957	140,399	107,473	150,829
	White wine (other), not v.q.p.r.d., in	57,153	42,455	46,164	45,031	57,426	53,018	41,450

	bottles/hl							
Red Wine	Quality wine/grape must with fermentation prevented or arrested by the addition of alcohol, v.q.p.r.d. of an alcoholic strength of =>15%, in bulk/hl	220,751	170,404	227,101	179,693	234,130	386,396	441,808
	Quality wine/grape must with fermentation be prevented or arrested by the addition of alcohol, v.q.p.r.d. of an alcoholic strength of =>15%, in bottle's/hl	33,797	21,155	25,155	32,284	40,313	45,482	69,574
Wine	Distilled grape wine/hl	-	-	-	-	3,014	1,499	1,953
	Other wines,(excl. those from special geographical regions), in bulk/hl	206,896	168,030	199,652	150,589	205,731	190,953	147,604
	Other wines,(excl. those from special geographical regions), in bottles/hl	29,747	29,322	42,053	26,904	24,714	30,554	18,380
Beer	Beer made from malt (excluding non-alcoholic beer, beer containing = 0.5% by volume of alcohol, alcohol duty)/hl	680,217	716,034	694,916	669,657	695,346	718,124	635,926

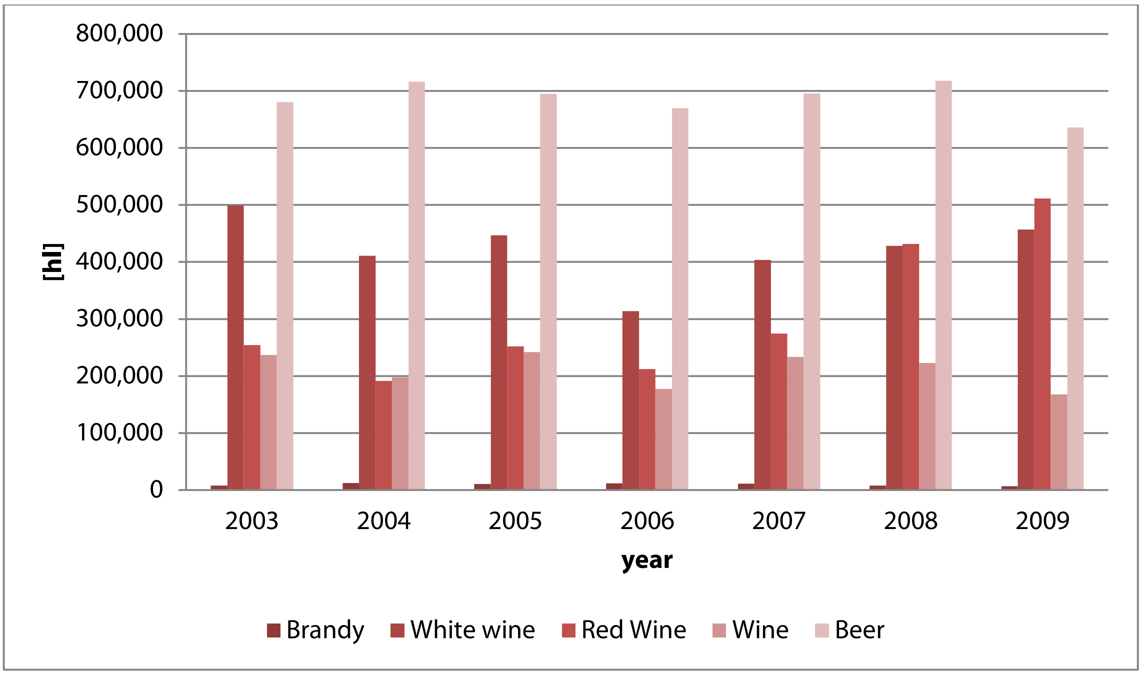


Figure 4.2.3.26. Production of beverage by type in the period 2003–2009 [hl]

Table 4.2.3.31. NMVOC emissions from the beverage production sector [kg]

Categories	NMVOC [kg]						
	2003	2004	2005	2006	2007	2008	2009
Brandy	18,931	15,788	13,435	14,199	19,335	17,840	13,435
White wine	20,364	15,325	40,911	16,958	21,955	34,550	40,911
Red Wine	17,464	14,381	6,730	10,974	14,124	5,617	6,730
Wine	23,808	25,061	22,257	23,438	24,337	25,134	22,257
Beer	27,391	43,113	23,282	41,409	39,330	27,752	23,282

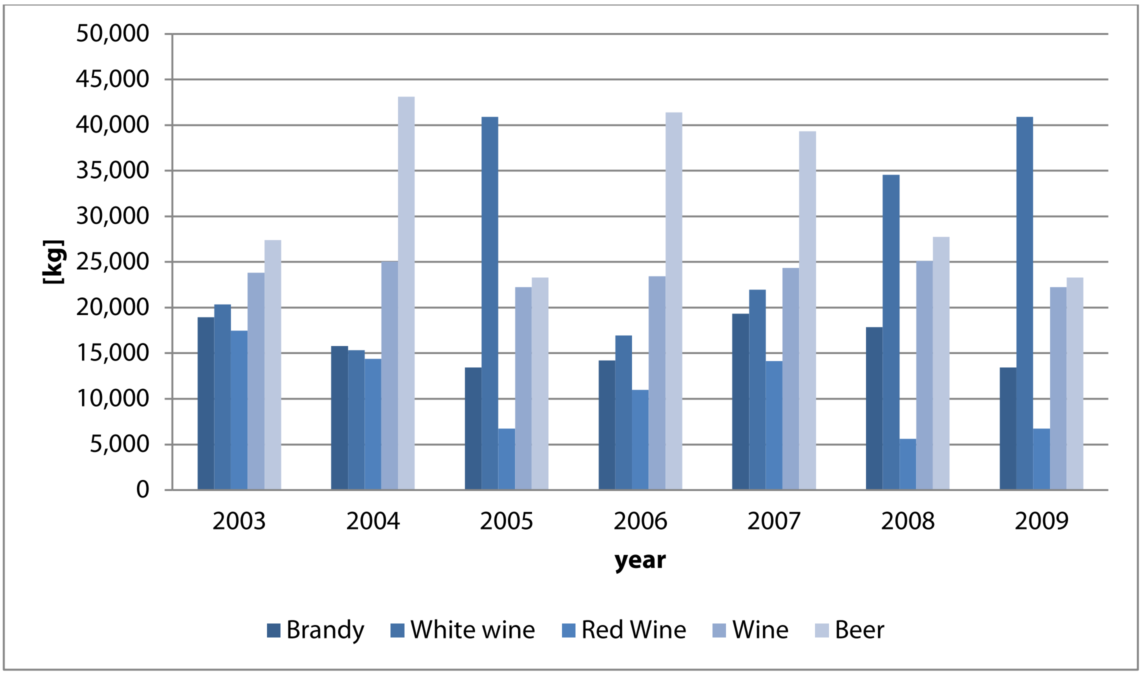


Figure 4.2.3.27. NVMOC emissions from the beverage production sector [kg]

The emissions from this sector (Table 4.2.3.32.) resulting from feedstock usage are NMVOCs. Emissions are calculated based on the production rate (Table 4.2.3.31.) and so will fluctuate significantly according to changes in inter-annual production. Changes in the production data in this sector are mainly the result of changes in domestic market demand and imports and exports.

Bread and Other Food

Food manufacturing may involve the heating of fats and oils and foodstuffs containing such fats and oils, the baking of cereals, flour and beans, fermentation in the making of bread, the cooking of vegetables and meats, and the drying of residues. Emissions occur primarily from the following sources: the cooking of meat fish and poultry, releasing mainly fats and oils and their degradation products; the processing of sugar beet and cane and the subsequent refining of sugar; the processing of fats and oils to produce margarine and solid cooking fat; the baking of bread, cakes biscuits and breakfast cereals; the processing of meat and vegetable by-products to produce animal feeds; the roasting of coffee beans. For obtaining the emission estimate for NMVOCs from each of these categories, national production statistics from the State Statistical Office were multiplied by the default emission factors from the EMEP/CORINAIR Guidebook (SNAP 040605). It was assumed that no controls of emissions are in place.

Table 4.2.3.32. Food production in the period 2003–2009 [t]

FOOD	ACTIVITY RATE, [t]						
	2003	2004	2005	2006	2007	2008	2009
Meat, fish and poultry	9,143	13,009	89,473	14,505	92,858	99,989	89,473
Sugar	33,377	27,810	23,714	19,325	36,502	44,179	23,714
Margarine and solid cooking fats	16,548	26,919	39,052	28,565	27,298	39,828	39,052

Cakes, biscuits and breakfast cereals	2,601	1,229	109,145	2,818	8,107	8,271	109,14 5
Bread	47,257	45,750	47,272	44,774	54,757	50,408	47,272
Animal feed	99,604	83,715	63,904	67,508	77,467	71,069	63,904
Coffee roasting	143	1,885	2,675	2,327	2,822	2,794	2,675

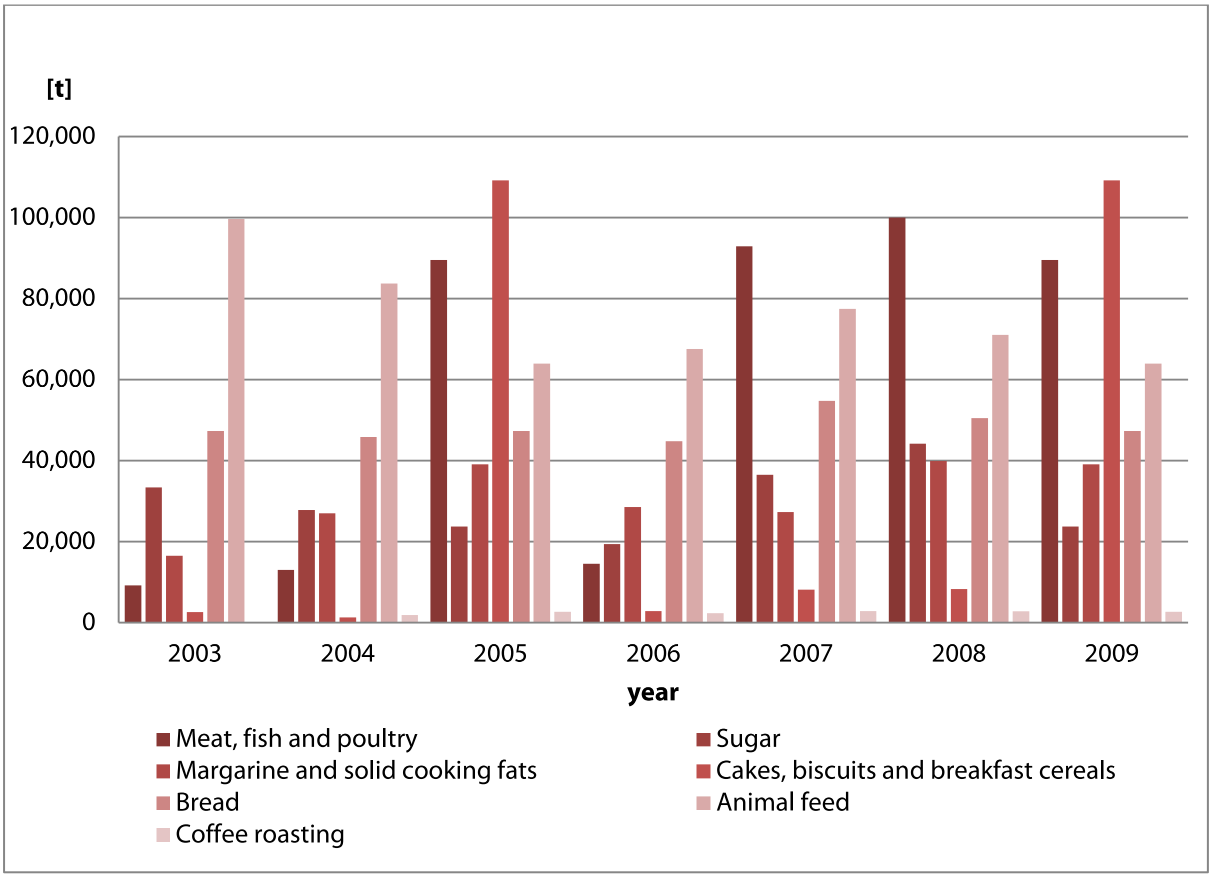


Figure 4.2.3.28. Food production in the period 2003–2009 [t]

The emissions from this sector (Table 4.2.3.34.) which arise from feedstock usage are NMVOCs. Emissions are calculated based on the production rate (Table 4.2.3.33.) and so will fluctuate according to changes in inter-annual production. The changes of the production data in this sector are mainly the result of the level of domestic market demand and imports and exports.

Table 4.2.3.33. NMVOCs emissions from the food production sector [kg]

Categories	**NMVOC [kg]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Meat, fish and poultry	2,743	3,903	26,842	4,352	27,857	29,997	26,842
Sugar	333,770	278,100	237,140	193,250	365,020	441,790	237,140
Margarine and solid cooking fats	165,480	269,190	390,520	285,650	272,980	398,280	390,520

Cakes, biscuits and breakfast cereals	2,601	1,229	109,145	2,818	8,107	8,271	109,145
Bread	378,056	366,000	378,176	358,192	438,056	403,264	378,176
Animal feed	99,604	83,715	63,904	67,508	77,467	71,069	63,904
Coffee roasting	79	1,037	1,471	1,280	1,552	1,537	1,471

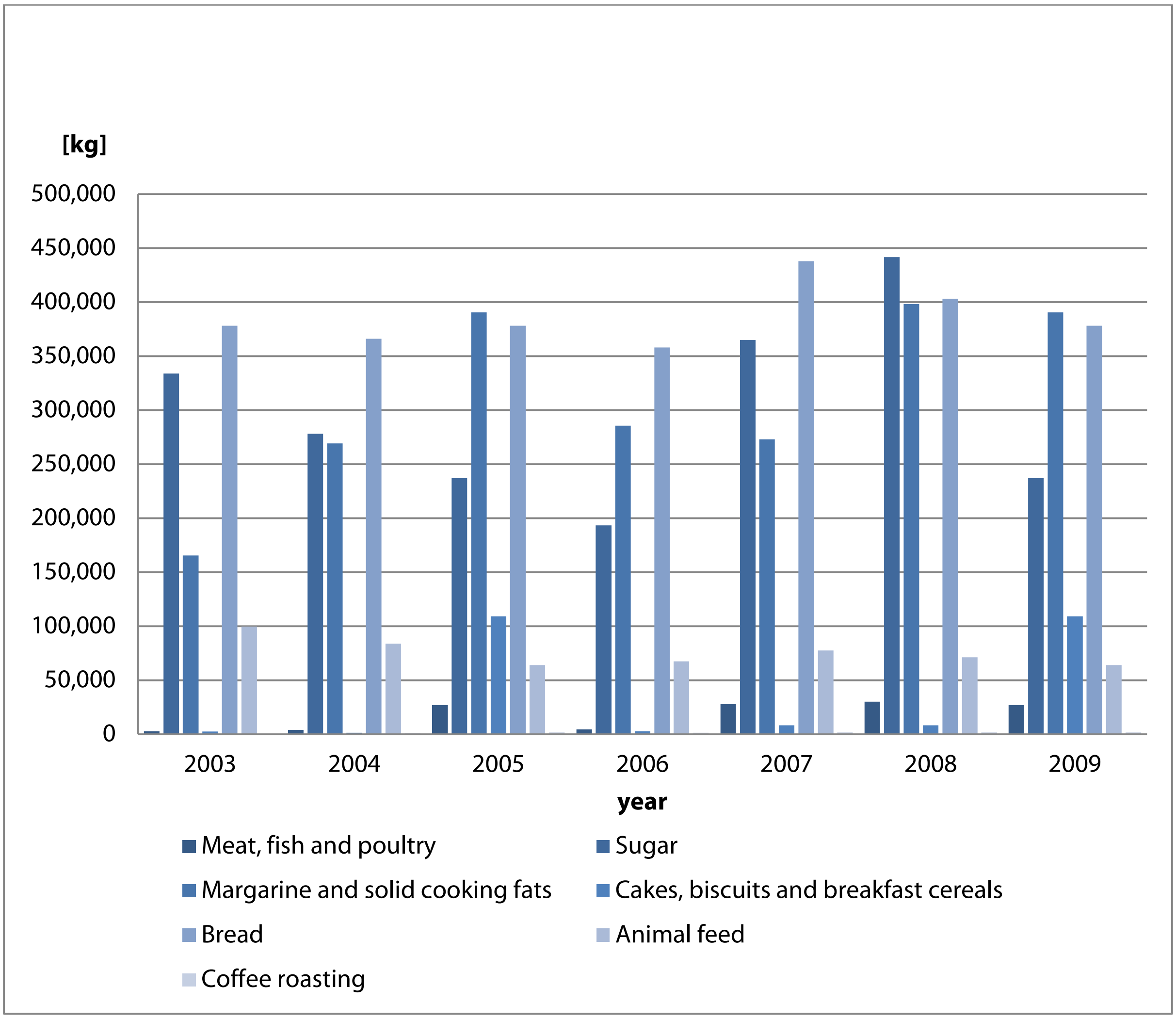


Figure 4.2.3.29. NMVOC emissions from the food production sector [kg]

PRODUCTION AND CONSUMPTION OF HALOCARBONS AND SULPHUR HEXAFLUORIDE

Partially fluorinated hydrocarbons (HFCs), perfluorinated hydrocarbons (PFCs), and sulphur hexafluoride (SF_6) are used as alternatives to the ozone-depleting substances that are being phased out under the Montreal Protocol.

Ozone-depleting substances such as chlorofluorocarbons (CFCs), halons, carbon tetrachloride, methyl chloroform, and hydrochlorofluorocarbons (HCFCs) are used in a variety of industrial applications, including refrigeration and air-conditioning equipment, solvent cleaning, foam production, sterilization, fire extinguishing equipment and aerosols.

Emissions from this category occur as leakage from different types of equipment and from the destruction of such equipment after use.

The activity data on HFCs consumption was taken from a Ministry of Environment and Physical Planning's HCFC Management Phase-Out Plan. This document constitutes one of the country's environmental policies specifically designed to protect the ozone layer. The HCFC Management Phase-Out Plan was created to enable the Government to meet the country's obligations arising from the Montreal Protocol and its Amendments.

In preparing the inventory, special attention was paid to the recovery and recycling of refrigerants (including HCFCs). The Recovery and Recycling Scheme offered service shops the opportunity to apply for grants to upgrade their equipment and established three official recycling centres in the country. Data on reused HFCs are shown in the table below.

Table 4.2.3.34. Consumption of recovered HFCs [kg]

ACTIVITY RATE	**[kg]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Consumption of HFC (recovered)	173.00	25425.00	28630.00	7776.00	17450.00	21104.00	NA

Table 4.2.3.35. CO_2-eq emissions from the consumption of HFCs [kt].

Emissions	**[kt]**						
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
CO_2-eq	2.25	330.53	372.19	101.09	226.85	274.35	

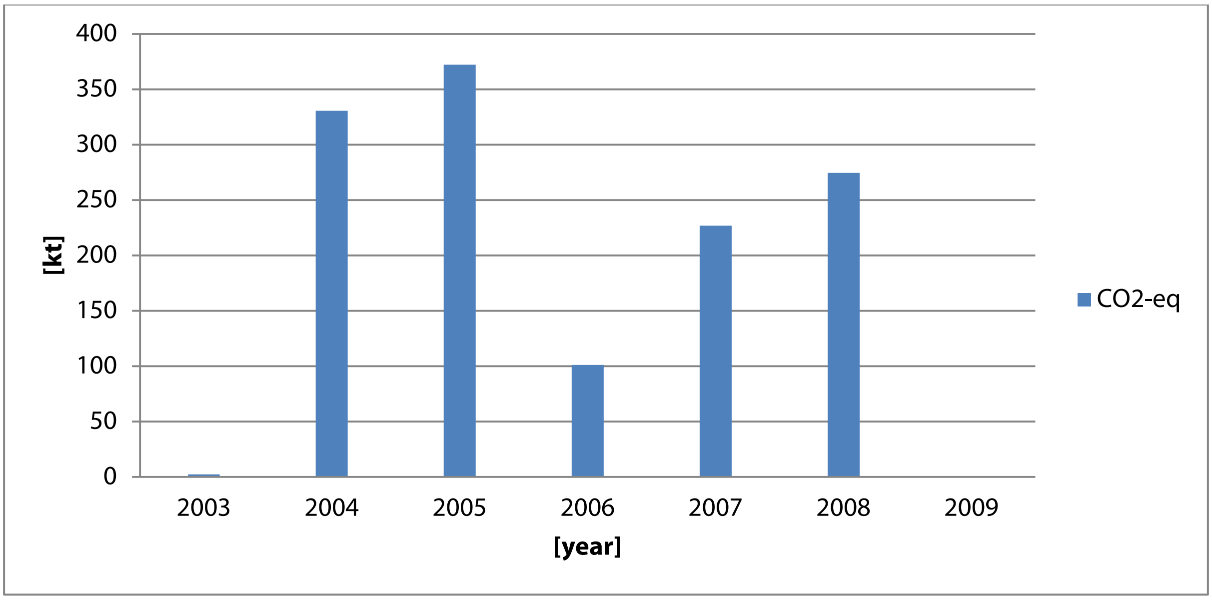


Figure 4.2.3.30. CO_2-eq emissions from the consumption of HFCs [kt]

The IPCC Guidelines suggest that HFC emissions should be calculated on the basis of data on the assembly, operation, and disposal of refrigeration and air-conditioning equipment. However, the unavailability of such data and the lack of sufficient research in this area meant that only the reused amount of HFCs could be calculated in the inventory. The general recommendation of the IPCC guidelines is not to include the recycled amount of HFCs in the inventory. However, since HFCs were not included in previous inventories, they have been included as 'new' amounts in this inventory. Recalculations will be conducted once better data is available.

4.4. Conclusion

Greenhouse-gas emissions from the industrial processes sector fluctuated during the period 2003–2009, falling to a minimum in 2009 due primarily to insufficient data on the usage of HFCs in refrigeration and air-conditioning. Another important reason for the decline in industrial activities was the global economic crisis in 2008, leading to an almost 50% reduction of the activity rate in the metal industry sector, especially in the production of ferro-alloys, which is one of the key categories in the period 2003–2009. Excluding the consumption of HFCs, emissions of greenhouse gases from the Industrial Processes sector were more or less stable in the period of 2003–2008 before falling in 2009. Data on the consumption of HFCs was gathered from the HCFC Management Phase-Out Plan compiled on the basis of research conducted by the Ozone Unit Office. The main aim of this research was to help develop inventories of the ODS covered by the Montreal Protocol, including information on HFC-134a but excluding those gases that were subject to this GHG inventory. This exclusion resulted in insufficient and unreliable data on the consumption of HFCs and thus to fluctuation in the recorded rates of CO_2-eq emission in the first and last year of the prepared inventory. The average share of CO_2-eq emissions in the overall GHG inventory is 7.02 %.

Emissions of indirect GHGs are generated by the subsectors of Road Paving and Food and Beverages. A major spike in emissions of NMVOCs can be seen in 2004 and 2005 when major reconstruction was undertaken of the central infrastructure. The Food industry showed slight growth in 2007–2009 as a result of the government's grant programs in this sector, resulting in increased emissions of NMVOCs.

A number of new sectors, such as Asphalt Paving, were introduced in the calculations for the inventory prepared for the Third National Communication, as well as new, higher tier methodologies. In the process of creating the inventory, a stronger connection was made with industrial installations, leading to deeper knowledge about the specific types of process in each plant, the use of feedstock and the quality of products, and this allowed for a more accurate estimation of GHG emissions.

To overcome the lack of any efficient data-collection system able to meet the IPCC requirements for higher tier methodologies, a new online system was developed for the inventory that will collect all the necessary data for reporting in accordance with the IPCC guidelines. Given that most emissions are generated by a small number of installations, uncertainties in data can be reduced by establishing and maintaining direct communications between the sector expert and industry throughout the reporting period as the best possible way to apply higher tier methodologies.

5. Solvent Use

The use of solvents manufactured using fossil fuels as feedstock can lead to evaporative emissions of various non-methane volatile organic compounds (NMVOCs) which are subsequently further oxidized in the atmosphere.

Methodologies for estimating these NMVOC emissions can be found in the EMEP/CORINAIR Emission Inventory Guidebook (EEA, 2005). 'Solvent use' is treated as a separate source category because the nature of this source requires a somewhat different approach to estimating emissions than that used for calculating other emission categories.

- SNAP 0601: Paint application
- SNAP 0602: De-greasing, dry-cleaning and electronics;
- SNAP 0603: Chemical products manufacturing and processing, including the processing of polyester, PVC, foams and rubber, manufacture of paints, inks, glues and adhesives and the finishing of textile
- SNAP 0604: Other uses of solvents and related activities, including such activities as 'enduction' (i.e., coating) of glass wool and mineral wool, the printing industry, fat and oil extraction, uses of glues and adhesives, wood preservation, domestic solvent use (other than paint application) and vehicle under-seal treatment and vehicle de-waxing.

Due to lack of data, this chapter was not covered in the First National Communication on Greenhouse Gases. For the purpose of the Second National Communication, an assessment was made of the consumption of solvents and other compounds that release VOC for the period 1997–2002, but no data was gathered on the non-industrial consumption of paints. Therefore, bearing in mind that the average annual consumption of paint per capita in Europe is about 4.5 kg, and given that Macedonia does not have a car industry, which is typically the biggest consumer of paints, it was assumed for the purpose of the Second National Communication that the annual consumption of paints per capita in Macedonia is about 3 kg.

For the purposes of the Third National Communication, data on imports and exports of solvents, paint, varnish-remover, etc., was derived from the UN Commodity Trade Statistics Database (UN Comtrade) which stores annual international trade statistics detailed by commodities and partner countries. These data were then subsequently transformed into the United Nations Statistics Division standard format, with consistent coding and valuation using the UN/OECD CoprA internal processing system.

An emission factor of 1 was applied for all organic solvents and other volatile organic compounds, while emissions of NMVOC from paints were calculated using an emission factor of 0.5 in accordance with the CORINAIR Guidelines. However, there was no data to distinguish paints from other substances.

Table 5.1. Imports and exports of solvents in the Republic of Macedonia [kg] and NMVOC emissions from solvent use

Year	Flow	Trade(USD)	Quantity [kg]	NMVOC Emissions, [kg]
2009	Import	1,171,649	710,97	**701,15**
2009	Export	20,88	9,82	
2008	Import	1,275,185	609,36	**609,36**
2008	Export	NA	NA	
2007	Import	1,015,373	537,01	**522,44**
2007	Export	30,93	14,57	
2006	Import	1,021,901	633,83	**616,97**
2006	Export	29,06	16,86	
2005	Import	912,58	538,32	**433,76**
2005	Export	156,65	104,56	
2004	Import	875,90	554,31	**471,86**
2004	Export	134,85	82,46	
2003	Import	757,95	619,04	**504,40**
2003	Export	144,17	114,64	

6. AGRICULTURE

Activity data on the agriculture sector for the Third National Communication was derived from the Statistical Yearbooks of the Republic of Macedonia. Statistics for goats and poultry were not provided for either the First or Second National Communications. The Tier 1 approach was employed in the calculation of revised emissions, using the *Revised 1996 IPCC Guidelines* and the GPG 2000. Major emissions in the sector took the form of methane and nitrous oxide. There was no available data for Tier 2.

The GHG Inventory for the Agriculture sector details emissions from the following source categories:

-CH_4 emissions from *enteric fermentation* in domestic livestock

-CH_4 emissions from *manure management*

-N_2O emissions from *manure management*

-CH_4 and N_2O emissions from *savannah burning*

-CH_4 and N_2O emissions from the *burning of agricultural residue*

-direct N_2O emissions from *agricultural soils*

-indirect N_2O emissions from *nitrogen used in agriculture*

-CH_4 emissions from *rice production*

Other gases such as: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and SO_2 are not associated with agricultural activities.

6.1 INVENTORY UP TO 2002

In the part of the Second National Communication covering Total Annual Methane Emissions from Domestic Livestock (kt) during the period 1990–2002, a significant variation was shown between emissions from different poultry species. Furthermore, goats were not included in further analysis because of a lack of official statistic data on the goat population in the Republic of Macedonia. Mules and asses were also excluded due to a lack of official data on their numbers.

