Republic of Macedonia
MINISTRY OF ENVIRONMENT AND PHYSICAL PLANNING

Second Biennial Update Report
on Climate Change

# NATIONAL INVENTORY REPORT

*Republic of Macedonia*

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Empowered lives.
Resilient nations.

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# Abbreviations and acronyms

| | |
|---|---|
| AFOLU | Agriculture, Forestry and Other Land Use |
| BUR | Biennial Update Report |
| CC | Climate Change |
| CHPs | Combined Heat and Power Plants |
| CLC | CORINE Land Cover |
| CMC | Center for Management of Crises |
| CORINE | Coordination of Information on the Environment |
| CRF | Common Reporting Format |
| CS | Country Specific |
| CTA | Chief Technical Advisor |
| DF | Default Factor |
| DOC | Degradable Organic Carbon |
| EC | European Commission |
| EEA | European Environment Agency |
| EFDB | Emission Factor Database |
| EO | Earth Observation |
| Eurostat | Statistical Office of the European Union |
| FAOStat | Food and Agriculture Organization of the United Nations Statistical Databases |
| FBUR | First Biennial Update Report |
| FFU | Firefighting Union |
| F-gas | Fluorinated gas |
| FNC | First National Communication |
| FOD | First Order Decay |
| FOLU | Forest and Other Land Use |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GHG | Greenhouse Gas |
| GSP | Global Support Programme |
| GWP | Global Warming Potential |
| IDT | Inventory Development Team |
| IE | Included elsewhere |
| IEA | International Energy Agency |
| IPCC | Intergovernmental Panel on Climate Change |
| IPPU | Industrial Processes and Product Use |
| IST | Imperial Smelt Technology |
| LPG | Liquefied Petroleum Gas |
| LU | Land Use |
| LUCF | Land-Use Change and Forestry |
| LULUCF | Land Use, Land-Use Change and Forestry |
| MAFWE | Ministry of Agriculture, Forestry and Water Economy |

| | |
|---|---|
| MAKSTAT | Database of the State Statistical Office of the Republic of Macedonia |
| MASA | Macedonian Academy of Sciences and Arts |
| MCC | Macedonian Chambers of Commerce |
| MKD | Macedonian Denar |
| MMR | Monitoring Mechanism Regulation |
| MMU | Minimum Mapping Unit |
| MNAV | Macedonian Navigation Agency |
| MOE | Ministry of Economy |
| MOEPP | Ministry of Environment and Physical Planning |
| MRV | Measurement, Reporting and Verification |
| NA | Not Applicable |
| NCCC | National Communication on Climate Change |
| NC | National Communication |
| NCV | Net calorific value |
| NE | Not estimated |
| NIR | National Inventory Report |
| NO | Not Occurring |
| ODS | Ozone-Depleting Substances |
| OECD | Organization for Economic Cooperation and Development |
| PV | Photovoltaic |
| QA | Quality Assurance |
| QAT | Quality Assurance Team |
| QC | Quality Control |
| RCESD | Research Center for Energy and Sustainable Development |
| RS | Remote Sensing |
| SAR | Second Assessment Report |
| SBUR | Second Biennial Update Report |
| SNC | Second National Communication |
| SSO | State Statistical Office |
| SWDS | Solid Waste Disposal Sites |
| T1 | Tier 1 |
| T2 | Tier 2 |
| TNC | Third National Communication |
| TWG | Technical Working Group |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USA | United States of America |
| USD | United States Dollar |

## Chemical symbols

| | |
|---|---|
| $CaCO_3$ | Limestone |
| $CaMgCO_3$ | Dolomite |
| $CH_4$ | Methane |
| $CO(NH_2)_2$ | Urea |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| $CO_2$-eq | Carbon Dioxide equivalents |
| $HCO3^-$ | Bicarbonate |
| HFCs | Hydro Fluorocarbons |
| N | Nitrogen |
| $N_2O$ | Nitrous Oxide |
| $Na_2CO_3$ | Sodium carbonate |
| $NH_3$ | Ammonia |
| $NH_4^{+2}$ | Ammonium |
| NMVOC | Non-Methane Volatile Organic Compound, |
| $NO_3^-$ | Nitrate |
| NOx | Nitrogen Oxides |
| $OH^-$ | Hydroxyl ion |
| PFCs | Per Fluorocarbons |
| $SF_6$ | Sulphur hexafluoride |
| $SO_2$ | Sulphur Dioxide |
| $SO_x$ | Sulphur Oxides |