Slight disparities as to the present number of non-dairy cattle in the Republic of Macedonia have no significant influence on the final amount of nitrogen excretion per animal waste management system (AWMS) from Solid Storage and Drylot. The values for CH_4 Emissions (kt) from rice fields in the revised inventory for agriculture in the period up to 2002 have shown no significant difference with the value from the previous inventory. The slight difference seen between the present inventory revision and the previous inventory in terms of the level of direct Nitrous Oxide emissions from agricultural fields (excluding the cultivation of histosols) is due to the difference in animal numbers used (excluding goats, mules and asses). Values for Direct Soil Emissions of nitrous oxide (kt N_20-N/yr) from animal waste were significant in 1991 at 0.40, while values for total nitrogen excretion from Nitrogen Used for Manure in the period up to 2002 had the lowest value compared with the previous document because of the non-inclusion of goats, mules and asses. The main source of emissions in the Agriculture sector are *enteric fermentation* and *agricultural soils*, both with 40–50% of total CO_2-eq emissions, while *rice fields* and *manure management* have a smaller share.

Table 6.1. GHG Emissions (kt CO_2-eq) from Agriculture for the period 1990–2002

Subsector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Enteric Fermentation	694.26	684.18	697.62	703.08	704.97	692.16	659.4	634.62	567.84	570.36	551.04	560.28	545.37
Manure management	168.46	166.99	164.52	162.26	166.87	167.67	172.19	170.72	162.63	165.36	163.05	158.48	158.27
Rice fields	9.24	9.03	9.03	5.46	1.89	1.26	4.41	5.46	4.62	4.41	3.99	1.68	1.89
Agricultural soils	1,035.40	1,007.50	1,010.60	985.80	964.10	964.10	846.30	759.50	728.50	536.30	654.10	368.90	368.90
Total	1,907.36	1,867.7	1,881.56	1,932.62	1,887.97	1,825.14	1,595.5	1,570.3	1,463.59	1,276.43	1,380.58	1,312.54	1,074.43

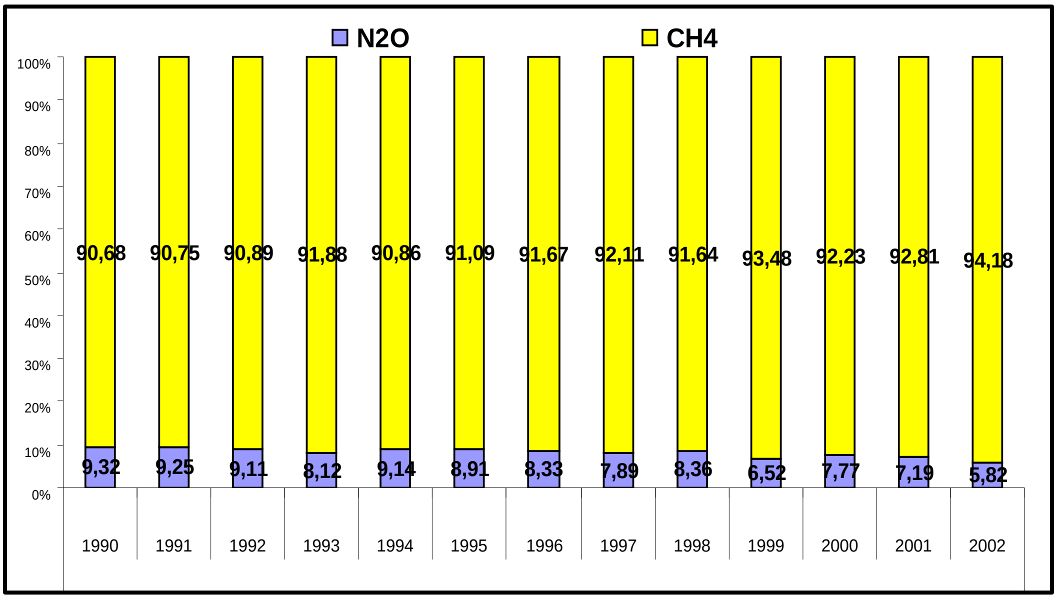


Figure 6.1 Contribution of individual GHGs to the total amount of GHG Emissions (%) from the Agriculture sector, 1990–2002

6.2 Inventory 2003–2009

6.2.1 Methane Emissions from Domestic Livestock, Enteric Fermentation and Manure Management

Various sources were used in estimating emissions of methane from the Agriculture sector. Databases were revised in all sub-sectors and all input data was taken from the official Statistical Yearbooks of the Republic of Macedonia for the analyzed period 2003–2009 (except for data on goats and buffalos, which was obtained from the FAO).

Methane emissions from manure management are usually lower than enteric fermentation emission and are principally associated with animal management facilities where manure is handled as a liquid. Methane is produced during the normal digestive process of animals. The amount of methane produced and excreted by an individual animal depends primarily on two factors:

- **The type of digestive system of the animal.** Thus, ruminant animals have the highest emissions because of significant methane production during fermentation, while pseudo-ruminants and monogastric animals produce lower methane emissions because much less methane-production fermentation takes place in their digestive systems.
- **Feed intake.** Methane is produced by the fermentation of food in animal’s digestive systems. Higher feed intake generally causes higher levels of methane emission.

The amount of methane emitted by a certain population of animals is calculated by multiplying the emission rate per animal by the number of animals. In order to estimate ***methane*** and ***nitrous oxide*** emissions from domestic livestock, enteric fermentation and manure management, the number of specified livestock types in a specific year and the emission factors constant for all years of the analyzed period are needed. The climate regions in the Republic of Macedonia are defined as **cool (<15°C).**

Table 6.2.1.1 Number of animals in the period 2003–2009

YEAR	2003	2004	2005	2006	2007	2008	2009
Livestock Type	Number of Animals (1000s)						
Dairy Cattle	**160.81**	**161.55**	**156.95**	**164.01**	**143.217**	**147.159**	**109.85**
Non-dairy Cattle	**99.16**	**93.24**	**90.133**	**90.70**	**110.54**	**105.95**	**139.75**
Buffalo	**2.02**	**1.43**	**1.10**	**1.12**	**0.64**	**0.64**	**2.09**
Sheep	**1,239.93**	**1,432.36**	**1,244.00**	**1,248.80**	**817.53**	**816.60**	**755.35**
Goats	**62.00**	**62.00**	**62.19**	**163.57**	**126.45**	**133.01**	**94.01**
Horses	**42.88**	**40.39**	**39.65**	**40.55**	**31.06**	**30.93**	**29.41**
Mules & Asses							
Swine	**179.05**	**158.23**	**155.75**	**161.63**	**255.14**	**246.87**	**193.84**
Poultry	**2,417.36**	**2,725.29**	**2,617.01**	**2,585.32**	**2,263.89**	**2,226.05**	**2,117.89**
Total	**4,203.22**	**4,674.52**	**4,366.79**	**4,455.73**	**3,748.49**	**3,707.23**	**3,442.23**

A decrease in the numbers of all animals is reported in the analyzed period, with the exception of non-dairy cattle, including buffalos, for which an increase of 35% is recorded over the six-year period. Emission factors for Enteric Fermentation were taken from the 1996 IPCC Guidelines Workbook, Module 4, Tables 4-3, and for Manure Management from Tables 4-4 and 4-5 (Manure Management Emission Factors, pp. 4.3–4.4.).

Table 6.2.1.2 Emission factors for Enteric Fermentation and Manure Management

Animal	***EF Enteric Fermentation***	***EF Manure Management***
Dairy Cattle	81	6
Non-dairy Cattle	56	4
Buffalo	55	3
Sheep	5	0.1
Goats	5	0.11
Camels	NO	NO
Horses	18	1.1

Mules & Asses	NO	NO
Swine	1	4
Poultry	n/a	0.012

Table 6.2.1.3 Total methane emissions from domestic livestock (kt) for the period 2003–2009

Year	CH4 emissions	Dairy Cattle	Non-dairy Cattle	Buffalo	Sheep	Goats	Horses	Mules & Asses	Swine	Poultry
2003	**Enteric Fermentation**	**13.03**	**5.55**	**0.11**	**6.20**	**0.31**	**0.77**	**NO**	**0.18**	**NO**
	Manure Management	**0.96**	**0.40**	**0.01**	**0.12**	**0.01**	**0.05**	**NO**	**0.72**	**0.03**
2004	**Enteric Fermentation**	**13.09**	**5.22**	**0.08**	**7.16**	**0.31**	**0.73**	**NO**	**0.16**	**NO**
	Manure Management	**0.97**	**0.37**	**0.00**	**0.14**	**0.01**	**0.04**	**NO**	**0.63**	**0.03**
2005	**Enteric Fermentation**	**12.71**	**5.05**	**0.06**	**6.22**	**0.31**	**0.71**	**NO**	**0.16**	**NO**
	Manure Management	**0.94**	**0.36**	**0.00**	**0.12**	**0.01**	**0.04**	**NO**	**0.62**	**0.03**
2006	**Enteric Fermentation**	**13.29**	**5.08**	**0.06**	**6.24**	**0.82**	**0.73**	**NO**	**0.16**	**NO**
	Manure Management	**0.98**	**0.36**	**0.00**	**0.12**	**0.02**	**0.04**	**NO**	**0.65**	**0.03**
2007	**Enteric Fermentation**	**11.60**	**6.19**	**0.04**	**4.09**	**0.63**	**0.56**	**NO**	**0.26**	**NO**
	Manure Management	**0.86**	**0.44**	**0.00**	**0.08**	**0.01**	**0.03**	**NO**	**1.02**	**0.03**
2008	**Enteric Fermentation**	**11.92**	**5.93**	**0.04**	**4.08**	**0.67**	**0.56**	**NO**	**0.25**	**NO**
	Manure Management	**0.88**	**0.42**	**0.00**	**0.08**	**0.01**	**0.03**	**NO**	**0.99**	**0.03**
2009	**Enteric Fermentation**	**8.90**	**7.83**	**0.12**	**3.78**	**0.47**	**0.53**	**NO**	**0.19**	**NO**
	Manure Management	**0.66**	**0.56**	**0.01**	**0.08**	**0.01**	**0.03**	**NO**	**0.78**	**0.03**

Emissions of *methane (CH_4)* from both enteric fermentation and manure management show a general decrease due to the constant decline in the number of animals for the whole period.

6.2.2 Nitrogen emissions - Nitrogen Excretion for Animal Waste Management Systems

For Nitrogen Excretion (Nex) and the Fraction of Manure Nitrogen per animal-waste management system (AWMS) (%/100) the following values were taken for Eastern Europe from the 1996 Revised Guidelines for GHG Inventories Workbook, Module 4: Agriculture, *Table 4-6: Tentative default values for nitrogen excretion per head of animal per region, p. 4.10* and *Table 4–7: Default values for the percentage of manure produced in different animal waste management systems in different world regions* (from Safley et al., 1992), p. 4.11.

A) Anaerobic lagoon systems

These systems are characterised by flush systems which use water to transport manure to lagoons. Water from the lagoon may be recycled as flush water or used to irrigate and fertilise fields. The storage time of manure varies between 30 days to 200 days. According to Table 4.7 from the Revised 1996 Guidelines for GHG Inventories Workbook (p. 4.11), these management systems are found in Eastern Europe only in the case of non-dairy cattle farming (8%), giving the values presented below in Table 6.2.2.1.

Table 6.2.2.1 Nitrogen Excretion - Nex (tonnes//yr) per animal waste management system (AWMS): Anaerobic Lagoons, in the period 2003–2009

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Non-dairy Cattle	404.74	378.74	364.94	367.30	444.75	426.37	567.40

Emissions ranged around 400 tonnes N/year, except in 2009 when they reached the highest value of 567.4 tonnes N/year due to an increase in the number of non-dairy cattle, from 90,000 in 2005 to 140,000 in 2009.

B) Nitrogen Excretion for Animal Waste Management Systems - Liquid systems

Input values for this sector included the number of non-dairy cattle (including buffalos), dairy cattle, poultry and swine. Nitrogen excretion (Nex) values of 50 kg per head per year were adopted for non-dairy cattle and 70 kg per head per year for dairy cattle, fraction of manure nitrogen per animal waste management system - AWMS (%/100): Non-dairy Cattle 0.3; Dairy Cattle 0.18; Poultry 0.28; Swine 0.29.

Nitrogen Excretion per animal waste management system: figures for liquid systems and nitrogen excretion (tonnes/N/yr) in the period 2003–2009 are presented in the following Table.

Table 6.2.2.2 Nitrogen excretion (Nex) from Liquid systems (tonnes/N/yr) in the period 2003–2009

YEAR	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Non-dairy Cattle	1,568.39	1,846.37	1,779.08	1,790.60	2,168.18	2,078.58	2,766.11
Dairy Cattle	2,026.20	2,035.58	1,977.57	2,066.56	1,804.53	1,854.20	1,384.21
Poultry	406.11	457.85	439.65	434.33	380.33	373.97	355.80

Swine	1,038.00	917.73	903.36	937.50	1,479.84	1,431.86	1,124.27
Total	**5,039.21**	**5,257.54**	**5,099.67**	**5,229.01**	**5,832.90**	**5,738.63**	**5,630.40**

C) Nitrogen Excretion for Animal Waste Management Systems - Solid Storage and Drylot

The input values used for calculating emissions from this sector were the Number of Non-dairy Cattle and Dairy Cattle. Nitrogen Excretion values of 50 (kg/head/yr) for Non-dairy Cattle and 70 (kg/head/yr) for Dairy Cattle were taken. Fraction values of Manure Nitrogen per AWMS (%/100) of 0.52 and 0.67 were taken for Non-dairy Cattle and for Dairy Cattle respectively.

The figures for Nitrogen Excretion per AWMS, Nex (kg/N/yr) in the period 2003–2009 are presented in Table 6.2.2.3.

Table 6.2.2.3 Nitrogen Excretion - Nex (tonnes/N/yr) per animal waste management system (AWMS) from Solid Storage and Drylot, in the period 2003–2009

YEAR	2003	2004	2005	2006	2007	2008	2009
Non-dairy Cattle	2,630.86	2,461.83	2,372.11	2,387.47	2,890.91	2,771.44	3,688.15
Dairy Cattle	7,541.98	7,576.88	7,360.95	7,692.21	6,716.87	6,901.75	5,152.34
Total	**10,172.85**	**10,038.71**	**9,733.06**	**10,079.68**	**9,607.79**	**9,673.20**	**8,840.49**

The slight difference as to the present number of non-dairy cattle in the Republic of Macedonia has no significant influence on the final amount of Nitrogen Excretion per animal waste management system (AWMS) from Solid Storage and Drylot.

D) Nitrogen Excretion for Animal Waste Management Systems - Pasture Ranges and Paddocks

Nitrogen Excretion for the Animal Waste Management System - Pasture Ranges and Paddocks comes from dairy cattle, poultry, sheep, swine and goats breeding. Input values for this sector were the number of dairy cattle, poultry, goats, swine, sheep and others (goats and horses).

The values for Nitrogen Excretion Nex (tonnes/N/yr) per animal waste management system (AWMS) in the period 2003–2009 are presented in Table 6.2.2.4.

Table 6.2.2.4 Nitrogen Excretion Nex (tonnes/N/yr) per AWMS: Pasture Ranges and Paddocks, in the period 2003–2009

YEAR	2003	2004	2005	2006	2007	2008	2009
Dairy Cattle	1,463.37	1,470.14	1,428.24	1,492.51	1,303.27	1,339.14	999.70
Poultry	14.50	16.35	15.70	15.51	13.58	13.35	12.70

Sheep	14,482.38	16,730.06	14,529.92	14,585.99	9,548.82	9,537.93	8,822.55
Swine	1,611.45	1,424.07	1,401.77	1,454.75	2,296.31	2,221.86	1,744.56
Others (including goats)	2,359.86	2,303.79	2,291.42	4,592.97	4,343.82	3,688.94	2,777.28
Total	**19,931.57**	**21,944.43**	**19,667.06**	**22,141.74**	**17,505.82**	**16,801.24**	**14,356.82**

Sheep breeding has been in decline in the Republic of Macedonia over the past two decades. Since sheep breeding is a major contributor (73%), this decrease in numbers has influenced the amount of excretion from nitrogen for AWMS (pasture ranges and paddocks). The highest value for this parameter was noted in 2004 when the number of sheep was at its highest: 1,432,369 2,400,000 in 1994). The constant decline in sheep numbers resulted in the lowest value for nitrogen excretion from the AWMS from pasture ranges and paddocks being recorded in 2009 (755,365 sheep).

E) Nitrogen Excretion for the Animal Waste Management System – Other

The input values for this sector are the number of non-dairy cattle, poultry, sheep, swine and horses. For the Nitrogen Excretion Nex, values of 0.6 (kg/head/yr) for Poultry, 20 (kg/head/(yr) for Swine and 25 (kg/head/yr) for Horses were taken. Fraction of the Manure Nitrogen per AWMS (%/100), of 0.71, 0.45 and 0.08 are taken for poultry, swine and horses, respectively. The values for Nitrogen Excretion per AWMS, Nex (kg/N/yr), in the period 1990–1998 are presented in Table 6.2.2.5.

Table 6.2.2.5 Nitrogen Excretion per AWMS from Other sources, Nex (tonnes/N/yr) in the period 2003–2009

YEAR	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Non-dairy Cattle	50.59	47.34	45.61	45.91	55.59	53.29	70.92
Poultry	1,029.79	1,160.97	1,114.84	1,101.34	964.41	948.29	902.22
Sheep	5,356.49	6,187.83	5,374.08	5,394.82	3,531.75	3,527.72	3,263.13
Swine	1,611.45	1,424.07	1,401.77	1,454.75	2,296.31	2,221.86	1,744.56
Others	209.76	204.78	203.68	408.26	315.03	327.90	246.87
Total	**8,258.10**	**9,025.01**	**8,140.00**	**8,405.09**	**7,163.11**	**7,079.09**	**6,227.71**

The yearly variation in the number of animal species correlates with the levels of nitrogen excretion from the AWMS from other species (Poultry, Swine and Others). An overall decrease may be noticed from 9,025 tN/yr in 2004 to 6,227 tN/yr in 2009. A significant decrease is seen in all categories, excluding non-dairy cattle excretion (50,59 to 70,92 tN/yr). Poultry excretion reduced by 23%, sheep by 47% (from 2004), swine excretion reduced by 24% from the 2007 value, while there was a 40% reduction from other animals (horses, goats, etc.) compared to the 2006 values.

Summary of Nitrogen excretion for animal waste management systems

Summary of Nitrogen emissions (tonnes N/yr) from various AWMS are presented below:

Table 6.2.2.6 Summary of Nitrogen excretion per AWMS (tonnes/N/yr)

2003	2004	2005	2006	2007	2008	2009
43,858.93	**46,695.66**	**43,055.67**	**46,324.91**	**40,650.91**	**39,800.53**	**35,684.55**

According to the results for manure management regarding the animal waste management systems this parameter has the highest value in 2004 (46,695 t/N/yr) when the numbers of animals were highest at 4,674,529, and the lowest value (35,684 t/N/yr) in 2009 when the number of animals was lowest at 3,442,231.

6.2.1 METHANE EMISSIONS FROM FLOODED RICE FIELDS

The input values applied for calculating emissions from this sector were the Harvested Area (m^2 /l 000 000 000) from Intermittently Flooded Rice Fields, since only this type of rice fields is present in Macedonia. Data on the harvested rice area were taken from the Statistical yearbook of the Republic of Macedonia, Sector: Agriculture, Table: Area and production of cereals. The value 0.5 was taken as the Scaling Factor for Methane Emissions, while 1.3 was taken as the *country-specific* correction factor for organic amendment and 10 (g/m^2) as the seasonally integrated emission factor for continuously flooded rice without organic amendment from the 1996 IPCC Revised National GHG Inventories. Output values for CH_4 Emissions (kt) from rice fields for the period 2003–2009 are presented in Table 6.2.3.

Table 6.2.3 CH_4 Emissions (kt) from rice fields in the period 2003–2009

YEAR	2003	2004	2005	2006	2007	2008	2009
CH_4 Emissions (kt)	0.20	0.18	0.17	0.16	0.16	0.17	0.20

The values for CH_4 emissions (kt) from rice fields in the revised inventory for agriculture in the period 2003–2009 show a mild decrease in values compared to the previous inventory, mostly due to the abandonment of rice cultivation because of very low purchase prices and conversion to more profitable crops.

6.2.2 AGRICULTURAL SOILS

DIRECT NITROUS OXIDE EMISSIONS FROM AGRICULTURAL FIELDS, EXCLUDING THE CULTIVATION OF HISTOSOLS

The input values applied for calculating emissions from this sector was/were the Amount of N Input (kg N/yr) from Synthetic fertilizer (F_{SN}), obtained from the *Statistical yearbooks for 2008 and 2009, section: Agriculture, Table. Consumption of fertilizers in agriculture (2003–2009), p.408*. Animal waste (F_{AW}), N-fixing crops (F_{BN})) *taken from FAOSTAT database for crop production in Macedonia (Source: http://faostat3.fao.org/home/index.html#VISUALIZE)* and Crop residue (F_{CR}). Factors for Direct Emissions EF_1 (kg N_2O-N/kg N) are the same for all inputs and are equal to 0.0125. Amounts of N input according to type of N input in (kg N/yr) are presented in Table 4.2.4.a. Output values for Direct Soil Emissions of nitrous oxide (kt N_2O-N/yr) for the period 2003–2009 are presented in table 6.2.4.1.

Table 6.2.4.1 Amounts of N input according to type of N input in tonnes N/yr for the period 2003–2009

Type of N input *Year*	*Synthetic fertiliser (FSN)*	*Animal waste (FAW)*	*N-fixing crops (FBN)*	*Crop residue (FCR)*
2003	**9,066**	**34,525**	**34,269**	**14,336**
2004	**8,937**	**36,422**	**30,761**	**17,713**
2005	**8,910**	**33,583**	**21,019**	**9,212**
2006	**8,771**	**36,133**	**22,291**	**9,766**
2007	**6,812**	**31,707**	**21,259**	**11,711**
2008	**7,011**	**31,044**	**5,640**	**12,921**
2009	**6,681**	**27,833**	**7,960**	**16,585**

The highest amounts of N input according to the type of N input from fertilizers occurred in 2003 at 9.066 t/N/yr, i.e., 26% higher than fertilizers use in 2009. The highest amount of input from animal manure was noted in 2004 at 36,422 t/N/yr, i.e. 1.3 times more than in 2009. The N input from nitrogen-fixing crops was highest in 2003 at 34,269 t/N/yr, before decreasing to a value of 7,960 t/N/yr in 2008. For N input from crop residue (FCR) 17,713 t/N/yr), the highest value was recorded in 2004 (in 2009 similar values).

Table 6.2.4.2 Direct Soil Emissions of nitrous oxide (kt N20-N/yr) for the period 2003–2009

Type of N input *Year*	**Synthetic fertiliser (FSN)**	**Animal waste (FAW)**	**N-fixing crops**	**Crop residue (FCR)**
2003	**0.11**	**0.43**	**0.43**	**0.18**
2004	**0.11**	**0.46**	**0.38**	**0.22**
2005	**0.11**	**0.42**	**0.26**	**0.12**
2006	**0.11**	**0.45**	**0.28**	**0.12**
2007	**0.09**	**0.40**	**0.27**	**0.15**
2008	**0.09**	**0.39**	**0.07**	**0.16**
2009	**0.08**	**0.35**	**0.10**	**0.21**
Total emissions	***0.71***	***2.89***	***1.79***	***1.15***

6.2.3 Nitrous Oxide Emissions from Manure Nitrogen

The input value adopted for calculating emissions from this sector was that of Total Nitrogen Excretion (kg N/yr). The fraction of Nitrogen Excreted During Grazing was 0.02 and the Fraction of Nitrogen Excrete Emitted as NOx and NH_3 was 0.2. These values remained constant throughout the analyzed period. The fraction of Nitrogen Burned for Fuel was taken as 0 (no re-usage for fuel) and the Fraction coefficient was 0.78.

The Amounts of Total Nitrogen Excretion (tonnes N/yr) are presented in Table 6.2.5.

Table 6.2.5 Manure Nitrogen Used (tonnes/yr) in the period 2003–2009

YEAR	**Total Nitrogen Excretion (Nex) tonnesN/yr)**	**Manure Nitrogen Used (Faw) tonnesN/yr**
2003	**44,263**	**34,525**
2004	**46,695**	**36,422**
2005	**43,055**	**33,583**
2006	**46,324**	**36,133**
2007	**40,650**	**31,707**
2008	**39,800**	**31,044**
2009	**35,684**	**27,833**

Manure Nitrogen Used had the highest value (36,422 tonnes N/yr) in 2004. This is due to the fact that livestock numbers were at their highest in that particular year.

6.2.4 Field burning of agricultural residues, Nitrogen Input from Crop Residues

Values on the production of the most important crops (in kilo tonnes) were entered in the inventory the first time. For calculating the fraction burned on fields, the default value 0.25 was used and the fraction oxidized 0.9 (according to Revised 1996 IPCC Guidelines).

Table 6.2.6.1 Crop production and characteristics

Crops	Residue to Crop Ratio	Quantity of Residue (kt biomass)	Dry Matter Fraction	Quantity of Dry Residue (kt dm)	Carbon Fraction of Residue	Total Carbon Released	Nitrogen -Carbon Ratio
wheat	1.3	352.44	0.78	274.91	0.4853	30.02	0.012
barley	1.2	175.64	0.78	137.00	0.4567	14.08	n/a
maize	1	154.23	0.3	46.27	0.4709	4.90	0.02
oats	1.3	6.37	0.15	0.96	0.45	0.10	0.009
rye	1.6	14.53	n/a	0.00	n/a	0.00	n/a
rice	1.4	27.82	0.78	21.70	0.414	2.02	0.014
millet	1.4	0.04	n/a	0.00	n/a	0.00	0.016

sorghum	1.4	0.07	n/a	0.00	n/a	0.00	0.02
pea	1.5	8.13	n/a	0.00	n/a	0.00	n/a
bean	2.1	12.37	n/a	0.00	n/a	0.00	n/a
soya	2.1	0.40	n/a	0.00	n/a	0.00	0.05
potatoes	0.4	81.88	0.3	24.57	0.422	2.33	0.2
fodder	0.3	66.70	0.1	6.67	0.407	0.61	n/a
sugarbeet	0.2	1.56	0.1	0.16	0.4	0.01	n/a
peanut	1	0.00	n/a	0.00	n/a	0.00	n/a
sunflower	2.1	16.32	0.26	4.24	0.433	0.41	n/a

Data was taken from the State Statistical Office's Statistical yearbooks for the agriculture sector (Table: 'Crop production') and from the FAO database on crop production in Macedonia. Figures for residue to crop ratios, fractions from dry matter, the carbon fraction of residue and the nitrogen-carbon ratio for each crop were taken from the Revised 1996 IPCC Guidelines, Reference manual: Agriculture, Table 4-17 Crop residue Statistics, p. 4.85; Revised 1996 IPCC Guidelines, Reference manual: Agriculture, p. 4.83 and from scientific journals: Debska B. et al (2012) The effect of post-harvest residue in maize, rapeseed and sunflower in soils, Journal of Environmental Sciences, vol. 21, no. 3, pp. 603–613; Ghaly, E *et al.* (1993) Determination of the Kinetic Parameters of Oat Straw using Thermogravimetric Analysis, Journal Biomass and Bioenergy, p. 457–465.

To conclude, there is a lack of data on fractions and ratios for some crops and this data needs to be determined by laboratory or field testing. In general, these figures should not contribute significantly to overall GHG emissions in this sub-sector.

Nitrogen Input from Crop Residues

The input value adopted for calculating emissions from this sector was the Production of non-Nitrogen-fixing crops (kg dry biomass/yr) and data on the Production of Pulses and Soybeans (kg dry biomass/yr) obtained from the FAOSTAT database for crop production in Macedonia (source: http://faostat3.fao.org/home/index.html#VISUALIZE), while the Fraction of Nitrogen of non-N-fixing crops was taken as 0.0015 (kg N/ kg dry biomass).

The fraction of Nitrogen in N-fixing crops was 0.03 (kg N/ kg dry biomass), the fraction of Crop Residue Removed from Fields was set at a constant value of 0.55, while the Fraction of Crop Residue Burned was set at 1. These values were constant for the analyzed period. The amounts of Total Nitrogen Input from Crop Residues (kg N/yr), are presented in Table 6.2.6.2.

Table 6.2.6.2 Amounts of Total Nitrogen Input from Crop Residues (tonnes N/yr) for the period 2003–2009

YEAR	Production of non-N-fixing crops (kt dry	Production of pulses and soybeans (kt dry	Nitrogen input from crop residues FCR (ktN/yr)

	biomass/yr)	biomass/yr)	
2003	896.91	34.26	*14.33*
2004	1,131.31	30.76	*17.71*
2005	578.36	21.01	*9.21*
2006	613.09	22.29	*9.76*
2007	746.16	21.25	*11.71*
2008	819.66	25.22	*12.92*
2009	1,051.79	32.55	*16.58*

Prescribed savannah burning

Category 4E, 'prescribed Savannah burning', does Not Occur (NO) in the country.

6.2.5 DIRECT NITROUS OXIDE EMISSIONS FROM THE CULTIVATION OF HISTOLS

The input value adopted for calculating emissions from this sector is the total Area of Cultivated Organic Soils recorded on the MAFWE webpage FQS (ha). Since the MAFWE has only recorded this data since 2005, values for the period 2003–2004 are shown as Not Estimated (NE).

Table 6.2.7.1 Area of cultivated organic soils (ha) 2003–2009

	2003	2004	2005	2006	2007	2008	2009
Area under Organic (ha)	**NE**	**NE**	**266.00**	**509.42**	**714.47**	**2,657.00**	**1,732.43**

The Emission Factor for Direct Soil Emissions (kg N_2O-N/ha/yr) is estimated at 5 and this value is constant for the analyzed period. Total direct emissions of N_2O from the cultivation of histols are presented in Table 6.2.7.2.

Table 6.2.7.2 Direct nitrous oxide emission from the cultivation of histols in 2003–2009

YEAR	2003	2004	2005	2006	2007	2008	2009

Total Direct emission of N_2O	1.81	1.84	1.43	2.35	2.58	3.27	1.98

6.2.6 Indirect Nitrous Oxide Emissions from Atmospheric Deposition of NH_3 and NO_x

Emission factors in this sub-sector are constant for each year of the analyzed period. The input values adopted for calculating emissions from this sector were the Synthetic Fertilizer N Applied to Soil (kt N/yr) and the Total N excretion by Livestock Nex (kt N/yr). Input values, emission factors and Nitrous Oxide Emissions (kt N_2O-N/yr) for the analyzed period are presented in Table 6.2.8. The fraction that volatilizes was taken as 0.1, the Fraction of Total Manure N Excreted that Volatilizes as 0.2, and Emission Factor EF4 0.01 – all of which are default values from the 1996 IPCC Guidelines.

Table 6.2.8 Indirect Nitrous Oxide Emissions from Atmospheric Deposition of NH3 and NOx for the period 2003–2009

YEAR	Synthetic Fertiliser N Applied to Soil, NFERT (kt N/yr)	Amount of Synthetic N Applied to Soil that Volatilizes (ktN/kgN)	Total N Excretion by Livestock NEX (kt N/yr)	Total N Excretion by Livestock that Volatilizes (ktN/kgN)	Nitrous Oxide Emissions (kt N_20-N/yr)
2003	10.07	1.00	44.63	8.85	0.08
2004	9.93	0.99	46.69	9.33	0.09
2005	9.90	0.99	43.05	8.61	0.09
2006	9.74	0.97	46.32	9.26	0.10
2007	7.56	0.75	40.65	8.13	0.10
2008	7.79	0.77	39.80	7.96	0.10
2009	7.42	0.74	35.68	7.13	0.10

The Indirect Nitrous Oxide Emissions from Atmospheric Deposition of NH_3 and NOx for the Period 2003–2009 have more or less the same values (0.08–0.10).

6.2.7 Indirect Nitrous Oxide Emissions from Leaching

The input values adopted for calculating emissions from this sector were those of Synthetic Fertilizer Use NFERT (kg N/yr) and Livestock N excretion Nex (kg N/yr). The emission factors in this sub-module were constant for each year of the analyzed period. From Table 3.4.6.1 it can be seen that the highest value of total nitrous oxide emissions, at 3.34 Gg, occurred in 1990 when indirect nitrous emissions also had the highest value (1.03 GgN_2O/yr). For the emission factor the default value was 0.3, while for emission factor no.5 was 0.025.

The input values, emission factors and Nitrous Oxide Emissions (kt N_2O-N/yr) for the analyzed period are presented in Table 6.2.9.

Table 6.2.9 Indirect Nitrous Oxide Emissions from Leaching for the Period 2003–2009

YEAR	Synthetic Fertilizer Use NFERT (kt N/yr)	Livestock N Excretion NEX (kt N/yr)	Nitrous Oxide Emissions From Leaching (kt N_2O-N/yr)	Total Indirect Nitrous Oxide Emissions (kt N_2O/yr)	Total Nitrous Oxide Emissions (kt)
2003	10.07	44.26	0.41	0.80	**3.23**
2004	9.93	46.69	0.42	0.83	**3.36**
2005	9.90	43.05	0.40	0.77	**2.83**
2006	9.74	46.32	0.42	0.82	**3.04**
2007	7.56	40.65	0.36	0.71	**2.67**
2008	7.79	39.80	0.36	0.70	**2.36**
2009	7.42	35.68	0.32	0.63	**2.26**

6.2.10 SUMMARY REPORT FOR THE AGRICULTURE SECTOR

Methane emissions account for 12.38% of total GHG emissions in Macedonia. One third of emissions are generated by enteric fermentation and manure management, and as a consequence these emissions are directly proportional to livestock numbers. 89% of CH_4 emissions are generated by enteric fermentation from domestic livestock, and these emissions have been continuously decreasing in line with the reduction of livestock populations in the period. Manure management emissions account for 8% of GHGs, while the remaining emissions come from rice fields and the burning of residues.

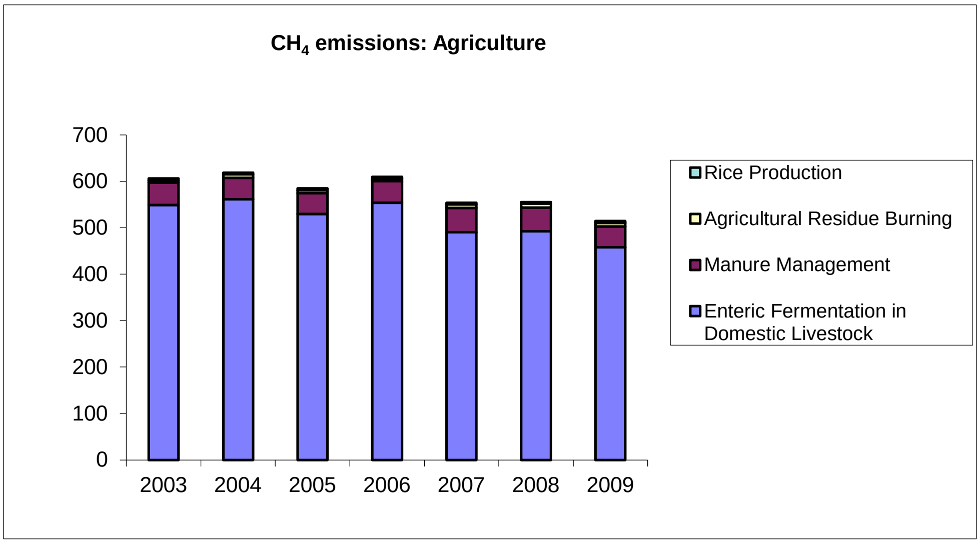


Figure 6.2.10.1 Summary CH_4 emissions by subsector

89% of N_2O emissions arise from the management of agricultural soils, including the use of fertilizers, the amount and type of manure applied, leaching, nitrogen-fixing crops and atmospheric deposition, while remaining emissions are generated by manure management and, to a less significant extent, from the burning of crop residues.

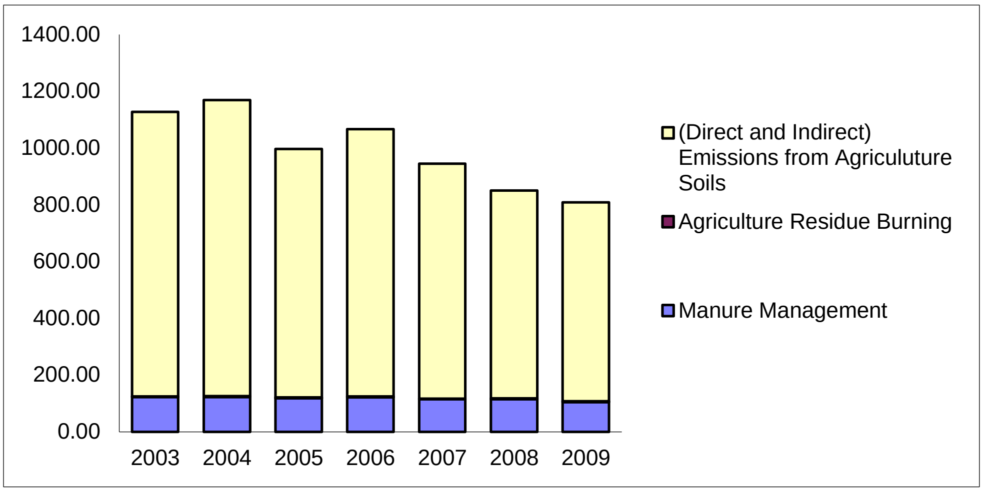


Figure 6.2.10.2 Summary of N_2O emissions by subsector

Table 6.2.10.1 Sectorial Report for Agriculture, GHG emissions (CO_2-eq kt)

SECTOR	2003	2004	2005	2006	2007	2008	2009
Total Agriculture	**1,733.51**	**1,787.87**	**1,581.21**	**1,676.00**	**1,498.88**	**1,404.94**	**1,322.27**
Enteric fermentation	549.16	561.62	529.65	553.97	490.64	492.25	458.02
Manure management	170.17	168.87	162.14	167.92	166.27	166.00	149.33
Rice fields	4.11	3.88	3.56	3.45	3.45	3.62	4.27
Agricultural soils	1,002.68	1,042.91	875.85	941.35	828.03	732.16	700.22
Agricultural residue burning	7.37	10.58	10.00	9.31	10.48	10.90	10.43

Table 6.2.10.2 Sectorial Report for the Agriculture sector, CH_4 and N_2O (kt)

SUBSECTOR	**2003**		**2004**		**2005**		**2006**		**2007**		**2008**		**2009**	
	CH_4	***N_2O***	***CH_4***	***N_2O***	***CH_4***	***N_2O***	***CH_4***	***N_2O***	***CH_4***	***N_2O***	***CH_4***	***N_2O***	***CH_4***	***N_2O***
Total Agriculture	**28.86**	**3.64**	**29.47**	**3.77**	**27.84**	**3.21**	**29.05**	**3.44**	**26.38**	**3.05**	**26.44**	**2.74**	**24.50**	**2.61**
Enteric fermentation	26.15	NO	26.74	NO	25.22	NO	26.38	NO	23.36	NO	23.44	NO	21.81	NO
Manure management	2.29	0.39	2.21	0.40	2.13	0.38	2.21	0.39	2.48	0.37	2.45	0.37	2.14	0.34
Rice fields	0.20	NO	0.18	NO	0.17	NO	0.16	NO	0.16	NO	0.17	NO	0.20.	NO
Agricultural soils	NO	3.23	NO	3.36	NO	2.83	NO	3.04	NO	2.67	NO	2.36	NO	2.26
Agricultural residue burning	0.22	0.01	0.34	0.01	0.32	0.01	0.29	0.01	0.37	0.01	0.37	0.01	0.34	0.01

Table 6.2.10.2 Percentage (%) of CH_4 and N_2O emissions by each subsector

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Enteric fermentation (% CH_4)	90.61	90.74	90.59	90.81	89.04	88.91	89.21
Manure management (% CH_4)	7.94	7.49	7.67	7.63	9.47	9.30	8.77
Agricultural residue burning (% CH_4)	0.77	1.14	1.14	1.00	1.41	1.40	1.40
Rice fields (% CH_4)	0.68	0.63	0.61	0.56	0.63	0.65	0.83
Manure management (% N_2O)	10.83	10.48	11.77	11.38	12.08	13.47	12.91
Agricultural residue burning (% N_2O)	0.24	0.30	0.34	0.30	0.29	0.37	0.40
Management of agricultural soils (% N_2O)	88.93	89.22	87.89	88.32	87.64	86.16	86.68

7. LAND USE, LAND USE CHANGE AND FORESTRY (LULUCF)

Land Use, Land Use Change and Forestry is a very important sector when investigating the overall balance of GHG gases both globally and in specific countries because it is the only sector that absorbs the emissions that originate from this and other sectors. The main emissions from this sector arise from the annual loss of biomass for commercial harvesting, changes in biomass stock, on-site and off-site burning of biomass, wood decay and changes in land use.

The GHG inventory for this sector consists of the inventory of CO_2 absorption – carbon sinks from forestland remaining forestland, cropland remaining cropland, grassland remaining grassland, settlements remaining settlements, changes in forest and other biomass stocks, biomass cleared in commercial harvesting – and emissions from land conversion and the management of agriculture lands, as well as the inventory of other non-CO_2 gases (CH_4, CO, N_2O and NO_x) generated by on- and off-site burning, in accordance with the *Revised 1996 IPPC Guidelines for National Greenhouse Gas Inventories: Reference Manual*. One problem in calculating values for LULUCF was the impossibility of obtaining accurate data on forests and forest land areas and annual forest growth and yield, since the last inventory of the country's forest was compiled in 1979. Input data was taken from the Statistical yearbook. This data has not been fully confirmed by the new inventory; however, it is the only usable source. Both inventories, from 1999–2002 and 2003–2009, were compiled using Tier 1 methodology because of the unavailability of accurate activity data which prevented the implementation of higher Tier methodology. Activity data was mainly used from the State Statistical Office of the Republic of Macedonia, and default emission factors were taken from the revised IPCC guidelines for GHG inventories and accompanying Manual. In this Inventory, a general reporting format from the IPCC was used and overall CO_2 emissions and removals were correctly inserted, while additional data was obtained from the Forestry Inspectorate within the Ministry of Agriculture, Forestry and Water Economy and PE Macedonian Forests.

THE GHG INVENTORY UP TO 2002

The LULUCF GHG inventory for the period 1999–2002 was developed in previous National Communications. The main problems with these values lay in the uncertainty of the activity data on the country's forest area, stock and annual forest growth, changes in land use, as well as loss of biomass due to commercial harvesting, illegal harvesting, wood decay in forests and processed industry. Data on the area of forest and other trees, forest growth and commercial harvest were taken from the Statistical yearbook, and data for the area burned from forest fires was taken from the Statistical yearbook of the Ministry of Internal Affairs. Using these elements, the annual balance of absorption and emissions of GHGs from this sector, together with the perceptual parts for different is shown in Table 7.1. For the analyzed period, this sector mostly absorbed all of its own emissions, except in 2000 when the balance between absorption and emission was negative due to numerous forest fires. Burning biomass (on- and off-site) contributes the highest share of emissions, and the most frequent gas is CO_2, at over 97 %. Other gases make very little contribution, except CO at little over 2%.

Table 7.1.1Summary of CO_2 [kt] from the LULUCF sector in the period 1990–2002

Year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Biomass (removals)	1,557.82	1,609.85	1,765.61	1,896.71	1,826.18	1,805.67	1,795.12	2,249.23	2,333.60	2,202.05	2,885.16	2,616.27	2,590.24
Soil (removals)	62.26	62.26	62.26	62.26	62.2	62.26	62.26	62.26	62.26	63.03	63.03	63.03	63.03
Forest and Grassland (release)	257.73	21.87	385.30	689.47	248.31	5.15	46.78	161.39	81.01	90.47	1711.95	291.90	31.65
TOTAL (removals)	**1,362.35**	**1,650.24**	**1,442.57**	**1,269.50**	**1,639.95**	**1,862.78**	**1,810.60**	**2,150.10**	**2,314.85**	**2,174.61**	**1,236.24**	**2,387.40**	**2,621.62**

INVENTORY 2003–2009

7.2.1 CHANGES IN FOREST AND OTHER WOODY BIOMASS STOCKS

A) Forestland remaining forestland

For changes in carbon stock in living biomass, data on the Annual Growth Rate were obtained from the Internal Publications of the Ministry of Agriculture, Forestry and Water Economy, and then compared to the 1979 Forest and Forest Land Inventory. These are the only available official sources that could be used. The data on the Carbon Fraction of Dry Matter (0.5) was taken from the Reference Manual, Module 5: Land Use Change and Forestry, page 5.5. The figure for urban and farm trees was taken from the Agriculture Chapter of the Statistical yearbook of the Republic of Macedonia produced by the Statistical Office of the Republic of Macedonia, Skopje.

Table 7.2.1.1 Data on forest types, growth rate and biomass increment and carbon uptake in forests

Year	Vegetation type	Area of Forest / Biomass Stocks (kha)	Annual Growth Rate (t dm/ha)	Annual Biomass Increment (kt dm)	Total Carbon Uptake Increment (kt C)
2003	Evergreen	109,454	6	656.72	328.36
	Deciduous	539,666	1.3	701.57	350.78
	Mixed	306,174	1.3	398.03	199.01
2004	Evergreen	85,104	6	510.62	255.31
	Deciduous	553,456	1.3	719.49	359.75
	Mixed	309,093	1.3	401.82	200.91
2005	Evergreen	83,665	6	501.99	251.00
	Deciduous	555,495	1.3	722.14	361.07
	Mixed	316,068	1.3	410.89	205.44
2006	Evergreen	87,569	6	525.41	262.71
	Deciduous	560,389	1.3	728.51	364.25
	Mixed	311,301	1.3	404.69	202.35
2007	Evergreen	80,009	6	480.05	240.03
	Deciduous	551,681	1.3	717.19	358.59
	Mixed	310,279	1.3	403.36	201.68
2008	Evergreen	80,576	6	483.46	241.73
	Deciduous	547,186	1.3	711.34	355.67
	Mixed	315,286	1.3	409.87	204.94

2009	Evergreen	83,583	6	501.50	250.75
	Deciduous	549,869	1.3	714.83	357.41
	Mixed	315,877	1.3	410.64	205.32

Table 7.2.1.2 Data on farm trees and associated emissions

Year	Number of trees (1000s)	Annual Growth Rate(kt dm/1000 trees)	Annual Biomass Increment (kt dm)	Total Carbon Uptake Increment (kt C)
2003	7,782	0.005	38.91	19.46
2004	8,442		42.21	21.11
2005	8,015		40.08	20.04
2006	8,249		41.25	20.62
2007	8,402		42.01	21.01
2008	8,368		41.84	20.92
2009	8,547		42.74	21.37

A general conclusion is that the number of farm trees and forest vegetation coverage are relatively stable, giving constant rates for annual biomass absorption and total CO_2 removals throughout the 7-year period covered by the inventory.

B) Cropland remaining cropland

Activity data were taken from the 2009 Statistical yearbook of Macedonia, Sector: Agriculture, Table: Agricultural area by categories of use, p.396 and Table: Area and production on meadows and pastures, p. 396, and data on organic production in Macedonia - certified area from 2005-2009 (Source: MAFWE web site: http://www.mzsv.gov.mk/?q=node/220.

Values for Annual Growth and Loss (G/L) were taken as default from the 1996 IPCC Guidelines, Chapter 3_3, Table 3.3.2.11 default coefficients for above-ground woody biomass and harvest cycles in cropping systems containing 12 perennial species, p.3.65**.** Reference carbon stock (SOCref): 34 default value from IPCC 1996 Guidelines, Chapter 3_3, Table 3.3.3, p.3.70. Stock change factor for land use or land-use change type in the beginning of the inventory year (FLU=0.82, FMG, AND FI=1): default values from the IPCC Guidelines, Chapter 3_3, Table 3.3.4, p.3.7.

Table 7.2.1.3 Cropland area and carbon sequestration in the period 2003–2009

Year	2003	2004	2005	2006	2007	2008	2009
Annual area of cropland with perennial woody biomass (ha)	19,013	17,888	15,872	16,034	16,239	17,686	18,497

CO_2-eq. removals (kt)	-183.49	-175.88	-174.90	-184.80	-197.28	-223.45	-273.89

Table 7.2.1.3 shows that the cropland area remained relatively constant in the 7-year period 2003–2009, while carbon sequestration (CO_2 removals) from biomass rose in line with constantly increasing CO_2 removals from organic cultivated land.

C) Grassland remaining grassland

Activity data for this category were taken from the Statistical yearbook of Macedonia, Agriculture Sector, p.379.

Table 7.2.1.4 Grassland area in Macedonia 2003–2009

	2003	2004	2005	2006	2007	2008	2009
Meadows	53,560	56,420	58,561	60,264	58,804	61,229	58,199
Pastures	732,963	697,066	682,771	687,324	549,860	542,478	500,468

Grasslands were constantly decreasing in area in the period 2003–2009, largely due to unfavorable subsidies and higher costs for raising livestock from the MAFWE, a decrease in the livestock population (see the Agriculture sector) and changing climate conditions such as longer dry seasons without rainfall and an increase in floods.

Emission factors were taken as default values from the 1996 Revised IPCC Guidelines, Chapter 3_4: LUCF Sector Good Practice Guidance, p.3.112. Liming surface (in ha) 670-Expert judgment from Agriculture Institute.

D) Settlements remaining settlements

There are two options for a Tier 1 estimation of changes in the amount of carbon stock in living biomass: a) the crown cover area method; and b) the tree growth-rate method. Inventory calculations were based on the crown cover area method. The crown cover factor (CRW) value was taken as 2.9 (as the default value adopted from the IPCC Guidelines). The total crown cover area is estimated at 8,104 ha, with 19.7% of the total settlement area in Macedonia, meaning 41,100 ha is under trees. This calculation is based on a scientific journal reporting tree coverage in the Skopje area (2010, the Faculty of Forestry which gives a constant value of 23.50 CO_2-eq. over the entire inventory period.

Carbon stock change in biomass loss was set at zero if the average age of the tree population was 20 years or less; otherwise it was assumed that carbon stock change in biomass growth was equal to loss.

E) *Wetlands remaining wetlands*

Although some data on the wetland area can be found in Corine land cover 2006-47,530 ha, there are no annual data on this sub-category in Macedonia and therefore it was reported as Not Estimated (NE). This is why the wetland area was not taken into account in the calculation of CO_2 emissions. Accurate data on flooding in all different land categories should be available from the Centre for Crisis Management, which can be used for estimating emissions from this category in future inventories.

E) *Other lands*

This category does not apply in Macedonia and was thus reported as Not Occurring (NO).

7.2.2 TOTAL BIOMASS REMOVED IN COMMERCIAL HARVESTING

To estimate the Total Biomass Removed in Commercial Harvesting (kt dm), the Total Biomass Consumption (kt dm) and Total Biomass Consumption from Stocks (kt dm), Commercial Harvesting (in 1000m^3 round wood) and Total Traditional Fuel Wood and Other Wood Consumption (kt dm), the Statistical Yearbook of the Republic of Macedonia was used (Chapter Forestry, Statistical Office of the Republic of Macedonia, Skopje). Biomass Conversion/Expansion Ratios (t dm/m^3), were taken from the local expert, Professor Mitko Nacevski and other professors at the Faculty of Forestry in Skopje.

Table 7.2.2 Annual Carbon Release, Annual Carbon Uptake (+) or Release (-) and Annual Emission (-) or Removal (+)

Year	Net Annual Carbon Uptake (+) or Release (-) (kt C)	Convert to CO_2 Annual Emission (-) or Removal (+) (kt CO2)
2003	-246.74	-904.72
2004	-250.09	-917.01
2005	-280.18	-1,027.32
2006	-235.37	-863.02
2007	-429,49	-1.574,81
2008	-301.12	-1,104.09
2009	-354.90	-1,301.31

Converting annual release to CO_2 removals is performed by multiplying the value by 44/12. In the years 2007 and 2009, most biomass was removed for harvesting, while values for the period as a whole remained relatively constant at around 1000 kt.

7.2.3 FOREST AND GRASSLAND CONVERSION – CO_2 FROM BIOMASS

Forest and Grassland Conversion is not an important category since grassland conversion goes towards creating croplands and forest conversion is a temporary category, due to the fact that reforestation occurs within a couple of years.

In order to estimate the annual Total of Biomass Cleared Area Converted (kha), and biomass before and after conversion (t dm/ha), data was taken from the statistical database of the Forestry Inspectorate within the Ministry of Agriculture, Forestry and Water Economy on the area of forest fires, as well as the Statistical yearbook of the Republic of Macedonia, Chapter Forestry, State Statistical Office of the Republic of Macedonia. For the total biomass before conversion, the values are 37 for Coniferous and 53 for Broadleaf, while for biomass after conversion the values of 11.1 and 16 respectively were obtained from experts at the Faculty of Forestry. Figures for the Fraction of Biomass Burned on Site (kt dm), the Fraction of Biomass Oxidized on Site (kt dm), and the Carbon Fraction of Above-Ground Biomass (kt C) were taken from the Reference Manual, Module 5: Land Use Change and Forestry, page 5.6., 5.15. Some data is available on above-ground biomass, below-ground biomass, dead wood and carbon in litter and deadwood from the FAO forestry department, FRA 2010 Global Forest Resources Assessment Database. *This data can be used for possible application of Tier 2 methodology but must be nationally adopted from studies.*

The area of forest converted annually (kha) and associated CO_2 emissions (kt) are presented below (Sources: Statistical Review in *Forestry* 2008 and 2009, Table: Replenishment of forests, p. 19, and Statistical Review in *Forestry* 2000–2007, Table: Replenishment of forests, p.13.)

Table 7.2.3 Conversion of forest and grassland

Year	**Area converted annually (kha)**		**Total CO_2 emissions(kt)**
	Coniferous	***Broadleaf***	
2003	0.19	0.03	***8.31***
2004	0.12	0.10	***9.20***
2005	0.29	0.04	***11.88***
2006	0.26	0.04	***11.00***
2007	33.57	5.40	***1,420.20***
2008	2.42	5.65	***361.15***
2009	0.10	0.71	***38.43***

Default values for the Fraction of Biomass Burned off Site (0.3), the Fraction of Biomass Burned on Site (0.5), the Fraction of Biomass Oxidized on/off Site (0.9), and the Carbon Fraction of Above-Ground Biomass on- and off-site (0.5) were taken from the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook Module 5: Land use change and Forestry, page 5.15, item 3 & item 5.

A large amount of forest land was converted (39,61 kha) in 2007 due to large-scale forest fires. In 2008, 8,07kha of forest land was lost to fires, resulting in 361 kt of CO_2 emissions.

7.2.4 ABANDONMENT OF MANAGED LANDS

This subsector was not calculated in any of the three inventories for the country due to lack of data. The data needed for estimating emissions are the values for the Total Area abandoned and regrown over 20 years and the Annual Rate of Above-Ground Biomass Growth. This category is also reported as Not Estimated (NE).

Data can be obtained from the European Forestry Institute and PE Macedonian Forests.

7.2.5 ON-SITE BURNING OF FOREST – NON CO_2 TRACE GASES FROM BURNING BIOMASS

To estimate Non-CO_2 trace gases from burning biomass, the Quantity of Carbon Released (kt C) should be multiplied with the Nitrogen-Carbon ratio to estimate the value for Total Nitrogen Released. Taking into account the Trace Gas Emissions Ratios, the Non-CO_2 trace gases emissions from burning biomass can be calculated. Data on burned biomass were taken from the Statistical database of the Forestry Inspectorate within the Ministry of Agriculture, Forestry and Water Economy. There was a significant increase of emissions in 2007 due to enormous forest area burned in the country (Table 7.2.5).

Table 7.2.5 Non-CO_2 trace gases emissions from burning biomass [kt] in the period 2003–2009

Year	CH_4	N_2O	NO_x	CO
2003	0.26	0.01	0.04	3.36
2004	0.22	0.01	0.04	2.83
2005	0.31	0.01	0.05	4.26
2006	0.31	0.01	0.04	4.23
2007	**2.75**	**0.04**	**0.27**	**43.42**
2008	0.84	0.02	0.10	12.58
2009	0.28	0.01	0.04	3.69

The default ratios for carbon compounds were obtained from the 1996 IPCC Revised Reference Manual, Module 5: Land Use Change and Forestry, page 5.18., tables 5-7.

As expected, non-CO_2 emissions were higher in 2007 due to extensive forest fires.