## Units and Metric Symbols

| UNIT | Name | Unit for |
|---|---|---|
| g | gram | mass |
| W | watt | power |
| J | joule | energy |
| m | meter | length |
| Wh | watt hour | energy |
| toe | ton of oil equivalent | energy |

| Mass Unit Conversion | | |
|---|---|---|
| 1g | | |
| 1kg | = 1 000 g | |
| 1t | = 1 000 kg | = 1 Mg |
| 1kt | = 1 000 t | = 1 Gg |
| 1Mt | = 1 000 000 t | = 1 Tg |

| Metric Symbol | Prefix | Factor |
|---|---|---|
| P | peta | $10^{15}$ |
| T | tera | $10^{12}$ |
| G | giga | $10^{9}$ |
| M | mega | $10^{6}$ |
| k | kilo | $10^{3}$ |
| h | hecto | $10^{2}$ |
| da | deca | $10^{1}$ |
| d | deci | $10^{-1}$ |
| c | centi | $10^{-2}$ |
| m | milli | $10^{-3}$ |
| µ | micro | $10^{-6}$ |
| n | nano | $10^{-9}$ |
| p | pico | $10^{-12}$ |

# Executive summary

Macedonia, as a Non-Annex I Party to the UNFCCC, has been developing Inventory of the anthropogenic emissions by sources and removals by sinks of greenhouse gases (GHGs) emitted to or removed from the atmosphere since 2000 as a part of its National Communications on Climate Change and Biennial Update Reports. Up to now, three National Communications (2003, 2008 and 2014) and the First Biennial Update Report (2015) have been delivered to the UNFCCC.

The first National GHG Inventory was developed under the First National Communication (FNC) for the period from 1990 – 1998 and under the Second National Communication (SNC), this period was revised and extended to cover the years 1999 – 2002. In the Third National Communication (TNC), the GHG inventory considered the time-frame 2003 – 2009. In these reports, the inventory was developed in accordance with the 1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories and the 2000 IPCC Good Practice Guidance. In the First Biennial Update Report (FBUR), the inventory was compiled using the IPCC Inventory Software, in compliance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The series was updated to consider the period 2010 – 2012 and additionally, the entire previous series of data from 1990 to 2009 were revised according to the requirements of the IPCC Inventory Software.

The inventory activities under the SBUR are built on the work done in the FBUR, in line with the **IPCC 2006 Guidelines**. Therefore, the data for 2012 have been revised and updated as necessary and the emission trend expanded by developing a GHG inventory for 2013 and 2014 in the **IPCC Inventory Software** (version 2.17 – Rev 1, available at the time of preparation of the Inventory).

The national inventory process includes the following **key players**:

- **Ministry of Environment and Physical Planning**, responsible for supervising the national inventory process and reporting the emissions to UNFCCC and also for other international reporting;
- **GHG Inventory Development Team**, composed of MASA team and external sectoral experts responsible for preparing the GHG inventory in four different sectors (Energy, IPPU, AFOLU and Waste) and calculation of Precursors and indirect emissions;
- **Data Suppliers**, with State Statistical Office being the most important data source;
- **Verification Team,** which includes experts working on Quality Control, as well as experts working on Quality Assurance. The last is also ensured by multilayer structure involving Chief Technical Advisor (CTA), the National Committee on Climate Change (NCCC), the Global Support Programme (GSP).

The preparation of the national GHG inventory is project based, supported by Global Environment Facility (GEF) and United Nations Development Program (UNDP). The estimated emissions in the inventory are publicly available at http://www.unfccc.org.mk/Default.aspx?LCID=244.

The reported emissions cover the following **GHGs**: $CO_2$, $CH_4$, $N_2O$, PFCs and HFCs., as well as **precursors and indirect emissions** of: CO, $NO_x$, NMVOC and $SO_2$. The emission of $SF_6$ is not estimated for Macedonia due to unavailability of activity data. The GHG emissions and removals are divided into following **main sectors**: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU) and Waste. Each sector comprises categories and subcategories, so that the inventory is compiled at subcategory level.

To estimate the GHG emissions the Tier 2 method was applied for $CO_2$ emission factors for lignite, residual fuel oil and natural gas for Fuel combustion activities in Energy sector. Tier 2 was also used in IPPU sector for emission factors in Mineral industry, for cement production and in Metal industry, for Iron and steel production and Ferroalloys production. The Waste sector is another sector with Tier 2 application, through IPCC FOD method and taking into account the country-specific activity data on waste disposal at solid waste disposal sites (SWDS) and the historical data on GDP and population. For the other sectors the default method, Tier 1, was used.