7.2.6 CARBON EMISSIONS FROM INTENSIVELY MANAGED ORGANIC SOILS

Organic production was added as a separate sub-category under croplands (Source: MAFWE, 'Capacities under organic production in Macedonia 2005–2009', available at http://www.mzsv.gov.mk/?q=node/220). This enabled the calculation of annual carbon loss from cultivated organic soils for the period 2005–2009, as presented in Table 7.2.6.

Table 7.2.6 Emissions from managed organic soils (CO_2-eq. in kt) for the period 2003–2009

2003	***2004***	***2005***	***2006***	**2007**	***2008***	***2009***
NE	**NE**	1.29	3.33	12.85	49.61	192.91

The area of organic production in Macedonia is constantly increasing mainly because of favorable subsidies from the Government's agricultural policy, awareness campaigns and growing demand on the market for healthy organic produce.

7.2.7 CARBON EMISSIONS FROM THE LIMING OF AGRICULTURAL SOILS

For the agricultural area, data was obtained from Statistical yearbooks, sector: Agriculture, p. 402. The carbon conversion factors 0.12 and 0.122 were taken as default value from the Revised 1996 IPCC Guidelines, Chapter 3.3: Croplands, p.3.75. Due to lack of official data, this Inventory used default values for lime application. Data on dolomite application of224 kg/ha was taken, (Source: EPA Analysis of Innovative Feedstock Sources and Production Technologies for Renewable Fuels, p.3.19) and for limestone application a default value of 400kg/ha was taken (Sources:http://www.agbrazil.com/opening_virgin_cerrado_land.htm).

For the Inventory it was hypothesized that around 670 ha of land are treated only with limestone (Source: Expert Judgment from Agriculture Institute). The results are presented in Table 7.2.7:

Table 7.2.7 Carbon emissions from liming (Annual CO_2 eq. emissions [kt])

Year	**Mg C**	**Total Annual Carbon Emissions**	**Converted to Total Annual CO_2 Emissions**
2003-2009	0.03	$0.03*10^{-3}$	$0.012*10^{-3}$

7.2.8 SUMMARY LULUCF SECTOR

Emissions from this sector increased significantly in 2007 due to massive forest fires which burned 39,612 ha of forest land. Emissions in other years seem more or less constant. Overall CO_2 emissions/removals range from -900 to -1,200 kt, with the exception of 2007 when carbon emissions were 7.76kt because of higher carbon releases.

Table 7.2.8 Summarized values for carbon releases - emissions (+) or carbon sink - removals (-) for the period 2003–2009 in CO_2-eq [kt].

Year	2003	2004	2005	2006	2007	2008	2009
Forest Land remaining Forest Land CO_2 [kt]	-748.86	-767.96	-881.78	-707.81	-1,474.78	-935.86	-1,106.85
Croplands remaining Croplands CO_2 [kt]	-183.49	-175.88	-174.90	-184.80	-197.28	-223.45	-273.89
Grasslands remaining Grasslands CO_2 [kt]	$0.03*10^{-4}$	0.07	0.26	0.52	2.72	12.50	51.24
Settlements remaining Settlements CO_2 [kt]	23.50	23.50	23.50	23.50	23.50	23.50	23.50
Wetlands remaining Wetlands CO_2 [kt]	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
Other Lands CO_2 [kt]	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Abandonment of managed Lands CO_2 [kt]	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
Forest and Grassland conversion CO_2 [kt]	8.31	9.2	11.88	11	1,420.2	361.15	38.43
Management of agricultural soils CO_2 [kt]	-85.4	-85.4	-84.11	-82.07	-72.54	-35.79	107.52
Forest Land remaining Forest Land-Forest fires N_20 [kt]	1.10	1.14	1.73	1.67	95.77	24.56	3.10
Forest Land remaining Forest Land-Forest fires CH_4 [kt]	3.84	3.18	5.25	5.15	139.15	36.33	6.01
TOTAL LULUCF CO2eq. [kt]	**-976.71**	**-988.89**	**-1,092.57**	**-927.27**	**7.76**	**-717.83**	**-1,146.25**
Forest Land remaining Forest	2.53	1.99	3.43	3.40	43.42	11.75	2.86

Land CO [kt]							
Forest Land remaining Forest Land –Forest fires NOx [kt]	0.01	0.01	0.02	0.02	0.271	0.07	0.02
Forest and grassland conversion NOx [kt]	0.01	0.01	0.01	0.01	0.96	0.24	0.03
Forest and grassland conversion CO [kt]	0.20	0.22	0.28	0.26	33.89	8.62	0.92

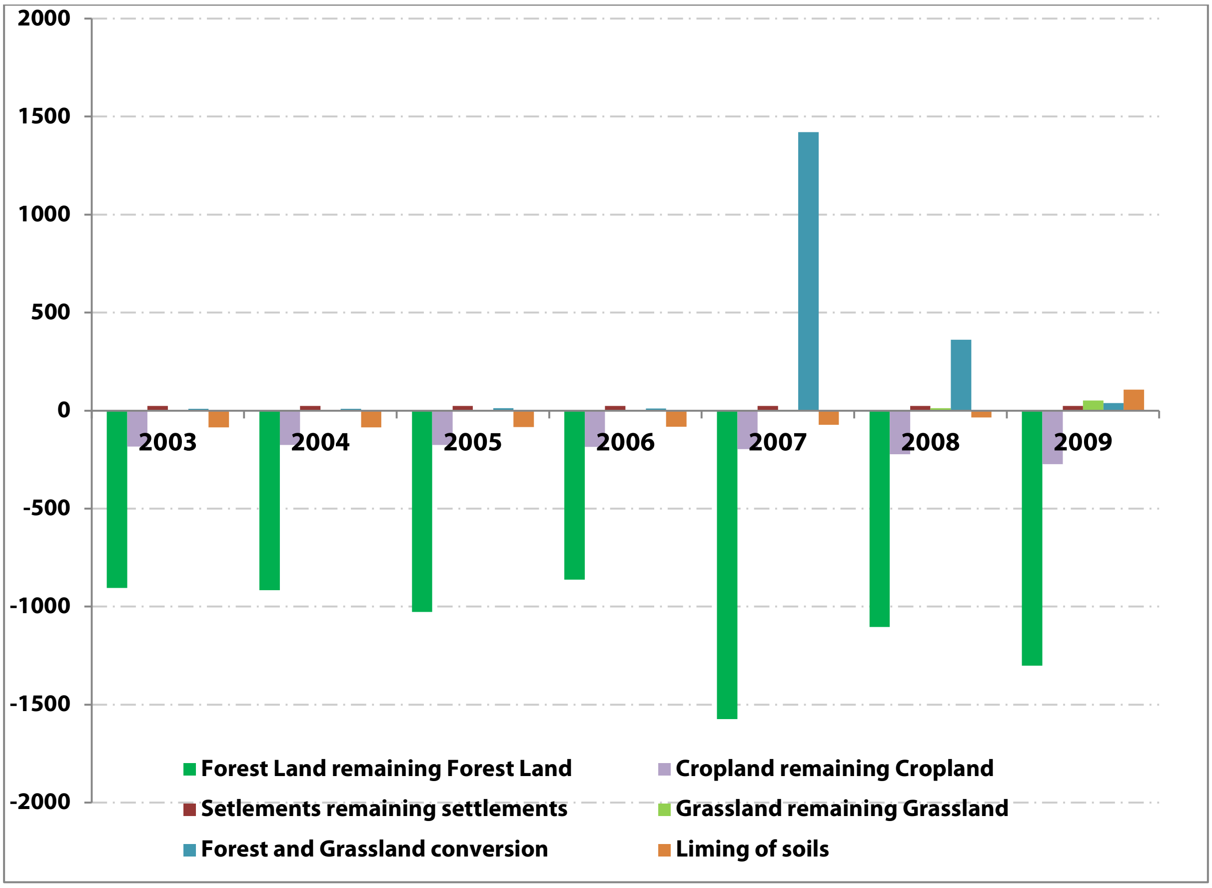


Figure 7.2.8 Emissions/removals from different Land Use categories CO_2-eq. [kt]

Figure 7.2.8 shows that forest land is responsible for most carbon removals, followed by cropland remaining cropland and the liming of agriculture soils, except in 2009 when soils were more intensively managed and carbon emissions were reported. Most emissions are generated by on- and off-site burning and forest and grassland conversion (only in 2007 and 2008 because of land destruction by fires), with smaller amounts arising from grassland remaining grassland and settlements remaining settlements.

8. WASTE

The revised 1996 IPCC Guidelines For National Greenhouse Gas Inventories provide an outline of two methods for estimating emissions of CH_4 from solid waste disposal sites: the default method (Tier 1) and the First Order Decay (FOD) method (Tier 2). The main difference between these two methods is that the FOD method produces a time-dependent emission profile that reflects the true pattern of the degradation process over time. *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (*GPG 2000*, IPCC, 2000) describes two methods for estimating CH_4 emissions from SWDS: the mass balance method (Tier 1) and the First Order Decay (FOD) method (Tier 2). In the IPCC Guidelines, the use of the mass balance method is strongly discouraged as it produces results that are not comparable with the FOD method which produces more accurate estimates of annual emissions. Instead of the mass balance method, the ***Tier 2 FOD methodology*** is suggested. The following sources are used for GHG emissions for the waste sector: CH_4 emissions from solid waste disposal sites, CH_4 emissions from residential/commercial wastewater and sludge, CO2 emissions from waste incineration, and N_2O emission from human sewage and domestic/industrial wastewaters.

8.1 INVENTORY UP TO 2002

The GHG Inventory for the Second National Communication for 1999–2002 (including the revision of the GHG Inventory for the Waste Sector under the FNC for the period 1990–1998) consists of the inventory of N_2O emissions from human sewage and methane emissions from sub-sectoral sources, including solid waste disposal sites, domestic/commercial organic wastewater and sludge, and industrial wastewater and sludge. Methane and nitrogen emissions from the Waste Sector were calculated according to both the *Revised 1996 IPPC Guidelines for National Greenhouse Gas Inventories: Workbook* and the *Revised 1996 IPPC Guidelines for National Greenhouse Gas Inventories: Reference Manual*. Activity data were taken mainly from the *Statistical Yearbooks of the Republic of Macedonia* published by the State Statistical Office of the Republic of Macedonia. The emission and conversion factors were taken from the *Revised 1996 IPPC Guidelines*. Because of missing data on the annual amount of waste, as well as historical waste quantities, the default method (Tier 1) was applied, based on the estimated amount of MSW using population figures and the MSW Disposal Rate of 0.79 kg per capita per day. Methane and N_2O emissions for the whole analyzed period remained relatively constant, ranging from 755.15 kt CO_2-equivalent in 1994 to 843.56 kt CO_2-equivalent emissions in 2000. A slight increase in methane emissions occurred in 1997 when the disposal of solid waste was increased at the Drisla landfill (managed type of SWDSs). A larger share in GHG emissions from the Waste Sector arise from methane emissions, amounting to 93–94 % of total emissions from this sector, while the N_2O emission portion is smaller at 6–7%. The main source of emissions in the Waste Sector is that of methane emissions from SWDSs at 86–89 %, while methane emissions from domestic/commercial and industrial wastewaters and sludge are very low. Furthermore, there are plans for building managed SWDSs in the country and these will increase the emission of methane from the Waste Sector. Increasing methane emissions can be also expected with the introduction of wastewater treatment plants for domestic/commercial and industrial wastewaters.

Summary of GHG emissions (CO_2-eq kt) from the Waste sector, 1990–2002:

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Methane emissions	32.27	32.50	33.13	33.29	31.21	32.18	32.95	34.70	35.05	35.04	35.71	35.36	35.65
SWDSs													
CO_2-equivalent	677	68	69	69	65	67	69	72	73	73	74	74	74
% of total	86.	85.	86.	86.	86.	86.	88.	88.	88.	88.	88.	88.	89.
Domestic/Commercial Organic Wastewater and Sludge													
Methane emission	1.61	1.63	1.66	1.68	1.56	1.58	1.34	1.35	1.36	1.38	1.39	1.39	1.38
CO_2-equivalent emission (kt)	33.81	34.23	34.86	35.28	33.39	33.81	28.56	28.77	28.77	28.98	29.19	29.19	28.98
% of total emissions from	4.31	4.31	4.32	4.36	4.42	4.34	3.64	3.50	3.46	3.50	3.46	3.49	3.44
Industrial Wastewater and Sludge													
Methane emission	1.0	1.16	1.01	0.92	0.65	0.81	0.58	0.58	0.60	0.49	0.56	0.52	0.45
CO_2-equivalent emission (kt)	21.21	24.36	21.21	19.32	13.65	17.01	12.18	12.18	12.60	10.29	11.76	10.92	9.45
% of total emissions from the from the Waste sector	2.70	3.07	2.63	2.39	1.81	2.18	1.55	1.48	1.52	1.24	1.39	1.31	1.13

Total methane emissions from the Waste Sector													
Total methane emission	**35.37**	**35.2**	**35.8**	**35.8**	**33.4**	**34.6**	**34.89**	**36.6**	**37.0**	**36.9**	**37.6**	**37.2**	**37**
CO_2-equivalent emission (kt)	**732.6**	**741.**	**751.**	**753.**	**702.**	**726.**	**732.69**	**769.**	**777.**	**775.**	**790.**	**782.**	**78**
% of total emission from sector Waste	93.29	93.36	93.09	93.11	93.02	93.23	93.29	93.59	93.65	93.63	93.75	93.69	93.
N_2O emissions from human sewage													
Total N_2O emission (kt)	**0.17**	**0.17**	**0.18**	**0.18**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.17**	**0.**
CO_2-equivalent emission (kt)	**52.70**	**52.7**	**55.8**	**55.8**	**52.7**	**52.7**	**52.70**	**52.7**	**52.7**	**52.7**	**52.7**	**52.7**	**52**
% of total emissions from sector Waste	6.71	6.64	6.91	6.89	6.98	6.77	6.71	6.41	6.35	6.37	6.25	6.31	6.2
Total CO_2-equivalent emission													
Total CO_2-eq mission from sector Waste (kt)	**795.47**	**793.79**	**807.60**	**809.49**	**755.15**	**779.30**	**785.39**	**822.35**	**830.12**	**827.81**	**843.56**	**835.37**	**839**

8.2 INVENTORY 2003–2009

8.2.1 METHANE EMISSIONS FROM SOLID WASTE DISPOSAL SITES

Data on the exact current amount of annual waste, as well as historical waste quantities, could not be obtained for Macedonia. Those data are available only for Drisla landfill where MSW from Skopje region is disposed.

The FOD methods require data on the amounts and composition of solid waste disposal over a 50-year period. Countries that do not have historical statistical data or equivalent data on solid waste disposal going back 50 years or more need to estimate these data using surrogates (extrapolations of population, economic and other drivers). Historical data was taken from official censuses from 1950, 1962, 1971, 1981, 1991, 2002 and current population estimations from the State Statistical Office. Data for the missing years were obtained by extrapolation. The same method was applied with waste generation per capita. The results were put into the FOD method Excel sheet and data was obtained with the use of ***Tier 2 FOD methodology***.

Default values for Methane Correction Factors were taken from the *Revised IPCC 1996 Guidelines*, Module 6, Table 6-2, p.6.8. Proportion of waste (by weight) in managed, unmanaged-deep and unmanaged-shallow sites taken from PE Drisla, Skopje, 2005, Internal report.

Table 8.2.1 Type of waste disposal sites, proportion of waste, and the methane correction factor in Macedonia

Type of Site	**Proportion of Waste (by weight) for Each Type of SWDSs**	**Methane Correction Factor (MCF)**	**Weighted Average MCF for Each Type of SWDS**
Managed	0.283	1	0.28
Unmanaged - deep (>=5m waste)	0.318	0.8	0.26
Unmanaged - shallow (< 5m waste)	0.4	0.4	0.16
Total	*1*	**0.6**	*0.70*

The DOC value was calculated using Equation 2, while the values for major waste streams were obtained from the *Revised 1996 IPCC Guidelines, Workbook*, Tables 6-3, p.6.9:

DOC = (0.4*A) + (0.17*B) + (0.15*C) + (0.3*D)

A = Fraction of paper in MSW (value 21.8) and textile (4.7)
B = Fraction of garden waste in MSW (value 10.99)
C = Fraction of food waste in MSW (value 30.1)
D = Fraction of wood waste in MSW (value 7.5)

These values were set as a ***country-specific value* of 0.19.**

Default values for DOCF which Actually Degrades (0.77) and the Fraction of carbon released as Methane (0.5) were obtained by using the *Revised 1996 IPCC Guidelines, Workbook*, p.6.10.

Emissions of methane (in kt) from SWDSs in the period 2003 to 2009 are shown in Table 6.2.1. It can be seen that the amount of emissions of methane was reduced by about 25–28 % compared to the previous calculation. For comparison purposes, data calculated with Tier 1 Mass balance method is also presented.

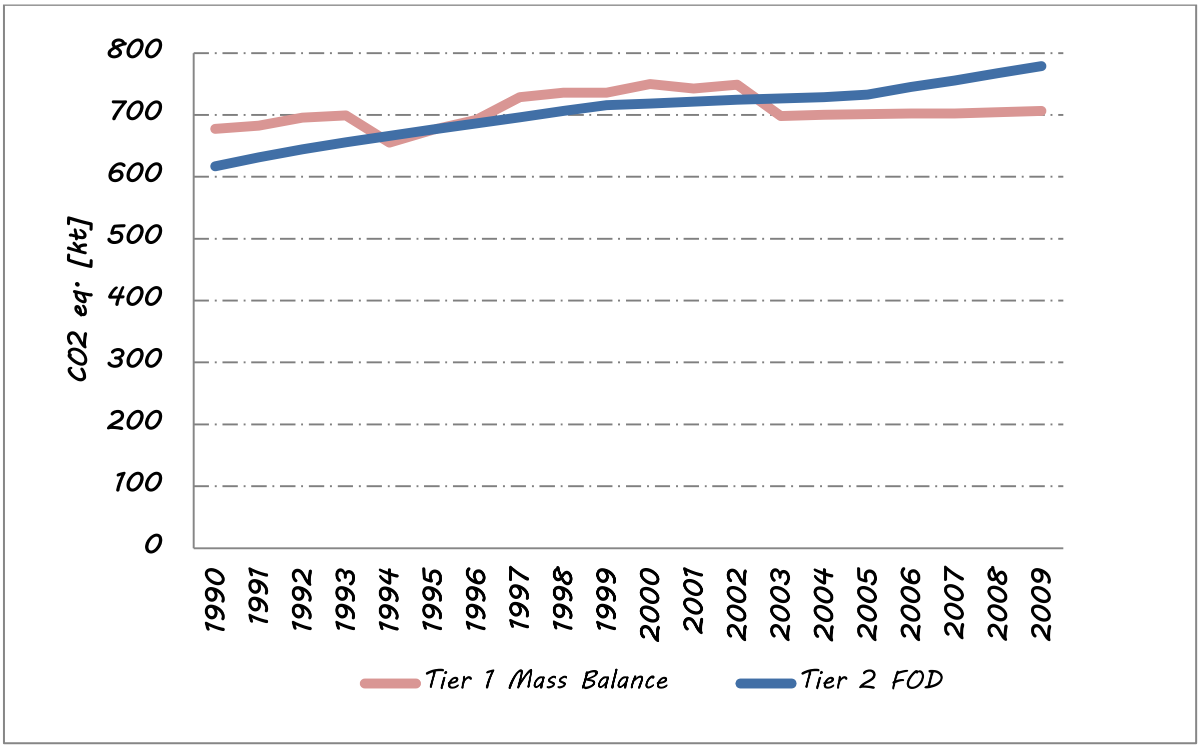


Figure 8.2.1.1 Two different methods for the calculation of emissions from SWDS

Figure 8.2.1.1 shows that data obtained by Tier 2 FOD corresponds more closely to the real situation, giving more precise data on emissions from solid waste disposal sites. Since methane emissions from MSW are directly dependent on the country's population and the amount of produced waste per capita, it is only logical to assume a slight increase in GHG emissions during the inventory period.

Table 8.2.2 Emissions of methane (CO_2-eq. kt) from SWDSs in the period 2003–2009

Year	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***
Net annual methane emissions/kt CH_4	34.61	34.69	34.89	35.49	35.97	36.54	37.08
CO_2-equivalent emissions/kt CO_2 ((FOD default Tier 2)	726.78	728.53	732.69	745.30	755.45	767.44	778.70
CO_2-equivalent emissions/kt CO_2 (Mass balance Tier 1)	698.34	700.17	701.31	702.49	702.30	704.20	706.20

To obtain more precise information on methane emissions from municipal solid waste transported to solid waste disposal sites, the territory of Macedonia was divided into eight Statistical regions (see Fig. 8.2.1.2: projected Total CO_2-eq. emissions from SWDS in 2009).

Vardar region	58.76	<50
East region	68.36	50-100
Southwest region	84.23	100-150
Southeast region	65.42	150-200
Pelagonia region	89.08	200-300
Polog region	118.81	300-500
Northeast region	66.57	500-1000
Skopje region	227.43	**>1000**
Total	**778.69**	

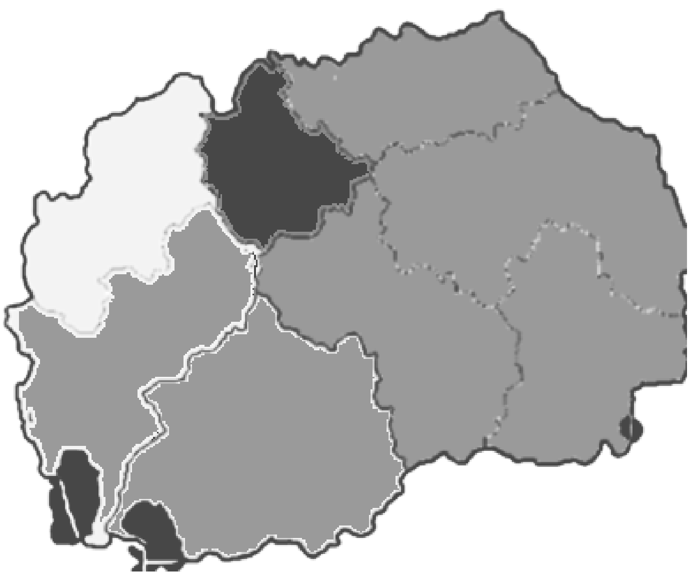


Figure 8.2.1.2 CO2-eq. emissions in 2009 from SWDS from regions in Macedonia

As expected, the highest emission values are in the Skopje Region (227 kt CO2eq.), followed by the Polog Region (119 kt) and the Pelagonia Region (89 kt). Other regions have lower emissions in the range of 60–100 CO_2-eq.

8.2.2 METHANE EMISSIONS FROM DOMESTIC/COMMERCIAL ORGANIC WASTEWATER AND SLUDGE

Most wastewater produced in rural areas of Macedonia is managed without formal handling and/or treatment systems. This means that the suggestion that wastewater from rural areas should be excluded from further calculations, as given in the *Revised 1996 IPPC Guidelines for National Greenhouse Gas Inventories: Workbook* and *Revised 1996 IPPC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, applies to Macedonian conditions. The proportion of the country's population living in urban areas ***(59.9%)*** was taken into consideration when calculating methane emissions since only they are connected to sewage networks and some kind of treatment prior to disposal in the recipients (rivers). (Source: *The State of the Environment in 2011*, MoEPP, p. 65.)

The territory of Macedonia was also divided into eight Statistical regions in order to obtain more reliable information about quantities of domestic wastewaters.

Figures for GHGs from domestic and commercial organic wastewater are presented in Table 8.2.2.

Table 8.2.2 Emission of methane (in kt) and CO_2-equivalent from Domestic/Commercial Organic Wastewater and Sludge in the period 2003–2009

Year	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***
Population (1000s)	2,029	2,035	2,038	2,041	2,043	2,046	2,052

Urban population (1000s)	1,21 5	1,219	1,221	1,223	1,224	1,226	1,229
Total domestic/ commercial organic wastewater (tonnes BOD/yr)	22,1 90	22,248	22,284	22,322	22,339	22,37 6	22,43 9
Total domestic/ commercial organic sludge (kg BOD/yr)	NE	NE	NE	NE	NE	NE	NE
Methane emission from domestic/co mmercial wastewater (kt)	1.39	1.39	1.39	1.4	1.4	1.4	1.4
Methane emission from domestic/co mmercial sludge (kt)	NE	NE	NE	NE	NE	NE	NE
Total methane emission from domestic/ commercial wastewater and sludge (kt)	2.21	2.37	2.31	2.19	2.12	2.12	1.95
CO_2-equivalent emission from domestic/ commercial wastewater and sludge (kt)	46.4 4	49.8	48.43	45.95	44.42	44.54	40.96

The values for organic wastewater load from domestic and commercial sectors remained stable at around 22,000 (tonnes BOD/year), despite the steady rise of the urban population, mainly because wastewater treatment remained unchanged over the period. Thus, GHG emissions during the whole inventory period were in the range of 41–49 kt.

8.1.1 METHANE EMISSIONS FROM INDUSTRIAL WASTEWATER AND SLUDGE

To estimate methane emissions from industrial wastewater and sludge, the following data were entered (Source: State Statistical Office of Macedonia, Statistical Reviews 2002–2007, 2004–2009 and 2006–2011, Table: Industrial production data): industrial output for each industry (iron and steel, non-ferrous metals, fertilizer, food and beverage, paper and pulp, petroleum refining/petrochemicals, rubber (together with plastics) and other industries, including textiles, soaps and cleaning agents, pharmaceuticals and organic chemicals), the amount of wastewater produced by each industry (in m^3/tonnes product), degradable organic component (in kg COD/m^3 wastewater) were taken as default values from IPCC Guidelines, Module 6, Reference manual, p.6.24 and 6.25 and some values used in old Inventory), fraction of DOC *removed as sludge set to be 0* (due to data unavailability). To estimate the emission factor for industrial wastewater, the value of the fraction of wastewater treated by the handling system was considered. The value for the fraction of wastewater was taken as 0.9 for aerobic and 0.1 for anaerobic treatment. The value of the methane conversion factor for the aerobic handling system was taken as 0 and 1 for the anaerobic handling system.

Table 8.2.3.1 Fraction of treated wastewater in different systems

Wastewater Handling System	Fraction of Wastewater Treated by the Handling System	Methane Conversion Factor (MCF)
aerobic	0.9	0
anaerobic	0.1	1

Maximum methane production capacity was taken to be 0.25 kg CH_4/kg DOC, and the Emission factor for industrial wastewater was 0.3 kg CH_4/kg COD for the whole period. For the estimation of the emission factor for sludge, the same data were used as for the estimation of the emission factor from industrial wastewater.

Data on total industrial output and the degradable organic component in kg COD/m^3 wastewater for the products are given in Table 8.2.3.2.

Table 8.2.3.2 Total industrial output, degradable organic components, and the fraction of DOC removed as sludge from industry

Year	DOC/ kg COD/m^3	Waste water produced/ m^3/tonne product	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Industry			Output (tonnes/yr)						
Iron and Steel	0.0003	0.1	1,192,285	1,331,138	1,533,359	1,264,820	687,367	658,043	618,812

Non-ferrous metals	0.00049	130.2	150,073	2,392	3,328	13,718	31,744	34,782	110,199
Fertilizer	0.3	6.9	10,074	9,931	9,900	57,167	73,890	128,874	52,960
Food & Beverage									
Canneries	3	26	2,700	1,062	1,015	3,474	4,049	4,824	5,267
Beer	17	5	68,021	71,603	69,492	66,966	69,535	67,706	64,229
Wine	1.5	23	101,095	153,316	94,049	70,301	61,319	17,447	89,701
Meatpacking	4.1	13	4,290	8,940	8,900	13,196	9,143	10,153	6,831
Dairy products	2.8	7	55,696	53,516	62,458	60,557	57,155	58,216	62,780
Sugar	3.2	10	33,377	27,810	39,069	19,325	35,927	43,731	23,472
Fish processing	2.5	0	0	0	0	0	0	0	229
Oil & grease	0.3	1.6	12,165	26,919	30,604	24,754	27,298	39,828	31,623
Coffee	9	1	143	1,926	1,731	2,449	2,822	2,794	2,675
Soft drinks	2	2	114,497	109,392	117,383	1,311,188	147,967	163,692	163,669
Paper & Pulp	2	83.2	31,47	30,510	35,503	37,640	38,533	39,631	40,42

			0						4
Petroleum refining/Petrochemicals	1.3	1.2	971,987	990,369	1,142,445	1,022,322	1,047,111	1,036,507	962,762
Rubber and plastics	3.7	0.6	41,837	11,715	11,230	9,201	10,454	13,843	97,843
Other	0.9	172	89,000	117,375	104,127	53,280	55,302	63,771	8,708

As shown in the table, the wastewater produced (m³/tone product) from non-ferrous industries has the highest value, followed by the pulp and paper industries, canneries and wine production. It can be seen that overall industry production in the country declined during the observed period.

Table 8.2.3.3 Emissions of methane (in kt) and CO_2-equivalent from Industrial Wastewater and Sludge in the period 2003–2009

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total Organic Wastewater from Industrial Sources (t COD/yr)	32,987	39,179	36,533	32,421	28,513	28,896	21,914
Emission Factor (kg CH_4/kg COD)	0.03						
Methane emissions without recovery (t CH_4)	824.53	979.49	913.34	792.92	712.84	722.42	547.87
Total methane emissions from Industrie	0.82	0.98	0.91	0.82	0.71	0.72	0.55

s (kt CH_4)							
Total CO_2-eq. emissions from Industries (kt CO_2 eq.)	17.22	20.58	19.11	16.59	14.91	15.12	11.55

Since total industrial production decreased during the inventory period, industrial wastewater and total methane emissions from industries also decreased significantly, falling by 50% from 2004 to 2009.

8.1.2 NITROGEN EMISSIONS (N_2O) FROM HUMAN SEWAGE

Values on protein consumption per capita (gr/person/day) were obtained from FAOSTAT (source: http://faostat.fao.org/site/609/DesktopDefault.aspx?PageID=609#ancor). Data for N_2O emissions and CO_2-equivalent emissions are given in Table 6.2.4.

Table 8.2.4 Emission of N_2O (in kt) and CO_2-equivalent from human sewage in the period 2003–2009

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Population (1000s)	2,029	2,035	2,038	2,041	2,043	2,046	2,052
Protein consumption (kg/person/yr)	27.19	27.84	26.9	27.55	28.94	27.41	27.92
Total N_2O emission from human sewage (kt)	0.14	0.14	0.14	0.14	0.15	0.14	0.14
CO_2-equivalent emission from human sewage (kt)	**43.02**	**44.2**	**42.74**	**43.85**	**46.13**	**43.77**	**44.67**

It can be seen that although different values for protein consumption were used, Total N_2O emissions remained constant in the period 2003–2009.

8.1.3 EMISSIONS FROM WASTE INCINERATION

Like other types of combustion, incineration and the open burning of waste are sources of greenhouse gas emissions. Relevant gases emitted include CO2, methane (CH_4) and nitrous oxide (N_2O). Normally, emissions of CO2 from waste incineration are more significant than CH_4 and N_2O emissions.

In this inventory the greenhouse gases are reported for the first time. The total amount of municipal solid waste burned in the open was estimated with an Equation using Tier 1 methodology:

$MSW_B = P*Pfrac*MSWp*Bfrac*365*10^{-6}$

Where:
MSW_B = Total amount of municipal solid waste open-burned (kt/yr)
P = population (capita)
Pfrac = fraction of population burning waste (fraction)
MSW_P = per capita waste generation, kg waste/capita/day
Bfrac = fraction of the waste amount that is burned relative to the total amount of waste treated (fraction-0.6)
365 = number of days per year
10^{-6} = conversion factor.

Data on waste incineration were taken for the Drisla landfill, which is the only incineration facility in Macedonia. For the amount of incinerated MSW (69.97%), data was obtained for the Skopje region only, i.e. from the Drisla Landfill Feasibility Study (2011), pp. 12–13. Factions for carbon content, fossil carbon and combustion efficiency were taken as default values from the *IPCC Good Practice Guidelines and Uncertainty Management in National Greenhouse Gas Inventories*, Chapter: Waste, Table 5.6, p. 5.29. Emission Factors were taken from Tables 5.6 and 5.7 of the IPCC *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, Chapter: Waste, pp. 5.29 and 5.30 and for methane emission factor of 6500 g/t MSW for open burning, taken from 2006 Guidelines, Volume 5: Waste, Chapter 5: Incineration and Open Burning of Waste, p.5.20. Clinical waste data: 1.000 tonnes (360t. incinerated), taken from Yearly reports of the MoEPP and the National Plan for waste management for 2009–2015, p.34. Hazardous waste data: 618,3 t/year, 54% incinerated:1145t/y from households (source: National Plan for waste management 2009-2015, p.33).

Table 8.2.5 Summary of Emissions from waste incineration [kt] 2003–2009

	2003	2004	2005	2006	2007	2008	2009
CO2 Emissions from Waste Incineration	64.91	65.07	65.18	65.28	63.95	65.65	65.99
N2O Emissions	0.71	0.71	0.71	0.71	0.71	0.72	0.77

from Waste Incineration							
CH4 Emissions from Waste Incineration	15.61	15.6	15.65	15.67	15.66	15.75	15.76

Since the Drisla landfill does not conduct any selection or treatment of wastes, the calculations are based only as emissions from the open burning of wastes. Clinical and hazardous waste amounts are relatively constant over the period, giving constant emissions over time. Municipal waste and the amount of disposed waste per capita increase with the size of the population, as do incineration and the emissions from burning MSW.

According to IPCC GPG 2000 (Section 5.3.1, p. 5.25), CO_2 emissions from the incineration of biogenic waste *should not be included* in total GHG emission calculations, since such waste is mostly comprised of biomass materials (paper, food waste or wood).

8.1.4 SUMMARY OF THE WASTE SECTOR

Summarized data are presented in Table 8.2.5, giving annual emissions of CH_4, N_2O and CO_2-equivalent emissions [kt] from the Waste sector. These values show that the waste sector has become a significant source of emissions at 7% of total GHG emissions in the country and needs to be addressed more thoroughly in the future. Some 89% of these emissions are CH_4 emissions from SWDS, incineration and wastewaters, 5% are N_2O from human sewage, incineration and wastewaters, and 7.4% are CO_2 emissions from incineration.

Table 8.2.6 Summary of emissions from the waste sector (CO_2-eq. kt) in the period 2003–2009

Year	2003	2004	2005	2006	2007	2008	2009
CH_4 emissions [kt] Solid Waste Disposal Sites	726.78	728.53	732.69	745.30	755.45	767.44	778.70

CH_4 emissions [kt] Wastewater Handling	46.44	49.77	48.43	46.32	44.29	44.54	40.96
CH_4 Emissions from Waste Incineration [kt]	15.61	15.6	15.65	15.67	15.66	15.75	15.76
Total CO_2-eq. emissions from Industries (kt CO_2 eq.)	17.22	20.58	19.11	16.59	14.91	15.12	11.55
Total CH_4 emissions (kt CO2eq.)	806,05	814,53	815,88	823,88	830,31	842,85	846,96
N_2O emissions [kt] Wastewater Handling	43.02	44.16	42.74	43.85	46.13	43.77	44.67
N_2O Emissions from Waste Incineration [kt]	0.71	0.71	0.71	0.71	0.71	0.72	0.77
Total N_2O emissions (kt CO2eq.)	43.73	44.87	43.45	44.56	46.84	44.48	45.44
CO_2 emissions from waste incineration[kt]*	64.91	65.07	65.18	65.28	63.95	65.65	65.99
Total emissions (kt CO_2eq.)	**849,78**	**859,40**	**859,33**	**868,44**	**877,16**	**887,33**	**892,40**

* According to IPCC GPG 2000, CO_2 emissions from the incineration of biogenic waste should not be included in total GHG emission calculations and reporting.

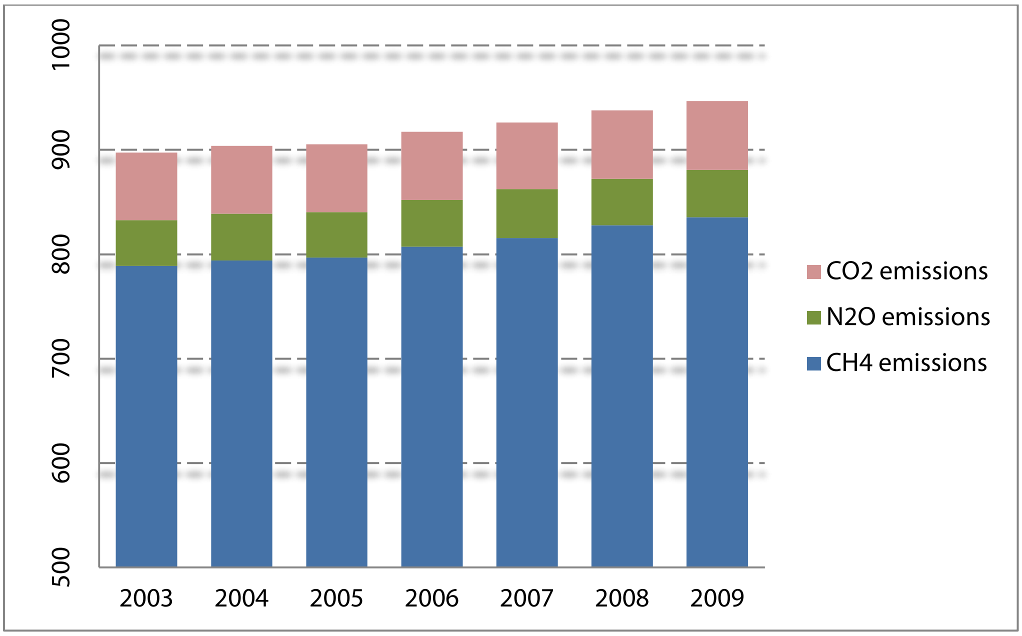


Figure 8.2.6 Summary of emissions from the Waste sector CO_2-eq. [kt]

Table 8.2.7 Percentage of GHG emissions (%) from different subsectors

	2003	2004	2005	2006	2007	2008	2009
Total CO_2 emissions	7.23	7.20	7.20	7.12	6.90	7.00	6.97
Total CH_4 emissions	87.90	87.84	88.00	88.02	88.04	88.26	88.23
Total N_2O emissions	4.87	4.96	4.80	4.86	5.06	4.74	4.80
Emissions from Wastewater Handling	9.97	10.39	10.07	9.83	9.76	9.42	9.04
Emissions from Solid Waste Disposal Sites	80.98	80.60	80.92	81.26	81.57	81.83	82.24
Emissions from Waste Incineration	9.05	9.01	9.01	8.90	8.67	8.76	8.71

Most of the GHG emissions in this sector come from solid waste disposal sites (methane emissions), while emissions from incineration and wastewater handling have an equal importance in total emissions.

Emissions from this sector slowly increased during the inventory period, since the increased population produces higher emissions from the disposal and incineration of municipal solid waste.

9. KEY SOURCE ANALYSIS

The identification of key source categories is described in Chapter 7 of the IPCC's Good Practice Guidance (IPCC-GPG, 2000), which defines a key source category as one that is prioritized within the National System because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions, the trend in emissions, or both. In accordance with the Good Practice Guidance, the national key source categories for each inventory should be identified in a systematic and objective manner by performing a quantitative analysis of the relationships between the level and the trend of each source category's emissions and total national emissions.

9.1. KEY SOURCE ANALYSIS METHODOLOGY

When using the Tier 1 approach, key source categories are identified using a predetermined cumulative emissions threshold of 95% of total national emissions. This was performed for the period 2003–2009.

The contribution of each source category to the total national inventory level is calculated according to (9.1):

$$L_{x,t} = \frac{E_{x,t}}{E_t}, \qquad (9.1)$$

where $L_{x,t}$ is the Level Assessment for source *x* in year *t*; $E_{x,t}$ is the emission estimate of source category *x* in year *t* and E_t the total inventory estimate in year *t*.

Level Assessment should be performed for all years for which inventory estimates are available. Key source analysis for the Third National Communication was performed for the period 2003–2009. Any source category that meets the 95% threshold in any year should be identified as a key source category.

9.2. SUMMARY RESULTS FROM THE KEY SOURCE ANALYSIS

Following the IPCC Good Practice Guidance for LULUCF (IPCC-GPG, 2003), the key category analysis was performed once for the inventory, excluding LULUCF categories and then repeated for the full inventory including the LULUCF categories. Non-LULUCF categories identified as key in the first analysis but which do not appear as key when the LULUCF categories are included are still be considered key sources.

Table 9.2.1. summarizes the results of the analysis, presenting the Key Source Categories. The table lists all the source categories which appeared to be a key source at least in one year of the period

2003–2009. A table presenting the detailed Key Source Categories analysis can be found in the Annex (Table A.2.).

Table 9.2.1. Key Source Analysis – Summary Results (excluding LULUCF activities)

IPCC Source Category	**Sector**	**Source Categories to be Assessed in Key Source Category Analysis 1**	**Applicable GHG**	**Number of years being a key category**
1.A.1	Energy	CO_2 Emissions from Energy Industries - Coal - Lignite	CO_2	7
1.A.3	Energy	CO_2 Mobile Combustion: Road Vehicles	CO_2	7
4.D	Agriculture	N_2O (Direct and Indirect) Emissions from Agricultural Soils	N_2O	7
6.A	Waste	CH_4 Emissions from Solid Waste Disposal Sites	CH_4	7
1.A.2	Energy	CO_2 Emissions from Manufacturing Industries and Construction	CO_2	7
4.A	Agriculture	CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	7
1.A.5	Energy	Other (Energy)-	CO_2	7
1.A.1	Energy	CO_2 Emissions from Energy Industries - Oil - Residual Fuel Oil	CO_2	7
2.A	Industrial Processes	CO_2 Emissions from Cement Production	CO_2	7
1.B.1	Energy	CH_4 Fugitive Emissions from Coal Mining and Handling	CH_4	7
1.A.4	Energy	Other Sectors: Residential CO_2	CO_2	7
2.C	Industrial Processes	CO_2 Emissions from Ferroalloy production	CO_2	6
4.B	Agriculture	N_2O Emissions from Manure Management	N_2O	5
2.E	Industrial Processes	HFCs Emissions from HFC Consumption	HFCs	5
1.A.4	Energy	Other Sectors: Residential CH_4	CH_4	4
1.A.1	Energy	CO_2 Emissions from Energy Industries - Gas - Natural Gas	CO_2	2

Table9.1.2. Key Source Analysis – Summary Results (including LULUCF activities)

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis with LULUCF	Applicable GHG	Number of years being a key category
1.A.1	Energy	CO_2 Emissions from Energy Industries - Coal - Lignite	CO_2	7
1.A.3	Energy	CO_2 Mobile Combustion: Road Vehicles	CO_2	7
4.D	Agriculture	N_2O (Direct and Indirect) Emissions from Agricultural Soils	N_2O	7
6.A	Waste	CH_4 Emissions from Solid Waste Disposal Sites	CH_4	7
1.A.2	Energy	CO_2 Emissions from Manufacturing Industries and Construction	CO_2	7
4.A	Agriculture	CH_4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	7
1.A.5	Energy	Other (Energy)-	CO_2	7
1.A.1	Energy	CO_2 Emissions from Energy Industries - Oil - Residual Fuel Oil	CO_2	7
2.A	Industrial Processes	CO_2 Emissions from Cement Production	CO_2	7
1.B.1	Energy	CH_4 Fugitive Emissions from Coal Mining and Handling	CH_4	7
1.A.4	Energy	Other Sectors: Residential CO_2	CO_2	7
5.A	LULUCF	Forest Land remaining Forest Land	CO_2	7
5.B	LULUCF	Cropland remaining Cropland	CO_2	7
2.C	Industrial Processes	CO_2 Emissions from Ferroalloy production	CO_2	6
4.B	Agriculture	N_2O Emissions from Manure Management	N_2O	6
2.E	Industrial Processes	HFCs Emissions from HFC Consumption	HFCs	5
1.A.4	Energy	Other Sectors: Residential CH_4	CH_4	3
1.A.1	Energy	CO_2 Emissions from Energy Industries - Gas - Natural Gas	CO_2	2

The key source with the highest contribution to national total emissions is 1.A.1.: CO_2 Emissions from Energy Industries - Coal - Lignite. The contribution of such emissions from the Energy Industries to total national emissions in the last analyzed year (2009) was 47.17%. It ranked number one in all level assessments. From Table 9.2.1. it can be seen that 11 categories were considered key sources in the seven examined years.

After performing key source analysis including the LULUCF sector it can be seen from Table 9.2.2. that the annual change in the carbon stock of living biomass had a significant impact on total GHG emissions/removals.

9.3. Application of the Key Source Analysis Results

Identifying key source categories is important because the resources available for preparing inventories are finite and their use should be prioritised. It is essential that estimates be prepared for all key source categories in order to ensure completeness. As far as possible, key source categories should receive special consideration in terms of two important inventory aspects:

- Additional attention must be focused on key source categories with respect to the methodological choice. Whenever a method used for the estimation of emissions of a key source category is not consistent with the requirements of the IPCC Good Practice Guidance, the method will have to be improved in order to reduce uncertainty.
- It is good practice to give additional attention to key source categories in terms of quality assurance and quality control.

10. UNCERTAINTY

For the purposes of the Second National Communication to the UNFCCC, an uncertainty analysis was performed as part of the Sectoral Approach for the Energy Sector for 2000. This analysis applied the Monte Carlo algorithm which calculates the maximum, minimum and mean values as well as the standard deviation for emissions from each subsector and from the whole Energy Sector. The uncertainties in data on the Energy Sector in the period 2003–2009 year are approximately the same as those calculated in the previous National Communication.

The uncertainty of data in the Third National Communication to the UNFCCC was estimated only for the Industrial processes sector. The Industrial Processes sector was particularly interesting as a subject of uncertainty assessment because the cumulative result for this sector depends on many variables with high uncertainty. Within industrial processes there were inter-annual fluctuations as well as significant changes from one year to the next due to the introduction of new industrial production or temporary or permanent plant closures.

Changes in processes, production intensity and technology can also cause significant fluctuations. Emission trends for each category and/or sub-category can be explained in terms of some type of economic or technological change. This is why this sector is so sensitive to change and why it is important to conduct an uncertainty analysis to confirm whether the results are within the confidence range.

The uncertainty analysis was performed for each CO_2-emitting sub-category in the Industrial Processes category for every year in the period 2003–2009.

10.1. METHODOLOGY FOR UNCERTAINTY ESTIMATION

The Monte Carlo algorithm was used for estimating uncertainty because it is suitable for detailed category-by-category assessment of uncertainty, particularly where uncertainties are significant. For every variable, random values were generated for each input used in the methodology formula to calculate the desired outputs. This process was repeated with over 40,000 iterations in order to compute multiple estimates of the model output.

Step 1: Specify category uncertainties. Estimate the parameters and activity data, their associated means and probability density functions and any correlations.

Table 10.1.1. Estimated uncertainties by category

Categories	**UNCERTAINTY AND ASSUMPTIONS**
2 - Industrial Processes and Product Use	
2.A - Mineral Industry	

Cement production	**Emission Factor (Chemical Analysis/Composition)** - 3-8% Assumption of 65% CaO in clinker **Production Data** - 10% Use of estimated country (or aggregated plant) production data (national statistics). **CKD** - 10-35% Estimation of % calcination of CKD **Imports/Exports** - 50% Overestimation from failure to deduct net clinker imports for consumption
Lime production	**Emission Factor** -2% Emission factor high calcium lime -2% Emission factor dolomitic lime - 15% Emission factor hydraulic lime **Production data** The uncertainty of the activity data is likely to be much higher than for the emission factors, based on experience in gathering lime data. Omission of non-marketed lime production may lead to order of magnitude underestimates.
Limestone and Dolomite Use	**Emission Factor** - 7.5% The emission factors for lime production are roughly based on stoichiometry and so do not vary significantly; however, limestone and dolomite are rarely pure. **Production/Usage data** - 50% The data was calculated based on the activity data of other products (e.g. steel production)
Glass Production	**Emission Factor** -Uncertainty associated with the use of the Tier 1 emission factor and cullet ratio is significantly higher, and may be in the order of +/- 60 percent. **Production data** -Glass production data are typically measured fairly accurately (+/-5 percent) for Tier 1 and Tier 2.
2.C - Metal Industry	
Iron and Steel Production	**Emission Factor** - 10% Material-Specific Default Carbon Contents National Reducing Agent & Process Materials Data **Production data** - 10% National Production Data
Ferroalloy Production	**Emission Factor** - 5% Company-Derived Reducing Agent & Process Materials ;National Reducing Agent & Process Materials Data **Production data** - 5% National Production Data
Aluminium production	**Emission Factor** - 10% **Production data** - 5% National Production Data

Step 2: Select random variables. Selection of input values. Input values are the estimates applied in the inventory calculation. This is the start of the iterations. For each input data item, a number is randomly selected from the probability density functions of that variable.
Step 3: Estimate emissions and removals. The variables selected in Step 2 are used to estimate annual emissions and removals based on input values. Since the emission calculations should be the same as those used to estimate the national inventory, the Monte Carlo process can be fully integrated into the annual emission estimates.
Step 4: Iterate and monitor results. Iteration and monitoring of results. The calculated total from Step 3 was stored, and the process then repeated from Step 2. The results from the repetitions are used to calculate the mean and the probability density functions.

10.2. Uncertainties in Data on Emissions from the Industrial Processes Sector

Like all methodologies, Monte Carlo analysis only provides satisfactory results when properly implemented. This requires the analyst to have a scientific and technical understanding of the inventory and the Monte Carlo method itself. Of course, the results will only be valid to the extent that the input data, including any expert judgments, are sound.

For the purposes of the uncertainty analysis, random values were generated in 40,000 iterations for each of the input variables. The input data for uncertainty is given in Table 10.1.1. and the production data is given in Table 10.2.1., while the emission factors can be derived directly from the Inventory Excel files or the *'National CO_2 and non-CO_2 emission factors for key sectors under IPCC and CORINAIR methodologies'.* The results of the Monte Carlo Simulation are given in Table 10.2.2.

Table 10.2.1. Input values for activity data

Categories	ACTIVITY RATE [t]						
	2003	2004	2005	2006	2007	2008	2009
2 - Industrial Processes and Product Use							
2.A - Mineral Industry							
Cement production	768,000	752,000	827,000	867,000	768,000	768,000	768,000
Lime production	6,194	9,028	14,196	11,184	6,194	6,194	6,194
Limestone and Dolomite Use	25,106	26,944	27,823	30,880	25,106	25,106	25,106
2.C - Metal Industry							
Iron and Steel Production	583,871	626,599	647,036	718,130	583,871	583,871	583,871
Ferroalloy Production	55,534	72,082	79,390	69,965	55,534	55,534	55,534
Ferro-nickel	5,629	5,313	8,141	10,942	15,321	15,026	12,000
Ferro-silicon	49,905	66,769	71,249	59,023	34,215	42,674	7,657
Ferro-silico-manganese	0	0	0	0	70,472	54,931	0
Ferro-manganese	0	0	0	0	0	12,623	0
Aluminium production	3,793	194	20	230	3,793	3,793	3,793

Table 10.2.2. Summary Results of the Monte Carlo simulation of CO_2 emissions from the Industrial processes sector for the period 2003–2009

	MAX	MIN	MEAN	ST.DEV	DEV/MEAN
2003					
Cement production	417.54	144.07	273.81	62.04	22.66%
Lime production	5.45	4.34	4.90	0.28	5.79%
Limestone and Dolomite Use	17.26	5.34	11.18	3.24	28.93%
Iron and Steel Production	62.70	42.66	52.62	4.43	8.41%
Ferroalloy Production	0.00	0.00	0.00	0.00	0.00%
Ferro-nickel	24.90	20.56	22.59	0.95	4.19%
Ferro-silicon	228.18	189.20	208.60	8.51	4.08%
Ferro-silico-manganese	0.00	0.00	0.00	0.00	
Ferro-manganese	0.00	0.00	0.00	0.00	
Aluminium production	6.24	5.22	5.70	0.23	4.01%
TOTAL	**727.69**	**452.26**	**579.39**	**63.04**	**10.88%**
2004					
Cement production	429.81	142.13	265.09	63.08	23.79%
Lime production	7.96	6.34	7.14	0.41	5.80%
Limestone and Dolomite Use	19.01	5.62	11.93	3.56	29.80%
Iron and Steel Production	68.22	46.07	56.25	4.76	8.47%
Ferroalloy Production	0.00	0.00	0.00	0.00	0.00%
Ferro-nickel	23.49	19.45	21.36	0.87	4.08%
Ferro-silicon	306.15	252.87	278.66	10.96	3.93%
Ferro-silico-manganese	0.00	0.00	0.00	0.00	
Ferro-manganese	0.00	0.00	0.00	0.00	
Aluminium production	0.32	0.27	0.29	0.01	4.21%
TOTAL	**797.36**	**499.91**	**640.72**	**64.01**	**9.99%**
2005					
Cement production	483.44	155.63	293.72	71.93	24.49%
Lime production	12.55	9.91	11.17	0.68	6.08%
Limestone and Dolomite Use	19.09	5.93	12.34	3.52	28.52%
Iron and Steel Production	69.67	47.76	58.20	4.82	8.29%
Ferroalloy Production	0.00	0.00	0.00	0.00	0.00%
Ferro-nickel	35.88	29.60	32.84	1.35	4.12%
Ferro-silicon	324.39	270.91	297.42	12.37	4.16%
Ferro-silico-manganese	0.00	0.00	0.00	0.00	
Ferro-manganese	0.00	0.00	0.00	0.00	
Aluminium production	0.03	0.03	0.03	0.00	4.19%
TOTAL	**891.55**	**552.17**	**705.72**	**73.09**	**10.36%**
2006					
Cement production	502.85	151.77	304.70	75.38	24.74%
Lime production	9.86	7.83	8.79	0.51	5.83%
Limestone and Dolomite Use	21.28	6.51	13.43	4.07	30.31%
Iron and Steel Production	77.55	52.90	64.37	5.36	8.33%
Ferroalloy Production	0.00	0.00	0.00	0.00	0.00%
Ferro-nickel	48.24	40.07	43.93	1.82	4.15%
Ferro-silicon	270.77	225.53	246.46	9.96	4.04%

Ferro-silico-manganese	0.00	0.00	0.00	0.00	
Ferro-manganese	0.00	0.00	0.00	0.00	
Aluminium production	0.38	0.31	0.34	0.01	4.15%
TOTAL	**908.02**	**512.59**	**682.02**	**76.31**	**11.19%**
2007					
Cement production	447.52	147.80	274.66	64.89	23.62%
Lime production	5.46	4.34	4.89	0.28	5.83%
Limestone and Dolomite Use	17.75	5.13	11.06	3.29	29.77%
Iron and Steel Production	62.82	43.13	52.90	4.34	8.20%
Ferroalloy Production	0.00	0.00	0.00	0.00	0.00%
Ferro-nickel	67.79	55.82	61.63	2.42	3.93%
Ferro-silicon	156.81	130.74	142.52	5.80	4.07%
Ferro-silico-manganese	119.55	99.26	109.49	4.41	4.03%
Ferro-manganese	0.00	0.00	0.00	0.00	
Aluminium production	6.24	5.15	5.69	0.22	3.88%
TOTAL	**824.65**	**521.13**	**662.85**	**65.74**	**9.92%**
2008					
Cement production	445.65	137.58	266.93	65.51	24.54%
Lime production	5.47	4.35	4.89	0.28	5.72%
Limestone and Dolomite Use	17.31	5.41	11.03	3.04	27.60%
Iron and Steel Production	63.44	43.10	52.82	4.65	8.80%
Ferroalloy Production	0.00	0.00	0.00	0.00	0.00%
Ferro-nickel	65.82	55.09	60.15	2.37	3.94%
Ferro-silicon	195.96	162.37	178.48	7.32	4.10%
Ferro-silico-manganese	93.50	77.31	85.25	3.46	4.06%
Ferro-manganese	18.68	15.41	17.02	0.76	4.46%
Aluminium production	6.23	5.16	5.71	0.24	4.14%
TOTAL	**880.30**	**548.07**	**682.28**	**66.23**	**9.71%**
2009					
Cement production	450.77	143.80	269.99	68.17	25.25%
Lime production	5.45	4.36	4.88	0.29	5.91%
Limestone and Dolomite Use	17.52	5.26	11.07	3.22	29.07%
Iron and Steel Production	63.10	43.09	52.49	4.36	8.31%
Ferroalloy Production	0.00	0.00	0.00	0.00	0.00%
Ferro-nickel	53.01	43.63	48.15	2.01	4.17%
Ferro-silicon	34.99	29.10	31.95	1.33	4.17%
Ferro-silico-manganese	0.00	0.00	0.00	0.00	
Ferro-manganese	0.00	0.00	0.00	0.00	
Aluminium production	6.23	5.18	5.70	0.23	4.11%
TOTAL	**609.40**	**295.51**	**424.24**	**68.39**	**16.12%**

10.3. Reasons for the occurrence of uncertainty in the Macedonian GHG Inventory

Inventory estimates of emissions and removals may differ from the calculated value in the inventory for many reasons. Some causes of uncertainty may generate well-defined, easily characterized estimates of the range of potential uncertainty. Other causes of uncertainty (e.g., biases) may be much more difficult to identify. It is good practice to consider the uncertainties and clearly document whether some causes of uncertainties have not been included. The causes for uncertainty occurrence in each sector are stated below:

- **Cement production**

Since most CO_2 emissions are generated during the calcination process for clinker production and there is no official data available on clinker production, this value was derived from the cement production data from the State Statistical Office. To improve the clinker production estimation there is a need for data that estimates total imports and exports of clinker. This data was provided for recent years but not for the most of the years included in this GHG inventory. This is the main reason for uncertainty in this subcategory. Since there is only one cement plant in Macedonia, the nationally estimated emission factor and CKD are considered to be more reliable.