The aggregate GHG emissions and removals (net emissions) are estimated to 10,720.7 Gg $CO_2$-eq in 2013 and 9,023 Gg $CO_2$-eq in 2014 (including the FOLU sector). The Figure 1 shows the time series of emissions and removals, including the net emissions (in $CO_2$-eq), from 1990 to 2014. Significant fluctuations in the net emissions can be seen in 2000, 2007, 2008 and 2012, where increased $CO_2$ emissions can be noticed in FOLU sector (instead removals) as a result of the intensified forest fires/wildfires.

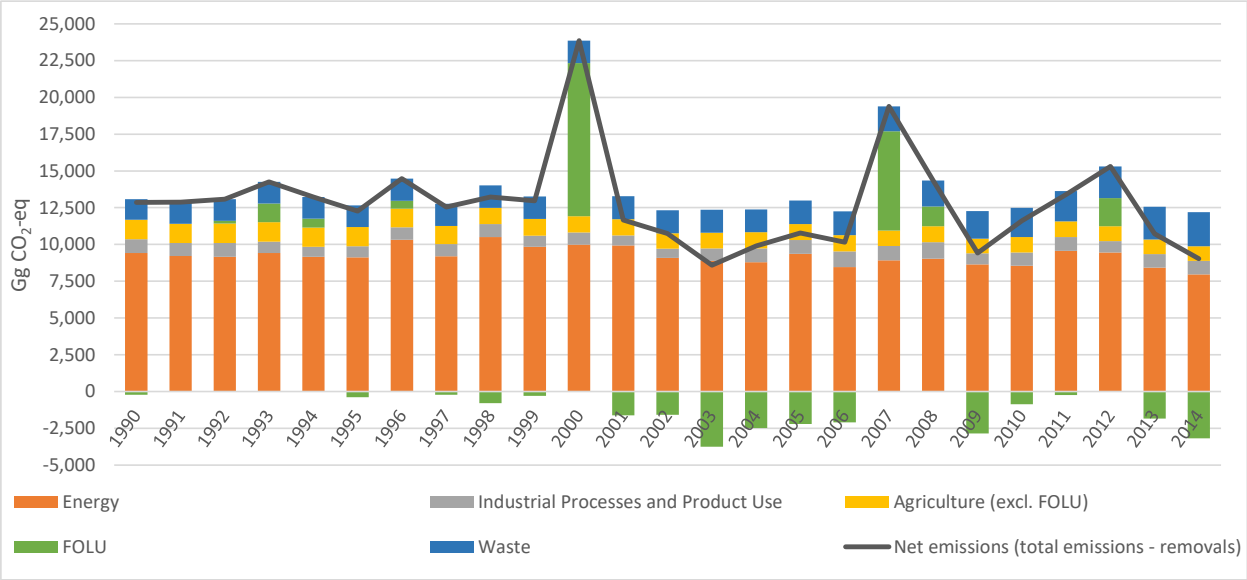



***Figure 1. GHG emissions and removals by sector (in Gg $CO_2$-eq)***

If the emissions and removals from FOLU sector are not accounted for, then the total GHG emissions are 12,557.7 Gg $CO_2$-eq in 2013 and 12,204 Gg $CO_2$-eq in 2014 (Figure 2). The greatest share of emissions is from the Energy sector, accounting for 65.2% in 2014, followed by the Waste sector with 19% share, Agriculture (excluding FOLU) with 8.2% and IPPU sector with 7.6%. The dominant share of emissions from the Energy sector is evident throughout the whole time series.

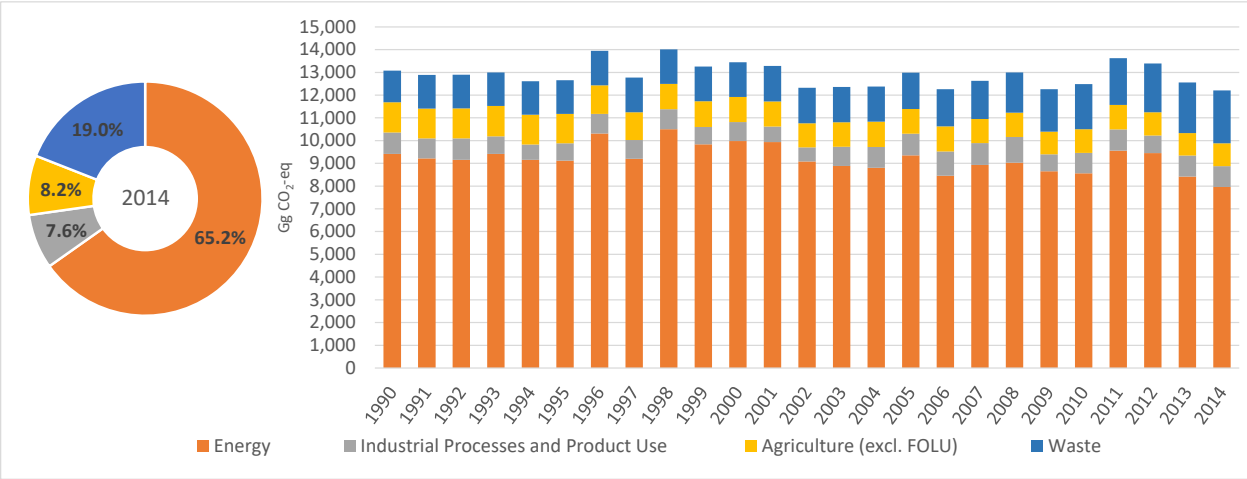



***Figure 2. Total GHG emissions by sector, excluding FOLU sector (in Gg $CO_2$-eq)***

Analyzing the GHG emissions by gas (excluding FOLU sector), it is evident that across the series the most dominant are the $CO_2$ emissions (Figure 3). Their share accounts for 69.3% in 2014, followed by the $CH_4$ emissions with 25.6%, then $N_2O$ emissions with 3.6% and all F-gasses with 1.5%.

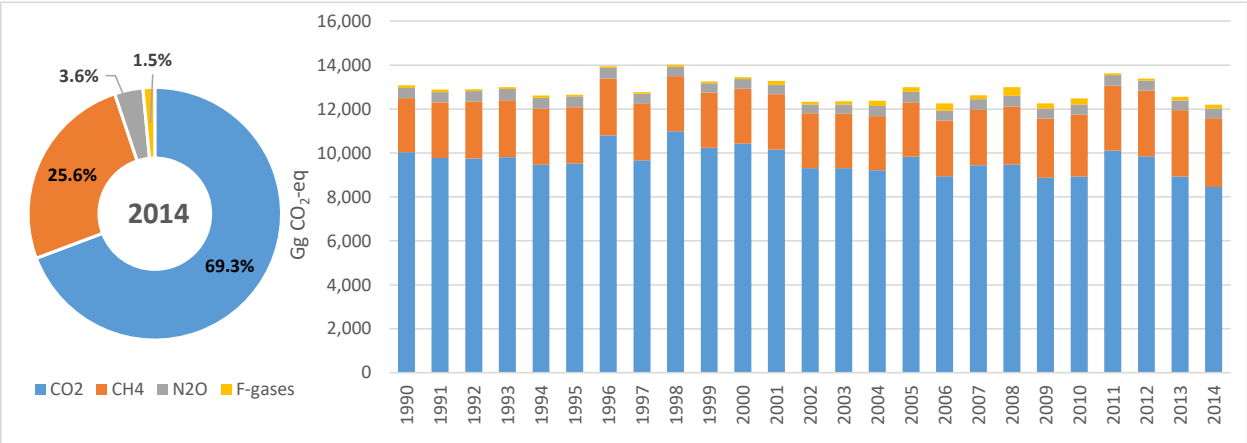



***Figure 3. Total GHG emissions by gas, excluding FOLU (in Gg $CO_2$-eq)***

**The GHG inventory in the Energy sector** accounts for the emissions released as a result of fuel combustion activities, as well as the fugitive emissions from extraction of solid and transmission and distribution of liquid and gaseous fuels. In this report, the emissions have been calculated by two methods: Reference approach (top-down) - using the apparent fuel consumption to account for the carbon flows into and out of the country and Sectoral approach - accounting for the fuel consumption by sectors. The estimated $CO_2$ emissions with the Reference approach are 8,519.8 Gg $CO_2$ in 2013 and 7,700.9 Gg $CO_2$ in 2014.

The emissions in the Sectoral approach are separated in the following categories: Energy Industries, Manufacturing Industries and Construction, Transport, Other sectors (Commercial/Institutional, Residential and Agriculture/Forestry/Fishing) and Non-Specified. In addition, the Fugitive emissions from extraction of lignite, oil refining and transmission of natural gas have been calculated. Therefore, the overall GHG emissions in Energy sector are 9,450.6 Gg $CO_2$-eq in 2013 and 7,957.5 Gg $CO_2$-eq in 2014. Most of the GHG emissions in 2014 come from the category Energy Industries (59.7%), then from the Transport (20.5%) and

Manufacturing Industries and Construction (14.2%). The other two categories together account for 3.8% of the total emissions in 2014 and the remaining 1.8% are Fugitive emissions.