- **Lime production**

The accuracy of lime production emission estimates depends primarily on determining the total amount of CaO and CaO•MgO produced in the country. Since these minerals are also used as feedstock for other industrial processes, complete production statistics can be difficult to obtain. The great uncertainty in this category originates from the assumption that only lime for commercial trade is included within the State Statistical Office yearbooks, which implies that only this amount is included in the GHG inventory, omitting the quantities produced by industrial plants for their own use. There is little uncertainty associated with the emission factor component since the stoichiometric ratio is an exact number and therefore the uncertainty of the emission factor is the uncertainty of lime composition which for the purpose of this analysis was gathered as a default value.

- **Limestone and Dolomite Use**

The State Statistical Office, which was used as the official source of data for the preparation of the GHG inventory, incorporates only production data but not data from the feedstock usage. The uncertainty in this sub-category is due to calculations used to estimate limestone and dolomite usage from production data (e.g. metal production).

- **Iron and Steel Production**

The most important type of activity data was the amount of steel produced. This data was derived from the State Statistical Office and estimated to have an uncertainty of $\pm$ 10 percent. The calculation of the country-specific emission factors was based on the use of data about the raw materials consumed in production, including the quantities of reducing agents in the production of iron and steel. This method was based on tracking carbon in the production process through the mass balance and carbon content in the respective materials used. Emission estimates were based on specific data about each plant. The uncertainty of the emission factors estimates is $\pm$ 5 percent.

- **Ferroalloy Production**

Uncertainties for ferroalloy production arise primarily from uncertainties associated with activity data, and to a lesser extent from uncertainty related to the emission factor. The activity data of ferroalloy production by product type originated from the State Statistical Office, which is a reliable source of information for metal production. Uncertainties were estimated at ± 5 percent. The emission factors for each ferroalloy were calculated with the method for emissions estimation that uses data on the input of raw material as well as about the consumption of the reducing agents used in ferroalloy production. Emission factors are expected to be lower than 5% since plant-specific carbon content data were used.

- **Aluminium production**

Since the closure of the most important industrial installation for aluminium production in 2003, emissions from this sub-category do not significantly influence the overall total of emissions. Activity data was derived from the State Statistical Office and estimated to have a ± 5% level of uncertainty.

It can be noticed that uncertainty remained steady over the period 2003–2008, followed by a spike in 2009 due to the economic crisis that began in 2008. The uncertainty is higher since the production of the goods with lower uncertainty has decreased.

11. PROBLEMS AND SOLUTIONS

11.1. ENERGY SECTOR

Data on the Energy sector are mainly generated from the Energy Balances of the Republic of Macedonia. The data given in the State Statistical Database 2005–2009 are adequate and fully meet the requirements for applying the Tier 1 methodology. There is no significant data gap in the Energy sector for Tier 1 methodology, except in the data given for biomass usage as an energy source.

A significant data gap was identified in the inventory preparation for the period 2003–2004, since there is no officially published Energy Balance for this period. The Inventory for these two years was developed with data from the Energy Balances of the Ministry of Economy and the International Energy Database of the IEA (International Energy Agency).

Concerning biomass, the data given in the statistical yearbook was aggregated for Wood Fuel, Wood Waste and Other Solid Waste. Each have different carbon content and a different emission factor and should be treated separately. Wood Fuel should also be separated by the type of wood used because of the different net calorific value and carbon content.

The exact amount of biomass used as an energy source differs from the statistical database because of illegal forest and wood cutting. A detailed forest inventory for the country needs to be developed and monitored every year in order to have better estimates for the illegal use of wood as an energy source.

When the TNC team started with the preparation of the Inventory, several issues were identified as obstacles to the application of the Tier 2 approach.

- Energy Industries: technology and fuel-specific emission factors for the Energy Industries are needed.

- Manufacturing and construction: fuel and technology-specific emission factors for each installation are needed.

- Residential sector: fuel-specific emission factors for fuel used as an energy source are needed.

All these issues were tackled by estimating the country-specific emission factor for the Key Sources, i.e., the main fuels used as an energy source in Macedonia. A higher Tier methodology was applied for estimating GHG emissions from the key sources.

11.2. Industrial Processes

Several problems were encountered during the process of inventory construction. In the inception stage there was a lack of previous relevant documentation for the Macedonian inventory from the First and Second National Communication. Some documentation was provided (only for one year) but this did not explicitly state the activity rate collection processes and calculation for more complex subsectors.

The second problem was encountered during the data collection process. The data was provided by the State Statistical Office but was not collected under the necessary nomenclature. This led to the unintentional discounting of some products as well as some uncertainty as to whether some products belong under the IPCC requirements. The biggest problem occurred in the collection of data on feedstock usage rather than product production (e.g. Soda Ash Use) since the State Statistical office does not report this kind of data in its Statistical Yearbooks and Statistical Reviews. Furthermore, these data were not well segregated, which is a primary requirement for selecting adequate emission factors. In order to overcome this issue, most of the bigger industrial installations were contacted and asked to provide relevant information about emission factors and ongoing processes in the plants. This communication was conducted via the Macedonian Chamber of Commerce and did not bring the desired results. Only a few installations reported the required data in the given timeframe.

Since direct contact via email or phone was not efficient and did not produce the desired results, special Emission-Monitoring inventory software was developed for data collection directly from the industrial installations. With the usage of this software there will be a possibility for calculating emissions with a higher tier methodology.

For the additional collection of data on activity rates, the National Committee for Climate Change was gathered at a workshop to identify other potential sources of data. The working group for industry identified the Ministry of Environment and Physical Planning and the State Statistical Office as primary data providers, and the Ministry of Economy, the Customs and the Chamber of Commerce as secondary sources.

All of the emission factors used in the First and Second National Communications were default emission factors from the IPCC guidelines. Aiming to provide a more accurate inventory, the next step taken was to hire a national consultancy company which calculated country-specific emission factors for the key sources. In the Industry sector, emission factors for Cement Production and Iron and Steel Production were calculated since these sectors were identified as key sources.

11.3. Agriculture

In the agriculture sector there is generally comprehensive data from the State Statistical Office in its Statistical yearbooks and Statistical Reviews on livestock numbers, livestock balance, growth rate and milk and wool production. With the Tier 1 approach, default values for animal weight, emission and conversion factors in the calculation of CH_4 from enteric fermentation and both CH_4 and N2O emissions from manure management can be used for Macedonia.

However, a gap was found in data on the goat and buffalo populations. In addition, poultry were not divided into sub-categories as broilers, ducks, chicks and hens, or turkeys, making it difficult to determine the methane emission factor CH_4 (kg CH_4/head year) and excretion rate for manure management. The same sub-categorization is required for cattle, swine, sheep and goats. Number of other livestock were not included in the previous Inventories, but in the census of agriculture of 2007 (State Statistical Office) rabbits are registered, which are not registered in Statistical yearbooks in the examined period (2003–2009). Mules and asses were not considered, since their numbers are relatively low.

The manure management system for poultry was not adequately defined, resulting in incorrect values for emissions. The total amount of synthetic fertilizers applied in agriculture is very difficult to define, and the statistical data used in this Inventory refers to the quantities used in agricultural companies and cooperatives. The amount of fertilizers used in the private sector is also very difficult to define since there is no instrument for controlling the amount and type of fertilizers used in this sector.

The *Revised 1996 IPCC Guidelines* suggest that livestock populations should be further sub-categorized since the amount of released CH_4 depends on the type, age, and weight of the animal, the quality and quantity of the feed, and the energy expenditure of the animal. As from 2009, statistical yearbooks have contained more detailed data on livestock, including sub-categories according to animal age, such as: kids, breeding female goats and billy goats (goats), lambs and yearlings; ewes for breeding and rams or sterile sheep (sheep); calves up to one year, cattle 1-2 years old and mature non-dairy cattle (other cattle); broilers, turkeys, hens and cocks, ducks and similar (poultry); and growing animals, sows, boars (swine). Gaps in data on goats and buffalos populations (prior to 2009) were filled with data from FAO statistics (FAOSTAT: livestock data R. Macedonia 2003–2008, available at http://faostat3.fao.org/home/index.html#VISUALIZE).

Emission factors and fractions for animals were not previously assessed and the revision of those used in the Second National Communication was made according to the *Revised 1996 IPCC Guidelines* for the agriculture sector.

With regard to the fertilization of crops, data on the total amounts of imported quantities were obtained through the records of the Customs Office and the Ministry of Economy. However, this data was only raw information on total imported quantities, whilst its final destinations and management (application techniques, quantities used, etc.) remain vague.

Urea fertilization data was taken from the FAOSTAT database Macedonia, available at http://faostat.fao.org/site/575/DesktopDefault.aspx?PageID=575_).

11.4. LULUCF

Since the last forest stocktaking in the Republic of Macedonia was accomplished in 1979, a difficulty appears with regard to annual forest growth and yield. Activity data is very uncertain and needs updating in the following areas: total forest area, stock and annual forest growth, changes in land use, as well as loss of biomass due to commercial harvesting, illegal harvesting, wood decay in forest or the processed wood industry. In previous Inventories, organic production was not taken into consideration as a separate cropland category. Since 2005 the Ministry of Agriculture, Forestry and Water Economy (MAFWE) has undertaken registers of organic farming, giving precise data on land converted to organic farming and data on annual changes in carbon stocks in organic soils. For the changes in land use, no official data was used in previous Inventories. *Conversion of forest land to cropland, grassland or settlements and vice-versa was not taken into account.* There are data on conversion from PE Macedonian Forests that needs to be obtained. No data were provided in previous inventories on biomass burning in terms of area burned on croplands or grasslands.

In respect to fires and other disturbances (pests, diseases, illegal lodging) in forests, until 2008 data was given only on the total annual forest land (in hectares), but not divided into sub-categories. Land conversion data were not obtained. Accurate and official data on illegal wood cutting was obtained from the yearly reports of the Public Enterprise ‘Macedonian Forests’, as well as the Forestry Inspectorate. The *Forestry Inspectorate* provided a comprehensive database for forest disturbances (area in hectares and biomass) for the years 2008 and 2009, divided into forest sub-categories. These data were used in the TNC Inventory, giving more accurate calculations for carbon sink in forests. For floods there are data available from the Centre for Crisis Management about flooded forest areas in the period 2005–2009.

11.5. WASTE

Data on the waste sector was obtained from yearly reports on the state of the environment in Macedonia published by the Ministry of Environment and Physical Planning. Data on generated municipal solid waste (MSW) and its composition (fractions: paper, textile, garden waste, food waste, wood and straw) is highly uncertain, since they are gathered from municipalities (which need to submit annual reports to the MoEPP) and only 60–80% of municipalities reported in the previous period. In addition, there are no exact data for the years 2006 and 2008. Another problem is that the fraction of MSW disposed of in Solid Waste Disposal Sites (SWDS) remains unknown although the MoEPP estimates that 75.78% of municipal waste is landfilled in the country. (The previous inventory made up for this lack by using the figure for Greece, at 93%.) Degradable organic carbon was defined as 0.17, based on expert judgment and data from PE Drisla, Skopje, but in the Third National Inventory a prescribed new default value of 0.19 (*country-specific)* was used. The First Order Decay (FOD) method used in Tier 2 requires more precise calculation of DOC from different fractions of waste, as well as historical data on waste generation (from 1950), which can be obtained from municipal landfills directly in combination with relevant research studies.

Sludge from both domestic and industrial wastewaters is not considered (value = 0). For domestic wastewater treatment and discharge, protein content per person data was obtained from the FAOSTAT database on daily protein intake. This database can be accessed at: http://faostat.fao.org/site/609/DesktopDefault.aspx?PageID=609#ancor).

12. GOOD PRACTICES

The preparation of three National Communications (NCs) over a period of thirteen years has enabled the accumulation of a considerable body of knowledge on the preparation of GHG inventories. A variety of major challenges have had to be overcome, including limited data availability, insufficient technical expertise and the need to coordinate a large number of institutions. The national team has made considerable progress in addressing these challenges, employing innovative approaches and enhancing the capacity of national professionals.

Below are outlined several good practices introduced during the preparation of the GHG inventory for the Third National Communication on climate change.

- **The introduction of a new institutional system for the preparation of GHG inventories**

A new institutional system was introduced to ensure the sustainability of the process of preparing GHG inventories. Three professionals were engaged to form a **GHG Inventory team** in order to assure continuous, regular updating of the national GHG inventories and to serve as a baseline for the introduction of a system of Monitoring, Reporting and Verification. An experienced national consultant was engaged as a Chief Technical Advisor to provide substantive training, guidance and support to the GHG Inventory team during the preparation of the updated GHG Inventory.

- **Strengthening the technical capacities of the GHG Inventory team**

Participation in additional training and workshops on climate change has significantly **improved the capacities** of the GHG Inventory team for the preparation of improved inventories. The GHG inventory team actively participated in the preparation of a Roadmap for the introduction of a Monitoring, Reporting and Verification system under the EU Emissions Trading Scheme. Based on the recommendations in the roadmap, the GHG team were nominated and accepted in the **UNFCCC Roster of Experts**, further strengthening their capacities for reviewing annual inventory submissions. This involved training in general guidelines and sector-specific issues as well as in the application of Tier 3 methods in reviewing inventories. Additional lectures were given on the review process under the Kyoto protocol. This training additionally strengthened the capacities of the GHG Inventory team for the preparation of more comprehensive inventories in line with the reporting requirements of UNFCCC.

The team actively participated in improving the new version of the IPCC guidelines and in developing special software for the preparation of GHG inventories. This software will be obligatory for all countries from 2014 onward and requires more detailed input for calculating national GHG emissions. Training in the use of this software significantly raised the capacities of the national GHG team for preparing future inventories.

The National Communication Support Programme (NCSP) added significant value in improving the quality of the inventory by providing technical support and guidelines when needed. The International conference organized by NCSP on Lessons Learned and Experiences from the Preparation of National Communications from Non-annex I Countries enabled the sharing f knowledge and good practices among countries. The Macedonian TNC coordinator presented a paper on good practices in the compilation of the country's GHG inventory. [1]

- **Improved procedures for Quality assurance/quality control**

Each member of the GHG Inventory team was responsible for one or more sectors. An **Enterer** was responsible for identifying/verifying data sources, entering and documenting the input data (activity data and emission factors), while a **Checker** was responsible for checking and validating the input data and emission estimates

In this way each team member had to focus on a specific part of the inventory preparation and make the calculations more thoroughly. This approach was introduced in the Second National Communication and was implemented again as a good practice in the Third National Communication, primarily overcome possible mistakes in data entry.

- **Improved Institutional Cooperation**

The **National Climate Change Committee** (NCCC) was revised and was closely involved in the NC preparation processes to provide information and policy guidance as well as to make use of the NC results by including NC recommendations in sectoral plans and national strategies. Regular consultations were held with relevant members of the NCCC on various issues. And bringing together representatives from all relevant institutions supported networking, knowledge transfer and sharing of experiences relating to climate change between the members of NCCC. The NCCC was closely involved in providing recommendations for resolving the identified data gaps, thus setting a baseline for the establishment of a national system for GHG inventory data collection.

Involving all relevant stakeholders from both the public and the **private sector** in the development of the GHG inventory increased access to information, thus providing data relevant for introducing higher Tier methodology and the development of highly technical components such as country-specific emission factors, particularly since major emitters of greenhouse gasses are source-point installations. Establishing **direct contact with these installations** and other national and governmental institutions, including the Chamber of Commerce and the State Statistical Office, proved essential in obtaining unpublished data collected only for internal purposes. This resulted in the introduction of several subsectors for the first time –such as aviation and the introduction of higher Tier methodology in many sub-sectors, including the cement industry, aviation, and railway transport.

The long-term agreement for cooperation and data exchange between the Macedonian Air Navigation Services Provider M-NAV and the Ministry of Environment and Physical Planning also added value. This cooperation provided the possibility for disaggregating the data on domestic and international aviation and allowed the application of higher Tier methodology in calculating emissions from the aviation subsector – a methodology that only 8 other countries in the world use at this time.

[1] Zdraveva P., Grncarovska Obradovic. T., Markovska N., Macedonia: Good practices in the preparation of Greenhouse Gas Inventories and V & A Assessment, in: Country papers: Preparation of National Communications from Non-Annex I Parties to the UNFCCC; A Compilation of Lessons Learned and Experiences from selected countries, National Communication Support Programme (NCSP), 2012, pp. 48–54.

- **Improved Documenting and Archiving**

The data documenting structure was reported for each activity rate, emission or conversion factor directly in the sectorial and sub-sectorial MS Excel worksheets in the IPCC software (version 1.3.2 of 1996 IPCC Software for National Greenhouse Gas Inventories). This documenting procedure increases the **long-term sustainability and transparency of the inventory process**. Below each table in the software there are links to the appropriate data source, enabling any newcomers to the inventory process or relevant stakeholders to understand the data collection process and rationale behind the selection of appropriate emission factors across the inventory.

- **Training Materials**

Training materials were prepared for *each sector*, including a step-by-step guide to the process of completing the inventory tables, explaining good practices and sources of data and emission factors. These training materials serve as a useful tool for those working on inventories for the first time.

- **Emission-Monitoring Inventory Software**

The Ministry of Environment and Physical Planning was additionally supported by the development of a new software solution for the industry sector: Emissions Monitoring in Industry. EMI is a web-based platform that gathers data directly from industry installations about annual production, feedstock usage, and specific production process details in a distributed manner. EMI effectively speeds up the process of data collection for the three inventories required of the industry sector by the MoEPP, i.e. the GHG inventory, the Air Pollutants cadastres and the Cadastre of Polluters. This software provides a single, user-friendly online form to be filled in once a year by appointed representatives from industries instead of many questionnaires sent sporadically throughout the year. Moreover, the software allows experts from different departments to have access to the raw data and reports with a separate administrative account.

- **Country-Specific Emission Factors developed**

Based on the recommendations given in the "Roadmap for the adoption of national emission factors and recommendations for the harmonization of emission factors between UNFCCC and CORINAIR methodologies and reporting guidance', a national company was engaged to develop country-specific emission factors for the key sources of GHG emissions. In cooperation with the project team, the company successfully managed to develop a significant number of country-specific emission factors for key emitting sectors. The development of country-specific emission factors enabled the application of improved methodology in the calculation of GHG emissions from key sources.

- **Revised Legal Framework for Inventory Data Collection**

A separate document was produced on the 'Preparation of legal provisions for the GHG inventory' exploring the possibilities for establishing a legally binding national system for the collection of data needed for developing a more detailed inventory of greenhouse gas emissions. The document proposes several amendments to the Law on Environment in order to establish a national system for the collection and management of data needed for the development of national GHGs inventories.

12. Recommendations for Future Improvement

12.1. Energy Sector

The following recommendations are given to improve the estimations of emissions from Transport and apply higher Tier Methodologies to this sector:

- Road transport. Fuel-specific and combustion-specific emission factors should be developed. An additional recommendation for higher Tier methodology is the establishment of an additional register of the country's vehicle fleet, by fuel type, specific EURO classification, average consumption and annual average mileage per vehicle.
- Railway transportation: fuel-specific and combustion-specific emission factors should be developed. An additional recommendation is the establishment of a database of the average annual mileage per locomotive type and the exact amount of fuel combusted, for in order to more accurately determine the specific emission factor.
- Domestic aviation. The data given in the statistical yearbooks is the amount of fuel tanked on domestic airports. But this data is insufficient for estimating emissions from domestic aviation. To achieve a precise estimation of the emissions produced from this subsector, a detailed database of all aviation traffic over the country is needed. The establishment of this database will enable higher Tier methodology in GHG estimation in the aviation subsector. In the framework of this project, the Ministry of Environment and Physical Planning established an agreement for cooperation and continuous data transfer with M-NAV (Macedonian national air navigation service provider). This cooperation should be sustainable and continuous in order to proceed with detailed estimations of emissions from aviation.

12.2. Industrial Processes and solvents use

The key to successfully developing a GHG inventory for industry is to provide relevant data with good quality. In order to establish a sustainable data collection in this sector it is important to develop transparent, comparable, coherent, complete and accurate measurement, reporting and verification (MRV) national systems.

Key recommendations for the industry sector are as follows:

- The reporting system should be robust, flexible, transparent and, most importantly, country driven so it can respond to national circumstances.
- Institutional arrangements should be based where possible on existing institutions and make efficient use of already existing staff.
- Deeper and stronger relations and collaboration with industry installations should be developed (a possible linkage could be made with the ongoing projects for introducing ETS in the country).

- The reporting system must be in line with the most recently adopted IPCC Guidelines (i.e. moving from the 1996 IPCC Guidelines to the 2006 IPCC Guidelines.
- The system must be based on the most cost-effective solutions at all stages and structural levels.
- The system should be multifunctional, making it possible to report under different conventions (e.g. CORINAIR and PRTR) with a single centralized data collection.
- New reporting tools should be developed and used. In this project an online software tool was developed for the Emission Monitoring Inventory (EMI) as a centralized database that collects the data in a distributed manner directly from industry installations. This data should be used to apply higher tier methodologies .
- An attempt should be made to incorporate GHG emissions in the reporting scheme of the A and BIPPC installations. This may be involve a separate project to train the responsible staff within the industry on the IPCC methodology.

12.3. Agriculture

- The Tier 2 approach is recommended for estimating methane emissions from enteric fermentation from cattle for those countries with large cattle populations. In contrast to the Tier 1 method, this approach requires much more detailed information on the livestock population (at least three sub-categories). Using this detailed information, more precise estimates of the cattle emission factors will be developed. (Source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, Sector 4: Agriculture, pp. 4.15–4.16) When the Tier 2 method is used, the default emission factors listed in Tier 1 for cattle are not used. Feed energy intake requirements for pregnancy needs to be added. The energy requirements for grazing need to be fixed and the equations used to relate gross energy intake to net energy used by the animal have been made more general to fit a wider variety of feed conditions. Also crop pattern, land use and agricultural management (animal waste treatment, quantities of mineral fertilizers applied are needed to apply improved methodology in estimating the emissions from the sector Agriculture

- . To overcome this problem there is an urgent need to establish a farm register and an Integrated Administration & Control System (IACS) – a sophisticated and accurate system for gathering all this data into one database.

- An instrument for controlling the amount and type of fertilizers used in this sector should be developed.

- It is good practice to divide the country into 8 defined regions and to set soil types accordingly, i.e. mineral, high activity clay mineral, low activity mineral. Macedonia has a cool temperate dry climate with an average temperature of 12° C.

- Crop production should be divided into 8 strategic planning regions in order to obtain a more precise picture of GHG emissions from each region.

12.4. LULUCF

GHG emissions from the LULUCF sector can be estimated with "tiered" approaches which mean increasing accuracy for the higher Tier. Tier 1 methodology comprehends estimation with limited activity data, while Tier 2 uses facility level activity data and Tier 3 uses equipment level activity data. Which methodology is used depends on the objectives of the inventory as well as the accuracy and "deepness" of the available activity data. In this sector, emissions are generated by only a small number of subsectors. This favours the application of a higher tier methodology in assessing GHG emissions. However, very limited activity data is available at present, making the implementation of a higher Tier approach practically impossible. Tier 1 is thus still considered the only appropriate approach.

Key recommendations for this sector are as follows:

- ***Develop a new forestry Inventory*** that will determine the area, stock, density, annual growth, tree species, commercial and illegal logging, ***fires and other disturbances, flooding*** as well ***as land conversion*** in forests, croplands, grasslands and settlements. This is needed to attain greater precision in estimates of GHG emissions with data from PE Macedonian Forests, the Ministry of Agriculture, Forestry and Water Economy, the Forestry Inspectorate, the Crisis Management Centre and PE Macedonian Pastures.

- IDRISI Selva software (Clark Labs, http://www.clarklabs.org/) should be used as extensively as possible. This is a revolutionary tool for Integrated modelling environments, including the Earth Trends Modeler (ETM) for image time series of environmental trends and the Land Change Modeler (LCM) for land change analysis and prediction. With ETM, users can rapidly assess long-term climate trends, measure seasonal trends in phenology, and decompose image-time series to seek recurrent spatio-temporal patterns. The 2006 CORINE LAND COVER Map of Macedonia should be used in modelling and needs to be updated.

12.5. WASTE

Precise data on the current and historic annual quantity of waste could not be obtained from official sources (except for the Drisla landfill) and therefore additional measures should be undertaken to enhance the capacity for obtaining data on other landfills and in order to apply more complex calculation methods. A study should be undertaken on the average composition of waste (at least in several rural and urban municipalities) in order to obtain reliable information on degradable organic content (DOC). DOC is a parameter that depends upon the composition of waste and is important in the application of the theoretical gas yield methodology. More detailed analyses of wastewater discharge systems in all regions should be undertaken. And an *atmospheric dispersion model* should be used to estimate the emission rate of methane from wastewater handling, This model produces the best estimate compared with measured values . The variables to be set in the dispersion model include the emission rate, wind-speed and direction, and atmospheric stability.

Including the above given suggestions for inventory improvement in every sector it is recommended the same approach for inventory compilation to be done on local level. This will help the local government to measure the impact of the mitigation actions that are undertaken within the municipalities.

ANNEX

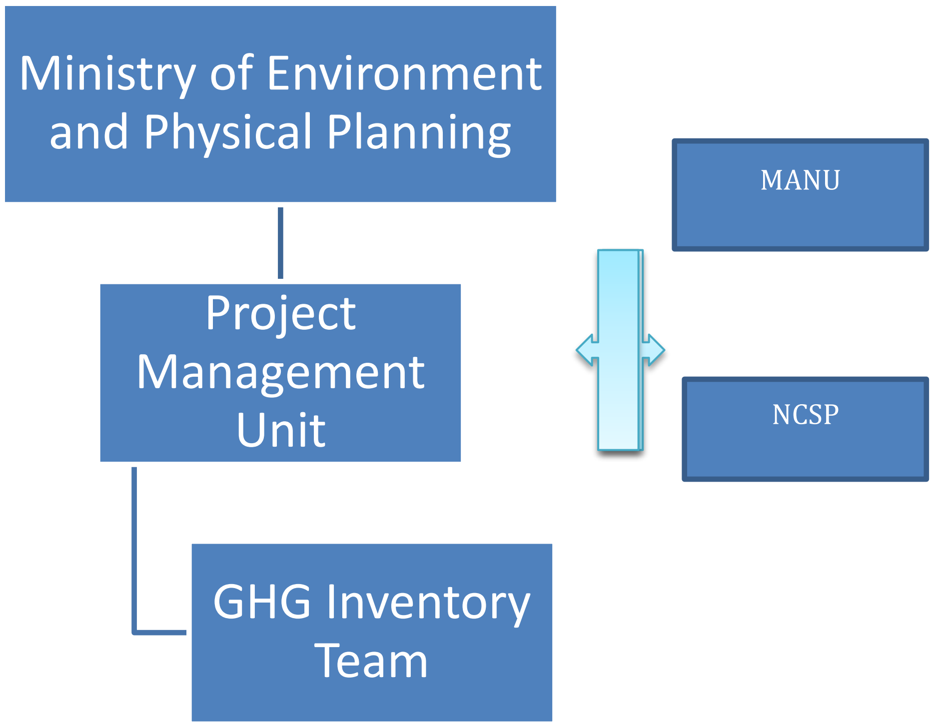


Fig A.1. National GHG Structure

Table A.1. Global Warming Potential of GHGs

GWP	Value	Reference
CO2	1.00	Second Assessments Report
CH4	21.00	Second Assessments Report
N2O	310.00	Second Assessments Report
HFCs	1,300.00	Second Assessments Report
NOx	6.70	Collins et al. (2002)
CO	1.90	Collins et al. (2002) and Berntsen et al. (2005).Averaging over the TAR values and the new estimates gives a mean of 1.9 for the 100-year GWP for CO
NMVOC	3.40	Collins et al. (2002) calculated indirect GWPs for 10 NMVOCs with a global three-dimensional Lagrangian chemistry-transport model. Impacts on tropospheric ozone. CH4 (through changes in OH) and CO2 have been considered. using either an 'anthropogenic' emission distribution or a 'natural' emission distribution depending on the main sources for each gas. The indirect GWP values are given in Table 2.15. Weighting these GWPs by the emissions of the respective compounds gives a weighted average of 100-year GWP of 3.4. Due to their short lifetimes and the nonlinear chemistry involved in ozone and OH chemistry. there are significant uncertainties in the calculated GWP values. Collins et al. (2002) estimated an uncertainty range of –50% to +100%.
SO2	none	n/a

Table A.2. Key Source Analysis Results (excluding LULUCF activities)

Inventory Year	**2004**					
IPCC Source Category	**Sector**	**Source Categories to be Assessed in Key Source Category Analysis 1**	**Applicable GHG**	**Emission Estimate (current year, non-LULUCF) (Gg CO2eq)**	**%**	**Cumulative %**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**5718.73**	**46.14%**	**46.14%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**1042.91**	**8.41%**	**54.55%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**996.51**	**8.04%**	**62.59%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**728.53**	**5.88%**	**68.47%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**561.62**	**4.53%**	**73.00%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**539.75**	**4.35%**	**77.35%**
1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**420.38**	**3.39%**	**80.74%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**372.35**	**3.00%**	**83.75%**
2.E	**Industrial Processes**	**HFCs Emissions from HFC Consumption**	**HFCs**	**330.53**	**2.67%**	**86.42%**
2.C	**Industrial Processes**	**CO2 Emissions from the Ferroalloy production**	**CO2**	**300.31**	**2.42%**	**88.84%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**264.93**	**2.14%**	**90.98%**
1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**152.91**	**1.23%**	**92.21%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**128.50**	**1.04%**	**93.25%**
4.B	**Agriculture**	**N2O Emissions from Manure Management**	**N2O**	**122.53**	**0.99%**	**94.23%**
1.A.4	**Energy**	**Other Sectors: Residential CH4**	**CH4**	**83.23**	**0.67%**	**94.91%**
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	76.95	0.62%	95.53%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	65.07	0.52%	96.05%
1.A.1	Energy	CO2 Emissions from Energy Industries - Gas - Natural Gas	CO2	59.10	0.48%	96.53%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	56.39	0.45%	96.98%
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	49.77	0.40%	97.38%
4.B	Agriculture	CH4 Emissions from Manure Management	CH4	46.34	0.37%	97.76%

6.B	Waste	N2O Emissions from Wastewater Handling	N2O	44.16	0.36%	98.12%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	41.50	0.33%	98.45%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	41.45	0.33%	98.78%
1.A.1	Energy	N2O (Non-CO2) Emissions from Stationary Combustion	N2O	24.53	0.20%	98.98%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and gas Operations	CH4	24.03	0.19%	99.18%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	16.50	0.13%	99.31%
6.D	Waste	CH4 Emissions from Waste Incineration	CH4	15.61	0.13%	99.44%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	11.86	0.10%	99.53%
1.A.5	Energy	Other (Energy)-	CH4	8.52	0.07%	99.60%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	8.42	0.07%	99.67%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	7.13	0.06%	99.72%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	7.08	0.06%	99.78%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	4.12	0.03%	99.82%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	3.95	0.03%	99.85%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	3.88	0.03%	99.88%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	3.50	0.03%	99.91%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.49	0.02%	99.93%
1.A.5	Energy	Other (Energy)-	N2O	1.96	0.02%	99.94%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Stationary Combustion	CH4	1.72	0.01%	99.96%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	1.67	0.01%	99.97%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.83	0.01%	99.98%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	0.74	0.01%	99.98%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.71	0.01%	99.99%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.57	0.00%	99.99%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.32	0.00%	100.00%
2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.29	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.17	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.08	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.02	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.01	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.01	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00	0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Water Borne Navigation	CO2	0.00	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Water Borne Navigation	CH4	0.00	0.00%	100.00%

1.A.3	Energy	N2O Mobile Combustion Water Borne Navigation	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00	0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00	0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00	0.00%	100.00%

Inventory Year	**2005**					
IPCC Source Category	**Sector**	**Source Categories to be Assessed in Key Source Category Analysis 1**	**Applicable Greenhouse Gas**	**Emission Estimate (current year, non-LULUCF) (Gg CO2eq)**	**%**	**Cumulative %**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**5891.85**	**45.26%**	**45.26%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**1117.25**	**8.58%**	**53.84%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**1002.53**	**7.70%**	**61.54%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**875.85**	**6.73%**	**68.27%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**732.69**	**5.63%**	**73.90%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**529.65**	**4.07%**	**77.96%**
1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**400.50**	**3.08%**	**81.04%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**382.37**	**2.94%**	**83.98%**
2.E	**Industrial Processes**	**HFCs Emissions from HFC Consumption**	**HFCs**	**372.19**	**2.86%**	**86.84%**
2.C	**Industrial Processes**	**CO2 Emissions from the Ferroalloy production**	**CO2**	**330.38**	**2.54%**	**89.37%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**291.35**	**2.24%**	**91.61%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**148.61**	**1.14%**	**92.75%**

1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**145.21**	**1.12%**	**93.87%**
4.B	**Agriculture**	**N2O Emissions from Manure Management**	**N2O**	**117.32**	**0.90%**	**94.77%**
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	79.70	0.61%	95.38%
1.A.4	Energy	Other Sectors: Residential CH4	CH4	75.66	0.58%	95.96%
1.A.1	Energy	CO2 Emissions from Energy Industries - Gas - Natural Gas	CO2	69.32	0.53%	96.50%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	65.18	0.50%	97.00%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	58.23	0.45%	97.44%
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	48.43	0.37%	97.82%
4.B	Agriculture	CH4 Emissions from Manure Management	CH4	44.83	0.34%	98.16%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	42.74	0.33%	98.49%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	40.81	0.31%	98.80%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and gas Operations	CH4	26.11	0.20%	99.00%
1.A.1	Energy	N2O (Non-CO2) Emissions from Stationary Combustion	N2O	24.15	0.19%	99.19%
6.D	Waste	CH4 Emissions from Waste Incineration	CH4	15.64	0.12%	99.31%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	14.94	0.11%	99.42%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	12.24	0.09%	99.52%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	11.21	0.09%	99.60%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	8.19	0.06%	99.67%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	6.65	0.05%	99.72%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	6.48	0.05%	99.77%
1.A.5	Energy	Other (Energy)-	CH4	5.54	0.04%	99.81%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	4.30	0.03%	99.84%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	3.56	0.03%	99.87%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	3.39	0.03%	99.90%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	3.35	0.03%	99.92%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.44	0.02%	99.94%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Stationary Combustion	CH4	1.68	0.01%	99.95%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	1.58	0.01%	99.97%
1.A.5	Energy	Other (Energy)-	N2O	1.56	0.01%	99.98%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.96	0.01%	99.98%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.88	0.01%	99.99%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.71	0.01%	100.00%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.36	0.00%	100.00%
2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.03	0.00%	100.00%

1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.02	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.01	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.01	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00	0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Waterborne Navigation	CO2	0.00	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Waterborne Navigation	CH4	0.00	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Waterborne Navigation	N2O	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00	0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00	0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00	0.00%	100.00%

Inventory Year	**2006**					
IPCC Source Category	**Sector**	**Source Categories to be Assessed in Key Source Category Analysis 1**	**Applicable Greenhouse Gas**	**Emission Estimate (current year, non-LULUCF) (Gg CO2eq)**	**%**	**Cumulative %**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**4913.57**	**41.21%**	**41.21%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**1113.64**	**9.34%**	**50.56%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**999.39**	**8.38%**	**58.94%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**942.42**	**7.90%**	**66.84%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**745.30**	**6.25%**	**73.09%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**553.97**	**4.65%**	**77.74%**

1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**532.48**	**4.47%**	**82.21%**
1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**322.61**	**2.71%**	**84.91%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**305.44**	**2.56%**	**87.48%**
2.C	**Industrial Processes**	**CO2 Emissions from the Ferroalloy production**	**CO2**	**290.55**	**2.44%**	**89.91%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**155.25**	**1.30%**	**91.22%**
1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**140.11**	**1.18%**	**92.39%**
4.B	**Agriculture**	**N2O Emissions from Manure Management**	**N2O**	**121.46**	**1.02%**	**93.41%**
2.E	**Industrial Processes**	**HFCs Emissions from HFC Consumption**	**HFCs**	**101.09**	**0.85%**	**94.26%**
1.A.4	**Energy**	**Other Sectors: Residential CH4**	**CH4**	**81.36**	**0.68%**	**94.94%**
1.A.1	Energy	CO2 Emissions from Energy Industries - Gas - Natural Gas	CO2	74.49	0.62%	95.56%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	65.28	0.55%	96.11%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	64.63	0.54%	96.65%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	64.02	0.54%	97.19%
4.B	Agriculture	CH4 Emissions from Manure Management	CH4	46.52	0.39%	97.58%
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	46.32	0.39%	97.97%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	43.85	0.37%	98.34%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	34.79	0.29%	98.63%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and gas Operations	CH4	28.26	0.24%	98.87%
1.A.1	Energy	N2O (Non-CO2) Emissions from Stationary Combustion	N2O	25.13	0.21%	99.08%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	16.02	0.13%	99.21%
6.D	Waste	Other (Waste)-	CH4	15.67	0.13%	99.34%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	13.59	0.11%	99.46%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	11.30	0.09%	99.55%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	8.84	0.07%	99.63%
1.A.5	Energy	Other (Energy)-	CH4	7.47	0.06%	99.69%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	6.13	0.05%	99.74%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	6.06	0.05%	99.79%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	4.40	0.04%	99.83%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	3.50	0.03%	99.86%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	3.45	0.03%	99.89%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	3.18	0.03%	99.91%

1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.40	0.02%	99.93%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Stationary Combustion	CH4	1.78	0.01%	99.95%
1.A.5	Energy	Other (Energy)-	N2O	1.75	0.01%	99.96%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	1.59	0.01%	99.98%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.86	0.01%	99.98%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.71	0.01%	99.99%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.58	0.00%	99.99%
2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.35	0.00%	100.00%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.31	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.03	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.02	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.01	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00	0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Water Borne Navigation	CO2	0.00	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Water Borne Navigation	CH4	0.00	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Water Borne Navigation	N2O	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00	0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00	0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00	0.00%	100.00%

Inventory Year	**2007**					

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis 1	Applicable Greenhouse Gas	Emission Estimate (current year, non-LULUCF) (Gg CO2eq)	%	Cumulative %
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**4938.51**	**39.82%**	**39.82%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**1345.95**	**10.85%**	**50.68%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**1144.22**	**9.23%**	**59.91%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**828.03**	**6.68%**	**66.58%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**755.45**	**6.09%**	**72.68%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**635.62**	**5.13%**	**77.80%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**490.64**	**3.96%**	**81.76%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**317.82**	**2.56%**	**84.32%**
2.C	**Industrial Processes**	**CO2 Emissions from the Ferroalloy production**	**CO2**	**313.80**	**2.53%**	**86.85%**
1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**301.47**	**2.43%**	**89.28%**
2.E	**Industrial Processes**	**HFCs Emissions from HFC Consumption**	**HFCs**	**226.85**	**1.83%**	**91.11%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**156.55**	**1.26%**	**92.37%**
1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**137.38**	**1.11%**	**93.48%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Gas - Natural Gas**	**CO2**	**115.19**	**0.93%**	**94.41%**
4.B	Agriculture	N2O Emissions from Manure Management	N2O	114.11	0.92%	95.33%
1.A.4	Energy	Other Sectors: Residential CH4	CH4	68.77	0.55%	95.89%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	66.70	0.54%	96.42%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	63.95	0.52%	96.94%
4.B	Agriculture	CH4 Emissions from Manure Management	CH4	52.16	0.42%	97.36%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	46.13	0.37%	97.73%
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	44.29	0.36%	98.09%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	41.57	0.34%	98.42%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and gas Operations	CH4	35.56	0.29%	98.71%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	33.38	0.27%	98.98%

1.A.1	Energy	N2O (Non-CO2) Emissions from Stationary Combustion	N2O	24.89	0.20%	99.18%
6.D	Waste	Other (Waste)-	CH4	15.66	0.13%	99.31%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	14.02	0.11%	99.42%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	13.63	0.11%	99.53%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	11.75	0.09%	99.62%
1.A.5	Energy	Other (Energy)-	CH4	6.99	0.06%	99.68%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	5.19	0.04%	99.72%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	4.78	0.04%	99.76%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	4.25	0.03%	99.80%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	4.21	0.03%	99.83%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	4.19	0.03%	99.86%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	3.45	0.03%	99.89%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	2.72	0.02%	99.91%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.70	0.02%	99.94%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	1.92	0.02%	99.95%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Stationary Combustion	CH4	1.82	0.01%	99.97%
1.A.5	Energy	Other (Energy)-	N2O	1.65	0.01%	99.98%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.78	0.01%	99.98%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.74	0.01%	99.99%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.71	0.01%	100.00%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.24	0.00%	100.00%
2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.11	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.03	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.02	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.01	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00	0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Water Borne Navigation	CO2	0.00	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Water Borne Navigation	CH4	0.00	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Water Borne Navigation	N2O	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00	0.00%	100.00%

4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00	0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00	0.00%	100.00%

Inventory Year	**2008**					
IPCC Source Category	**Sector**	**Source Categories to be Assessed in Key Source Category Analysis 1**	**Applicable Greenhouse Gas**	**Emission Estimate (current year, non-LULUCF) (Gg CO2eq)**	**%**	**Cumulative %**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**5480.28**	**43.98%**	**43.98%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**1184.55**	**9.51%**	**53.48%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**1179.82**	**9.47%**	**62.95%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**767.44**	**6.16%**	**69.11%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**732.16**	**5.88%**	**74.98%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**492.25**	**3.95%**	**78.93%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**348.51**	**2.80%**	**81.73%**
2.C	**Industrial Processes**	**CO2 Emissions from the Ferroalloy production**	**CO2**	**340.83**	**2.73%**	**84.46%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**303.65**	**2.44%**	**86.90%**
2.E	**Industrial Processes**	**HFCs Emissions from HFC Consumption**	**HFCs**	**274.30**	**2.20%**	**89.10%**
1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**221.47**	**1.78%**	**90.88%**
1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**161.04**	**1.29%**	**92.17%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Gas - Natural Gas**	**CO2**	**147.43**	**1.18%**	**93.35%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**141.39**	**1.13%**	**94.49%**
4.B	Agriculture	N2O Emissions from Manure Management	N2O	114.49	0.92%	95.41%

1.A.4	Energy	Other Sectors: Residential CH4	CH4	83.52	0.67%	96.08%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	65.65	0.53%	96.60%
4.B	Agriculture	CH4 Emissions from Manure Management	CH4	51.52	0.41%	97.02%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	46.29	0.37%	97.39%
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	44.54	0.36%	97.74%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	43.77	0.35%	98.10%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	42.86	0.34%	98.44%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and gas Operations	CH4	40.20	0.32%	98.76%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	30.24	0.24%	99.00%
1.A.1	Energy	N2O (Non-CO2) Emissions from Energy Industries	N2O	27.26	0.22%	99.22%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	16.60	0.13%	99.36%
6.C	Waste	CH4 Emissions from Waste Incineration	CH4	15.76	0.13%	99.48%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	11.66	0.09%	99.58%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	9.73	0.08%	99.65%
1.A.5	Energy	Other (Energy)-	CH4	6.52	0.05%	99.71%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	6.30	0.05%	99.76%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	5.41	0.04%	99.80%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	4.35	0.03%	99.84%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	3.63	0.03%	99.87%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	3.62	0.03%	99.89%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	3.14	0.03%	99.92%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.78	0.02%	99.94%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Energy Industries	CH4	1.75	0.01%	99.96%
1.A.5	Energy	Other (Energy)-	N2O	1.65	0.01%	99.97%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	1.65	0.01%	99.98%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	1.11	0.01%	99.99%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.72	0.01%	100.00%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.31	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.03	0.00%	100.00%
2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.02	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.02	0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.01	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.00	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00	0.00%	100.00%

1.A.3	Energy	CO2 Mobile Combustion Water Borne Navigation	CO2	0.00	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Water Borne Navigation	CH4	0.00	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Water Borne Navigation	N2O	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.00	0.00%	100.00%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00	0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00	0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00	0.00%	100.00%

Inventory Year	**2009**					
IPCC Source Category	**Sector**	**Source Categories to be Assessed in Key Source Category Analysis 1**	**Applicable Greenhouse Gas**	**Emission Estimate (current year, non-LULUCF) (Gg CO2eq)**	**%**	**Cumulative %**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**5297.01**	**46.21%**	**46.21%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**1273.52**	**11.11%**	**57.32%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**793.26**	**6.92%**	**64.24%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**778.70**	**6.79%**	**71.03%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**700.22**	**6.11%**	**77.14%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**483.85**	**4.22%**	**81.36%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**458.02**	**4.00%**	**85.35%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**301.20**	**2.63%**	**87.98%**

1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**267.25**	**2.33%**	**90.31%**
1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**156.73**	**1.37%**	**91.68%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**146.15**	**1.27%**	**92.95%**
4.B	**Agriculture**	**N2O Emissions from Manure Management**	**N2O**	**104.32**	**0.91%**	**93.86%**
1.A.4	**Energy**	**Other Sectors: Residential CH4**	**CH4**	**92.92**	**0.81%**	**94.67%**
2.C	Industrial Processes	CO2 Emissions from the Ferroalloy production	CO2	80.18	0.70%	95.37%
1.A.1	Energy	CO2 Emissions from Energy Industries - Gas - Natural Gas	CO2	78.65	0.69%	96.06%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	65.99	0.58%	96.63%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	49.31	0.43%	97.06%
4.B	Agriculture	CH4 Emissions from Manure Management	CH4	45.01	0.39%	97.46%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	44.67	0.39%	97.85%
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	40.96	0.36%	98.20%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	30.71	0.27%	98.47%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	28.79	0.25%	98.72%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and gas Operations	CH4	26.98	0.24%	98.96%
1.A.1	Energy	N2O (Non-CO2) Emissions from Energy Industries	N2O	24.48	0.21%	99.17%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	18.50	0.16%	99.33%
6.D	Waste	Other (Waste)-	CH4	15.84	0.14%	99.47%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	11.50	0.10%	99.57%
1.A.5	Energy	Other (Energy)-	CH4	9.15	0.08%	99.65%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	6.10	0.05%	99.71%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	5.58	0.05%	99.75%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	5.28	0.05%	99.80%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	4.27	0.04%	99.84%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	3.25	0.03%	99.87%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	3.03	0.03%	99.89%
1.A.5	Energy	Other (Energy)-	N2O	2.26	0.02%	99.91%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	2.14	0.02%	99.93%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	2.14	0.02%	99.95%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Energy Industries	CH4	1.66	0.01%	99.96%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	1.04	0.01%	99.97%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	0.92	0.01%	99.98%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.72	0.01%	99.99%
2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.56	0.00%	99.99%

1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.55	0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.26	0.00%	100.00%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.17	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.00	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00	0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Waterborne Navigation	CO2	0.00	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Waterborne Navigation	CH4	0.00	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Waterborne Navigation	N2O	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.00	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00	0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00	0.00%	100.00%
2.E	Industrial Processes	HFCs Emissions from HFC Consumption	HFCs	0.00	0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00	0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00	0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00	0.00%	100.00%

Table 9.4.2. Key Source Analysis Results (including LULUCF activities)

	2003						
IPCC Source Category	**Sector**	**Source Categories to be Assessed in Key Source Category Analysis 1**	**Applicable GHG**	**Emission Estimate (current year with LULUCF) (Gg CO_2eq)**		**%**	**Cumulative %**
1.A.1	**Energy**	**CO_2 Emissions from Energy Industries - Coal - Lignite**	**CO_2**	**5796.05**		**43.22%**	**43.22%**
1.A.3	**Energy**	**CO_2 Mobile Combustion: Road Vehicles**	**CO_2**	**1151.67**		**8.59%**	**51.81%**
4.D	**Agriculture**	**N_2O (Direct and Indirect) Emissions from Agriculutural Soils**	**N_2O**	**1002.68**		**7.48%**	**59.29%**
5.A	**LULUCF**	**Forest Land remaining Forest Land**	**CO_2**	**904.72**	**-904.72**	**6.75%**	**66.04%**
6.A	**Waste**	**CH_4 Emissions from Solid Waste Disposal Sites**	**CH_4**	**726.78**		**5.42%**	**71.46%**
1.A.2	**Energy**	**CO_2 Emissions from Manufacturing Industries and Construction**	**CO_2**	**620.81**		**4.63%**	**76.09%**
4.A	**Agriculture**	**CH_4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH_4**	**549.16**		**4.10%**	**80.18%**
1.A.5	**Energy**	**Other (Energy)-**	**CO_2**	**444.67**		**3.32%**	**83.50%**
1.A.1	**Energy**	**CO_2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO_2**	**332.58**		**2.48%**	**85.98%**
2.A	**Industrial Processes**	**CO_2 Emissions from Cement Production**	**CO_2**	**270.57**		**2.02%**	**88.00%**
2.C	**Industrial Processes**	**CO_2 Emissions from the Ferroalloy production**	**CO_2**	**231.12**		**1.72%**	**89.72%**
5.B	**LULUCF**	**Cropland remaining Cropland**	**CO_2**	**183.49**	**-183.49**	**1.37%**	**91.09%**
1.B.1	**Energy**	**CH_4 Fugitive Emissions from Coal Mining and Handling**	**CH_4**	**155.80**		**1.16%**	**92.25%**
1.A.4	**Energy**	**Other Sectors: Residential CO_2**	**CO_2**	**145.59**		**1.09%**	**93.34%**
4.B	**Agriculture**	**N_2O Emissions from Manure Management**	**N_2O**	**122.08**		**0.91%**	**94.25%**
1.A.4	**Energy**	**Other Sectors: Residential CH_4**	**CH_4**	**83.95**		**0.63%**	**94.87%**
1.A.1	Energy	CO_2 Emissions from Energy Industries - Gas - Natural Gas	CO_2	80.23		0.60%	95.47%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO_2	CO_2	70.69		0.53%	96.00%
6.C	Waste	CO_2 Emissions from Waste Incineration	CO_2	64.91		0.48%	96.48%
2.C	Industrial Processes	CO_2 Emissions from the Iron and Steel Industry	CO_2	52.55		0.39%	96.87%

4.B	Agriculture	CH4 Emissions from Manure Management	CH4	48.11		0.36%	97.23%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	47.98		0.36%	97.59%
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	46.44		0.35%	97.94%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	43.02		0.32%	98.26%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and gas Operations	CH4	27.11		0.20%	98.46%
1.A.1	Energy	N2O (Non-CO2) Emissions from Stationary Combustion	N2O	26.32		0.20%	98.66%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	24.34		0.18%	98.84%
5.E	LULUCF	Settlements remaining settlements	CO2	23.24	23.24	0.17%	99.01%
2.E	Industrial Processes	HFCs Emissions from HFC Consumption	HFCs	22.49		0.17%	99.18%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	16.60		0.12%	99.30%
6.D	Waste	Other (Waste)-	CH4	15.57		0.12%	99.42%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	11.05		0.08%	99.50%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	8.40		0.06%	99.56%
1.A.5	Energy	Other (Energy)-	CH4	7.99		0.06%	99.62%
2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	5.69		0.04%	99.67%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	4.89		0.04%	99.70%
5.A	LULUCF	Forest Land remaining Forest Land	CO	4.81	4.81	0.04%	99.74%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	4.66		0.03%	99.77%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	4.28		0.03%	99.80%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	4.11		0.03%	99.84%
5.A	LULUCF	Forest Land remaining Forest Land	CH4	3.37	3.37	0.03%	99.86%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.93		0.02%	99.88%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	2.71		0.02%	99.90%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	2.70		0.02%	99.92%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	2.02		0.02%	99.94%
1.A.5	Energy	Other (Energy)-	N2O	1.98		0.01%	99.95%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Stationary Combustion	CH4	1.84		0.01%	99.97%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	0.91		0.01%	99.97%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.84		0.01%	99.98%

5.A	LULUCF	Forest Land remaining Forest Land	N2O	0.77	0.77	0.01%	99.99%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.71		0.01%	99.99%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.69		0.01%	100.00%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.28		0.00%	100.00%
5.A	LULUCF	Forest Land remaining Forest Land	NOx	0.11	0.11	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.10		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.05		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.02		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.01		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.01		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00		0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CO2	0.00	0.00	0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Water Borne Navigation	CH4	0.00		0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Water Borne Navigation	CO2	0.00		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Water Borne Navigation	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00		0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00		0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00		0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CH4	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	N2O	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	NOx	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CO	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CH4	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	N2O	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	NOx	0.00		0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CO	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00		0.00%	100.00%

Inventory Year	2004						
IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis 1	Applicable GHG	Emission Estimate (current year with LULUCF) (Gg CO2eq)		%	Cumulative %
1.A.1	Energy	CO2 Emissions from Energy Industries - Coal - Lignite	CO2	5718.73		42.30%	42.30%
4.D	Agriculture	N2O (Direct and Indirect) Emissions from Agricultural Soils	N2O	1042.91		7.71%	50.02%
1.A.3	Energy	CO2 Mobile Combustion: Road Vehicles	CO2	996.51		7.37%	57.39%
5.A	LULUCF	Forest Land remaining Forest Land	CO2	917.01	-917.01	6.78%	64.17%
6.A	Waste	CH4 Emissions from Solid Waste Disposal Sites	CH4	728.53		5.39%	69.56%
4.A	Agriculture	CH4 Emissions from Enteric Fermentation in Domestic Livestock	CH4	561.62		4.15%	73.72%
1.A.2	Energy	CO2 Emissions from Manufacturing Industries and Construction	CO2	539.75		3.99%	77.71%
1.A.5	Energy	Other (Energy)-	CO2	420.38		3.11%	80.82%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil	CO2	372.35		2.75%	83.57%
2.E	Industrial Processes	HFCs Emissions from HFC Consumption	HFCs	330.53		2.45%	86.02%
2.C	Industrial Processes	CO2 Emissions from the Ferroalloy production	CO2	300.31		2.22%	88.24%
2.A	Industrial Processes	CO2 Emissions from Cement Production	CO2	264.93		1.96%	90.20%
5.B	LULUCF	Cropland remaining Cropland	CO2	175.88	-175.88	1.30%	91.50%
1.B.1	Energy	CH4 Fugitive Emissions from Coal Mining and Handling	CH4	152.91		1.13%	92.63%
1.A.4	Energy	Other Sectors: Residential CO2	CO2	128.50		0.95%	93.58%
4.B	Agriculture	N2O Emissions from Manure Management	N2O	122.53		0.91%	94.49%
1.A.4	Energy	Other Sectors: Residential CH4	CH4	83.23		0.62%	95.11%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	76.95		0.57%	95.67%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	65.07		0.48%	96.16%
1.A.1	Energy	CO2 Emissions from Energy Industries - Gas - Natural Gas	CO2	59.10		0.44%	96.59%
2.C	Industrial	CO2 Emissions from the Iron and Steel Industry	CO2	56.39		0.42%	97.01%

	Processes						
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	49.77		0.37%	97.38%
4.B	Agriculture	CH4 Emissions from Manure Management	CH4	46.34		0.34%	97.72%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	44.16		0.33%	98.05%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	41.50		0.31%	98.36%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	41.45		0.31%	98.66%
1.A.1	Energy	N2O (Non-CO2) Emissions from Stationary Combustion	N2O	24.53		0.18%	98.84%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and Gas Operations	CH4	24.03		0.18%	99.02%
5.E	LULUCF	Settlements remaining Settlements	CO2	23.50	23.50	0.17%	99.19%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	16.50		0.12%	99.32%
6.D	Waste	CH4 Emissions from Waste Incineration	CH4	15.61		0.12%	99.43%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	11.86		0.09%	99.52%
1.A.5	Energy	Other (Energy)-	CH4	8.52		0.06%	99.58%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	8.42		0.06%	99.65%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	7.13		0.05%	99.70%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	7.08		0.05%	99.75%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	4.12		0.03%	99.78%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	3.95		0.03%	99.81%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	3.88		0.03%	99.84%
5.A	LULUCF	Forest Land remaining Forest Land	CO**	3.79	3.79	0.03%	99.87%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	3.50		0.03%	99.89%
5.A	LULUCF	Forest Land remaining Forest Land	N2O	2.65	2.65	0.02%	99.91%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.49		0.02%	99.93%
1.A.5	Energy	Other (Energy)-	N2O	1.96		0.01%	99.95%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Stationary Combustion	CH4	1.72		0.01%	99.96%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	1.67		0.01%	99.97%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.83		0.01%	99.98%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	0.74		0.01%	99.98%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.71		0.01%	99.99%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.57		0.00%	99.99%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.32		0.00%	99.99%

2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.29		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.17		0.00%	100.00%
5.A	LULUCF	Forest Land remaining Forest Land	CH4	0.13	0.13	0.00%	100.00%
5.A	LULUCF	Forest Land remaining Forest Land	NOx*	0.08	0.08	0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.08		0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CO2	0.07	0.07	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.02		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.01		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.01		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00		0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Waterborne Navigation	CO2	0.00		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Waterborne Navigation	CH4	0.00		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Waterborne Navigation	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00		0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00		0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00		0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CH4	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	N2O	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	NOx	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CO	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CH4	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	N2O	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	NOx	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CO	0.00	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00		0.00%	100.00%

Inventory Year	**2005**						

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis 1	Applicable GHG	Emission Estimate (current year with LULUCF) (Gg CO2eq)		%	Cumulative %
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**5891.85**		**42.43%**	**42.43%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**1117.25**		**8.05%**	**50.48%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**1002.53**		**7.22%**	**57.70%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**875.85**		**6.31%**	**64.01%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**732.69**		**5.28%**	**69.28%**
5.A	**LULUCF**	**Forest Land remaining Forest Land**	**CO2**	**655.64**	**-655.64**	**4.72%**	**74.01%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**529.65**		**3.81%**	**77.82%**
1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**400.50**		**2.88%**	**80.70%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**382.37**		**2.75%**	**83.46%**
2.E	**Industrial Processes**	**HFCs Emissions from HFC Consumption**	**HFCs**	**372.19**		**2.68%**	**86.14%**
2.C	**Industrial Processes**	**CO2 Emissions from the Ferroalloy production**	**CO2**	**330.38**		**2.38%**	**88.52%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**291.35**		**2.10%**	**90.62%**
5.B	**LULUCF**	**Cropland remaining Cropland**	**CO2**	**174.90**	**-174.90**	**1.26%**	**91.88%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**148.61**		**1.07%**	**92.95%**
1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**145.21**		**1.05%**	**93.99%**
4.B	**Agriculture**	**N2O Emissions from Manure Management**	**N2O**	**117.32**		**0.84%**	**94.84%**
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	79.70		0.57%	95.41%
1.A.4	Energy	Other Sectors: Residential CH4	CH4	75.66		0.54%	95.96%
1.A.1	Energy	CO2 Emissions from Energy Industries - Gas - Natural Gas	CO2	69.32		0.50%	96.45%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	65.18		0.47%	96.92%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	58.23		0.42%	97.34%
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	48.43		0.35%	97.69%

4.B	Agriculture	CH4 Emissions from Manure Management	CH4	44.83		0.32%	98.02%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	42.74		0.31%	98.32%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	40.81		0.29%	98.62%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and gas Operations	CH4	26.11		0.19%	98.81%
1.A.1	Energy	N2O (Non-CO2) Emissions from Stationary Combustion	N2O	24.15		0.17%	98.98%
5.E	LULUCF	Settlements remaining settlements	CO2	23.50	23.50	0.17%	99.15%
6.D	Waste	CH4 Emissions from Waste Incineration	CH4	15.64		0.11%	99.26%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	14.94		0.11%	99.37%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	12.24		0.09%	99.46%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	11.21		0.08%	99.54%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	8.19		0.06%	99.60%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	6.65		0.05%	99.64%
5.A	LULUCF	Forest Land remaining Forest Land	CO**	6.52	6.52	0.05%	99.69%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	6.48		0.05%	99.74%
1.A.5	Energy	Other (Energy)-	CH4	5.54		0.04%	99.78%
5.A	LULUCF	Forest Land remaining Forest Land	CH4	4.57	4.57	0.03%	99.81%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	4.30		0.03%	99.84%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	3.56		0.03%	99.87%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	3.39		0.02%	99.89%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	3.35		0.02%	99.92%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.44		0.02%	99.93%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Stationary Combustion	CH4	1.68		0.01%	99.95%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	1.58		0.01%	99.96%
1.A.5	Energy	Other (Energy)-	N2O	1.56		0.01%	99.97%
5.A	LULUCF	Forest Land remaining Forest Land	N2O	1.04	1.04	0.01%	99.98%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.96		0.01%	99.98%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.88		0.01%	99.99%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.71		0.01%	99.99%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.36		0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CO2	0.26	0.26	0.00%	100.00%
5.A	LULUCF	Forest Land remaining Forest Land	NOx*	0.14	0.14	0.00%	100.00%

2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.03		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.02		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.01		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.01		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00		0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Waterborne Navigation	CO2	0.00		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Waterborne Navigation	CH4	0.00		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Waterborne Navigation	N2O	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00		0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00		0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00		0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CH4	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	N2O	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	NOx	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CO	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CH4	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	N2O	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	NOx	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CO	0.00	0.00	0.00%	100.00%

Inventory Year	**2006**						

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis 1	Applicable GHG	Emission Estimate (current year with LULUCF) (Gg CO2eq)		%	Cumulative %
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**4913.57**		**38.60%**	**38.60%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**1113.64**		**8.75%**	**47.34%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**999.39**		**7.85%**	**55.19%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**942.42**		**7.40%**	**62.60%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**745.30**		**5.85%**	**68.45%**
5.A	**LULUCF**	**Forest Land remaining Forest Land**	**CO2**	**588.33**	**-588.33**	**4.62%**	**73.07%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**553.97**		**4.35%**	**77.42%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**532.48**		**4.18%**	**81.61%**
1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**322.61**		**2.53%**	**84.14%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**305.44**		**2.40%**	**86.54%**
2.C	**Industrial Processes**	**CO2 Emissions from the Ferroalloy production**	**CO2**	**290.55**		**2.28%**	**88.82%**
5.B	**LULUCF**	**Cropland remaining Cropland**	**CO2**	**184.29**	**-184.29**	**1.45%**	**90.27%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**155.25**		**1.22%**	**91.49%**
1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**140.11**		**1.10%**	**92.59%**
4.B	**Agriculture**	**N2O Emissions from Manure Management**	**N2O**	**121.46**		**0.95%**	**93.54%**
2.E	**Industrial Processes**	**HFCs Emissions from HFC Consumption**	**HFCs**	**101.09**		**0.79%**	**94.34%**
1.A.4	**Energy**	**Other Sectors: Residential CH4**	**CH4**	**81.36**		**0.64%**	**94.98%**
1.A.1	Energy	CO2 Emissions from Energy Industries - Gas - Natural Gas	CO2	74.49		0.59%	95.56%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	65.28		0.51%	96.08%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	64.63		0.51%	96.58%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	64.02		0.50%	97.09%
4.B	Agriculture	CH4 Emissions from Manure Management	CH4	46.52		0.37%	97.45%

6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	46.32		0.36%	97.81%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	43.85		0.34%	98.16%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	34.79		0.27%	98.43%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and gas Operations	CH4	28.26		0.22%	98.65%
1.A.1	Energy	N2O (Non-CO2) Emissions from Stationary Combustion	N2O	25.13		0.20%	98.85%
5.E	LULUCF	Settlements remaining settlements	CO2	23.50	23.50	0.18%	99.04%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	16.02		0.13%	99.16%
6.D	Waste	Other (Waste)-	CH4	15.67		0.12%	99.29%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	13.59		0.11%	99.39%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	11.30		0.09%	99.48%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	8.84		0.07%	99.55%
1.A.5	Energy	Other (Energy)-	CH4	7.47		0.06%	99.61%
5.A	LULUCF	Forest Land remaining Forest Land	CO**	6.46	6.46	0.05%	99.66%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	6.13		0.05%	99.71%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	6.06		0.05%	99.76%
5.A	LULUCF	Forest Land remaining Forest Land	CH4	4.52	4.52	0.04%	99.79%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	4.40		0.03%	99.83%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	3.50		0.03%	99.85%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	3.45		0.03%	99.88%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	3.18		0.02%	99.91%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.40		0.02%	99.92%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Stationary Combustion	CH4	1.78		0.01%	99.94%
1.A.5	Energy	Other (Energy)-	N2O	1.75		0.01%	99.95%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	1.59		0.01%	99.96%
5.A	LULUCF	Forest Land remaining Forest Land	N2O	1.03	1.03	0.01%	99.97%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.86		0.01%	99.98%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.71		0.01%	99.98%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.58		0.00%	99.99%
5.C	LULUCF	Grassland remaining Grassland	CO2	0.52	0.52	0.00%	99.99%
2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.35		0.00%	100.00%

1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.31		0.00%	100.00%
5.A	LULUCF	Forest Land remaining Forest Land	NOx*	0.14	0.14	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.03		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.02		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.01		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00		0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Waterborne Navigation	CO2	0.00		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Waterborne Navigation	CH4	0.00		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Waterborne Navigation	N2O	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00		0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00		0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00		0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CH4	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	N2O	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	NOx	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CO	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CH4	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	N2O	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	NOx	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CO	0.00	0.00	0.00%	100.00%

Inventory Year	**2007**						

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis 1	Applicable GHG	Emission Estimate (current year with LULUCF) (Gg CO2eq)		%	Cumulative %
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**4938.51**		**34.40%**	**34.40%**
5.A	**LULUCF**	**Forest Land remaining Forest Land**	**CO2**	**1574.81**	**-1574.81**	**10.97%**	**45.38%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**1345.95**		**9.38%**	**54.75%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**1144.22**		**7.97%**	**62.72%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**828.03**		**5.77%**	**68.49%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**755.45**		**5.26%**	**73.76%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**635.62**		**4.43%**	**78.18%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**490.64**		**3.42%**	**81.60%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**317.82**		**2.21%**	**83.82%**
2.C	**Industrial Processes**	**CO2 Emissions from the Ferroalloy production**	**CO2**	**313.80**		**2.19%**	**86.00%**
1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**301.47**		**2.10%**	**88.10%**
2.E	**Industrial Processes**	**HFCs Emissions from HFC Consumption**	**HFCs**	**226.85**		**1.58%**	**89.68%**
5.B	**LULUCF**	**Cropland remaining Cropland**	**CO2**	**197.28**	**-197.28**	**1.37%**	**91.06%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**156.55**		**1.09%**	**92.15%**
1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**137.38**		**0.96%**	**93.10%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Gas - Natural Gas**	**CO2**	**115.19**		**0.80%**	**93.91%**
4.B	**Agriculture**	**N2O Emissions from Manure Management**	**N2O**	**114.11**		**0.79%**	**94.70%**
5.A	LULUCF	Forest Land remaining Forest Land	CO**	82.50	82.50	0.57%	95.28%
1.A.4	Energy	Other Sectors: Residential CH4	CH4	68.77		0.48%	95.76%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	66.70		0.46%	96.22%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	63.95		0.45%	96.67%
5.A	LULUCF	Forest Land remaining Forest Land	CH4	57.81	57.81	0.40%	97.07%
4.B	Agriculture	CH4 Emissions from Manure Management	CH4	52.16		0.36%	97.43%

6.B	Waste	N2O Emissions from Wastewater Handling	N2O	46.13		0.32%	97.75%
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	44.29		0.31%	98.06%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	41.57		0.29%	98.35%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and gas Operations	CH4	35.56		0.25%	98.60%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	33.38		0.23%	98.83%
1.A.1	Energy	N2O (Non-CO2) Emissions from Stationary Combustion	N2O	24.89		0.17%	99.00%
5.E	LULUCF	Settlements remaining settlements	CO2	23.50	23.50	0.16%	99.17%
6.D	Waste	Other (Waste)-	CH4	15.66		0.11%	99.28%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	14.02		0.10%	99.38%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	13.63		0.09%	99.47%
5.A	LULUCF	Forest Land remaining Forest Land	N2O	13.22	13.22	0.09%	99.56%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	11.75		0.08%	99.64%
1.A.5	Energy	Other (Energy)-	CH4	6.99		0.05%	99.69%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	5.19		0.04%	99.73%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	4.78		0.03%	99.76%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	4.25		0.03%	99.79%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	4.21		0.03%	99.82%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	4.19		0.03%	99.85%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	3.45		0.02%	99.87%
5.C	LULUCF	Grassland remaining Grassland	CO2	2.72	2.72	0.02%	99.89%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	2.72		0.02%	99.91%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.70		0.02%	99.93%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	1.92		0.01%	99.94%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Stationary Combustion	CH4	1.82		0.01%	99.96%
5.A	LULUCF	Forest Land remaining Forest Land	NOx*	1.82	1.82	0.01%	99.97%
1.A.5	Energy	Other (Energy)-	N2O	1.65		0.01%	99.98%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.78		0.01%	99.99%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.74		0.01%	99.99%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.71		0.00%	100.00%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.24		0.00%	100.00%
2.C	Industrial	CO2 Emissions from Aluminium Production	CO2	0.11		0.00%	100.00%

	Processes						
1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.03		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.02		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.01		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00		0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Waterborne Navigation	CO2	0.00		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Waterborne Navigation	CH4	0.00		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Waterborne Navigation	N2O	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00		0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00		0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00		0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CH4	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	N2O	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	NOx	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CO	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CH4	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	N2O	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	NOx	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CO	0.00	0.00	0.00%	100.00%

Inventory Year	**2008**						

IPCC Source Category	Sector	Source Categories to be Assessed in Key Source Category Analysis 1	Applicable GHG	Emission Estimate (current year with LULUCF) (Gg CO2eq)		%	Cumulative %
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**5480.28**		**39.47%**	**39.47%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**1184.55**		**8.53%**	**48.00%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**1179.82**		**8.50%**	**56.50%**
5.A	**LULUCF**	**Forest Land remaining Forest Land**	**CO2**	**1104.09**	**-1104.09**	**7.95%**	**64.45%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**767.44**		**5.53%**	**69.98%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**732.16**		**5.27%**	**75.25%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**492.25**		**3.55%**	**78.80%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**348.51**		**2.51%**	**81.31%**
2.C	**Industrial Processes**	**CO2 Emissions from the Ferroalloy production**	**CO2**	**340.83**		**2.45%**	**83.76%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**303.65**		**2.19%**	**85.95%**
2.E	**Industrial Processes**	**HFCs Emissions from HFC Consumption**	**HFCs**	**274.30**		**1.98%**	**87.93%**
5.B	**LULUCF**	**Cropland remaining Cropland**	**CO2**	**223.45**	**-223.45**	**1.61%**	**89.54%**
1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**221.47**		**1.60%**	**91.13%**
1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**161.04**		**1.16%**	**92.29%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Gas - Natural Gas**	**CO2**	**147.43**		**1.06%**	**93.35%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**141.39**		**1.02%**	**94.37%**
4.B	Agriculture	N2O Emissions from Manure Management	N2O	114.49		0.82%	95.20%
1.A.4	Energy	Other Sectors: Residential CH4	CH4	83.52		0.60%	95.80%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	65.65		0.47%	96.27%

4.B	Agriculture	CH4 Emissions from Manure Management	CH4	51.52		0.37%	96.64%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	46.29		0.33%	96.97%
6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	44.54		0.32%	97.30%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	43.77		0.32%	97.61%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	42.86		0.31%	97.92%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and Gas Operations	CH4	40.20		0.29%	98.21%
5.A	LULUCF	Forest Land remaining Forest Land	CO**	38.70	38.70	0.28%	98.49%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	30.24		0.22%	98.71%
1.A.1	Energy	N2O (Non-CO2) Emissions from Energy Industries	N2O	27.26		0.20%	98.90%
5.E	LULUCF	Settlements remaining settlements	CO2	23.50	23.50	0.17%	99.07%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	16.60		0.12%	99.19%
6.C	Waste	CH4 Emissions from Waste Incineration	CH4	15.76		0.11%	99.30%
5.A	LULUCF	Forest Land remaining Forest Land	CH4	15.64	15.64	0.11%	99.42%
5.C	LULUCF	Grassland remaining Grassland	CO2	12.50	12.50	0.09%	99.51%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	11.66		0.08%	99.59%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	9.73		0.07%	99.66%
1.A.5	Energy	Other (Energy)-	CH4	6.52		0.05%	99.71%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	6.30		0.05%	99.75%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	5.41		0.04%	99.79%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	4.35		0.03%	99.82%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	3.63		0.03%	99.85%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	3.62		0.03%	99.88%
5.A	LULUCF	Forest Land remaining Forest Land	N2O	3.58	3.58	0.03%	99.90%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	3.14		0.02%	99.92%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	2.78		0.02%	99.94%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Energy Industries	CH4	1.75		0.01%	99.96%
1.A.5	Energy	Other (Energy)-	N2O	1.65		0.01%	99.97%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	1.65		0.01%	99.98%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	1.11		0.01%	99.99%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.72		0.01%	99.99%
5.A	LULUCF	Forest Land remaining Forest Land	NOx*	0.49	0.49	0.00%	100.00%

1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.31		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Railways	N2O	0.03		0.00%	100.00%
2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.02		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Railways	CH4	0.02		0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.01		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.00		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00		0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Waterborne Navigation	CO2	0.00		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Waterborne Navigation	CH4	0.00		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Waterborne Navigation	N2O	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.00		0.00%	100.00%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00		0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savannah Burning	CH4	0.00		0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savannah Burning	N2O	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00		0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CH4	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	N2O	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	NOx	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CO	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CH4	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	N2O	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	NOx	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CO	0.00	0.00	0.00%	100.00%

Inventory Year	2009						
IPCC Source Category	**Sector**	**Source Categories to be Assessed in Key Source Category Analysis 1**	**Applicable GHG**	**Emission Estimate (current year with LULUCF) (Gg CO2eq)**		**%**	**Cumulative %**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Coal - Lignite**	**CO2**	**5297.01**		**40.37%**	**40.37%**
5.A	**LULUCF**	**Forest Land remaining Forest Land**	**CO2**	**1301.31**	**-1301.31**	**9.92%**	**50.28%**
1.A.3	**Energy**	**CO2 Mobile Combustion: Road Vehicles**	**CO2**	**1273.52**		**9.70%**	**59.99%**
1.A.2	**Energy**	**CO2 Emissions from Manufacturing Industries and Construction**	**CO2**	**793.26**		**6.05%**	**66.03%**
6.A	**Waste**	**CH4 Emissions from Solid Waste Disposal Sites**	**CH4**	**778.70**		**5.93%**	**71.97%**
4.D	**Agriculture**	**N2O (Direct and Indirect) Emissions from Agricultural Soils**	**N2O**	**700.22**		**5.34%**	**77.30%**
1.A.1	**Energy**	**CO2 Emissions from Energy Industries - Oil - Residual Fuel Oil**	**CO2**	**483.85**		**3.69%**	**80.99%**
4.A	**Agriculture**	**CH4 Emissions from Enteric Fermentation in Domestic Livestock**	**CH4**	**458.02**		**3.49%**	**84.48%**
2.A	**Industrial Processes**	**CO2 Emissions from Cement Production**	**CO2**	**301.20**		**2.30%**	**86.77%**
5.B	**LULUCF**	**Cropland remaining Cropland**	**CO2**	**272.52**	**-272.52**	**2.08%**	**88.85%**
1.A.5	**Energy**	**Other (Energy)-**	**CO2**	**267.25**		**2.04%**	**90.89%**
1.B.1	**Energy**	**CH4 Fugitive Emissions from Coal Mining and Handling**	**CH4**	**156.73**		**1.19%**	**92.08%**
1.A.4	**Energy**	**Other Sectors: Residential CO2**	**CO2**	**146.15**		**1.11%**	**93.20%**
4.B	**Agriculture**	**N2O Emissions from Manure Management**	**N2O**	**104.32**		**0.79%**	**93.99%**
1.A.4	**Energy**	**Other Sectors: Residential CH4**	**CH4**	**92.92**		**0.71%**	**94.70%**
2.C	Industrial Processes	CO2 Emissions from the Ferroalloy production	CO2	80.18		0.61%	95.31%
1.A.1	Energy	CO2 Emissions from Energy Industries - Gas - Natural Gas	CO2	78.65		0.60%	95.91%
6.C	Waste	CO2 Emissions from Waste Incineration	CO2	65.99		0.50%	96.41%
5.C	LULUCF	Grassland remaining Grassland	CO2	51.24	51.24	0.39%	96.80%
2.C	Industrial Processes	CO2 Emissions from the Iron and Steel Industry	CO2	49.31		0.38%	97.18%
4.B	Agriculture	CH4 Emissions from Manure Management	CH4	45.01		0.34%	97.52%
6.B	Waste	N2O Emissions from Wastewater Handling	N2O	44.67		0.34%	97.86%

6.B	Waste	CH4 Emissions from Wastewater Handling	CH4	40.96		0.31%	98.17%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - Gas/Diesel Oil	CO2	30.71		0.23%	98.41%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CO2	CO2	28.79		0.22%	98.63%
1.B.2	Energy	CH4 Fugitive Emissions from Oil and Gas Operations	CH4	26.98		0.21%	98.83%
1.A.1	Energy	N2O (Non-CO2) Emissions from Energy Industries	N2O	24.48		0.19%	99.02%
5.E	LULUCF	Settlements remaining Settlements	CO2	23.50	23.50	0.18%	99.20%
1.A.4	Energy	Other Sectors: Residential N2O	N2O	18.50		0.14%	99.34%
6.D	Waste	Other (Waste)-	CH4	15.84		0.12%	99.46%
1.A.3	Energy	CO2 Mobile Combustion: Railways	CO2	11.50		0.09%	99.55%
1.A.5	Energy	Other (Energy)-	CH4	9.15		0.07%	99.62%
4.F	Agriculture	CH4 Emissions from Agricultural Residue Burning	CH4	6.10		0.05%	99.66%
1.A.3	Energy	CH4 Mobile Combustion: Road Vehicles	CH4	5.58		0.04%	99.71%
5.A	LULUCF	Forest Land remaining Forest Land	CO**	5.44	5.44	0.04%	99.75%
1.A.1	Energy	CO2 Emissions from Energy Industries - Oil - LPG	CO2	5.28		0.04%	99.79%
4.C	Agriculture	CH4 Emissions from Rice Production	CH4	4.27		0.03%	99.82%
5.A	LULUCF	Forest Land remaining Forest Land	CH4	3.81	3.81	0.03%	99.85%
4.F	Agriculture	N2O Emissions from Agricultural Residue Burning	N2O	3.25		0.02%	99.87%
1.A.3	Energy	N2O Mobile Combustion: Road Vehicles	N2O	3.03		0.02%	99.90%
1.A.5	Energy	Other (Energy)-	N2O	2.26		0.02%	99.92%
2.A	Industrial Processes	CO2 Emissions from Lime Production	CO2	2.14		0.02%	99.93%
1.A.2	Energy	N2O Emissions from Manufacturing Industries and Construction	N2O	2.14		0.02%	99.95%
1.A.1	Energy	CH4 (Non-CO2) Emissions from Energy Industries	CH4	1.66		0.01%	99.96%
2.A	Industrial Processes	CO2 Emissions from Limestone and Dolomite Use	CO2	1.04		0.01%	99.97%
1.A.2	Energy	CH4 Emissions from Manufacturing Industries and Construction	CH4	0.92		0.01%	99.98%
5.A	LULUCF	Forest Land remaining Forest Land	N2O	0.87	0.87	0.01%	99.98%
6.C	Waste	N2O Emissions from Waste Incineration	N2O	0.72		0.01%	99.99%
2.C	Industrial Processes	CO2 Emissions from Aluminium Production	CO2	0.56		0.00%	99.99%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing CH4	CH4	0.55		0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion: Aircraft	CO2	0.26		0.00%	100.00%
1.A.4	Energy	Other Sectors: Agriculture/Forestry/Fishing N2O	N2O	0.17		0.00%	100.00%

5.A	LULUCF	Forest Land remaining Forest Land	NOx*	0.12	0.12	0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion: Aircraft	N2O	0.00		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion: Aircraft	CH4	0.00		0.00%	100.00%
1.A.3	Energy	CO2 Mobile Combustion Water Borne Navigation	CO2	0.00		0.00%	100.00%
1.A.3	Energy	CH4 Mobile Combustion Water Borne Navigation	CH4	0.00		0.00%	100.00%
1.A.3	Energy	N2O Mobile Combustion Water Borne Navigation	N2O	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CO2	CO2	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial CH4	CH4	0.00		0.00%	100.00%
1.A.4	Energy	Other Sectors: Commercial N2O	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Nitric Acid Production	N2O	0.00		0.00%	100.00%
2.B	Industrial Processes	N2O Emissions from Adipic Acid Production	N2O	0.00		0.00%	100.00%
2.E	Industrial Processes	HFCs Emissions from HFC Consumption	HFCs	0.00		0.00%	100.00%
4.E	Agriculture	CH4 Emissions from Savanna Burning	CH4	0.00		0.00%	100.00%
4.E	Agriculture	N2O Emissions from Savanna Burning	N2O	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	CH4	0.00		0.00%	100.00%
4.G	Agriculture	Other (Agriculture)-	N2O	0.00		0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CH4	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	N2O	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	NOx	0.00	0.00	0.00%	100.00%
5.B	LULUCF	Cropland remaining Cropland	CO	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CH4	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	N2O	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	NOx	0.00	0.00	0.00%	100.00%
5.C	LULUCF	Grassland remaining Grassland	CO	0.00	0.00	0.00%	100.00%
6.D	Waste	Other (Waste)-	CO2	0.00		0.00%	100.00%
6.D	Waste	Other (Waste)-	N2O	0.00		0.00%	100.00%
2.C	Industrial Processes	PFC Emissions from Aluminum Production	PFCs			0.00%	100.00%
2.C	Industrial Processes	SF6 from Magnesium Production	SF6			0.00%	100.00%
2.D	Industrial Processes	SF6 Emissions from Electrical Equipment	SF6			0.00%	100.00%

2.E	Industrial Processes	PFC Emissions from Semiconductor Manufacturing	SF6			0.00%	100.00%
2.E	Industrial Processes	HFC Emissions from Semiconductor Manufacturing	HFCs			0.00%	100.00%
2.E	Industrial Processes	SF6 Emissions from Semiconductor Manufacturing	PFCs			0.00%	100.00%
2.E	Industrial Processes	HFC-23 Emissions from HFC-22 Manufacture	HFC-23			0.00%	100.00%
2.F	Industrial Processes	SF6 Emissions from Other Sources of SF6	SF6			0.00%	100.00%
2.F	Industrial Processes	HFC Emissions from Substitutes for Ozone Depleting Substances (ODS Substitutes)	HFCs			0.00%	100.00%
2.F	Industrial Processes	PFCs Emissions from Substitutes for Ozone Depleting Substances (ODS Substitutes)	PFCs			0.00%	100.00%
2.G	Industrial Processes	Other (Industrial Processes)-	enter gas			0.00%	100.00%
2.G	Industrial Processes	Other (Industrial Processes)-	enter gas			0.00%	100.00%
Enter number	Energy	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Energy	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Energy	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Energy	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Energy	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Energy	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Energy	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Energy	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Energy	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Energy	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Industrial Processes	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Agriculture	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Agriculture	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Agriculture	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Agriculture	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Waste	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Waste	Additional categories to be entered if needed	enter gas			0.00%	100.00%

Enter number	Waste	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Waste	Additional categories to be entered if needed	enter gas			0.00%	100.00%
Enter number	Other	Other-A	enter gas			0.00%	100.00%
Enter number	Other	Other-B	enter gas			0.00%	100.00%
Enter number	Other	Other-C	enter gas			0.00%	100.00%
Enter number	Other	Other-D	enter gas			0.00%	100.00%
Enter number	Other	Other-E	enter gas			0.00%	100.00%