Analyzing the overall GHG emissions in Energy sector by gas (in Gg of $CO_2$-eq), it can be concluded that almost all of the emissions in 2014 are actually $CO_2$ emissions (96.8%), and $CH_4$ and $N_2O$ emissions amount to only 2.5% and 0.7%, respectively.

**The GHG emissions in the IPPU sector** in Macedonia come either from the manufacturing industries or the usage of ozone-depleting substances (ODS) substitutes for refrigeration and air-conditioning. The metal industry is the main contributor with dominant level of emissions from the ferroalloy production. This category is followed by the mineral industry where most of the emissions come from cement production. The rest of the emissions are a result of ODS substitutes usage in the country. Only small portion of emissions come from the chemical industry sector as there are no significant factories that produce chemicals.

The level of the overall greenhouse emissions from this sector is consistent throughout the entire period of 1990-2014. The emissions in 2013 amount to 923.1 Gg $CO_2$-eq or 9.1% and in 2014 it amounts 921.6 Gg $CO_2$-eq or 7.6% of the national emissions (excluding FOLU). The emissions from manufacturing industries follow generally decreasing trend, while emissions from product use follow increasing trend over the observed years.

**The GHG emissions from the AFOLU sector** include emissions associated with Livestock, Forestry and Land Use. Activities related to Livestock production emit $CH_4$ and $N_2O$. The $CH_4$ emission is caused by enteric fermentation during herbal digestion in ruminants but also $N_2O$ emission occurs during the metabolic processes. Additionally $N_2O$ is emitted as a result of manure storage and processing (management). Dairy cows and other cattle are emitting the majority of GHGs in livestock production. The emissions due to livestock activity in 2013 were 666.4 Gg $CO_2$-eq while in 2014 673.7 Gg $CO_2$-eq. This increase of about 1% in 2014 was due to increase of the number of cattle for over 3,000 heads.

Emissions of land use were evaluated throughout forest land, cropland, grassland, wetland, settlements and other land. Forestry sector is the major contributor of GHG sinks in Macedonia, with exception of several years (2000, 2007, 2008 and 2012) when the amounts of forest fires (burned areas) were significantly above the annual average. The area of forest land, the species composition (conifers, broadleaved, mixed) as well as the annual increment and removals from the forests are relatively stable. The average GHG sinks in this sector for 2014 is estimated on 3,471.2 Gg $CO_2$-eq. Cropland is a moderate contributor of GHG emissions accounting for 120.6 Gg $CO_2$-eq, 123.8 Gg $CO_2$-eq in years 2013 and 2014, respectively, followed by Grassland with 130.0 Gg $CO_2$-eq in 2013, 134.9 Gg $CO_2$-eq in 2014. The GHG emissions from the Settlements is estimated to 25.0 Gg $CO_2$-eq and 25.9 Gg $CO_2$-eq in 2013 and 2014, respectively. Even though areas under other land were significant this category is very small contributor of GHG emissions in Macedonia. The GHG emissions from the other land is estimated to 6.6 Gg $CO_2$-eq in 2013 and 5.5 Gg $CO_2$-eq in 2014.

Urea application on land as one of the aggregate sources and non-$CO_2$ emissions sources, is very small contributor of GHG emissions in Macedonia, with estimated emissions of 5.7 Gg $CO_2$-eq for 2013 and 2014. The direct $N_2O$ emission from managed soils is close by emission to direct $CO_2$ emissions from cropland or grassland and it is moderate contributor of GHG emissions in Macedonia. The GHG emissions from the direct $N_2O$ emissions from managed soils were estimated to 196.0 Gg of $CO_2$-eq in 2013 and 197.7 Gg of $CO_2$-eq in 2014. The indirect $N_2O$ emissions from managed soils were small and in 2013 and 2014 these emissions were about 71.3 Gg $CO_2$-eq and 72.0 Gg $CO_2$-eq, respectively. The indirect $N_2O$ emissions from manure management were also stable close to 27 Gg $CO_2$-eq in both years. The methane emissions from rice cultivation were small contributor of GHG emissions in Macedonia. The GHG emissions from the rice cultivation was estimated to 22.9 Gg $CO_2$-eq in 2013 and 25.4 Gg $CO_2$-eq in 2014.

**The GHG emissions from the Waste sector** cover the following categories: Solid Waste Disposal, Biological Treatment of Solid Waste, Incineration and Open Burning of Waste and Waste Water Treatment and Discharge. The overall emissions from this sector are estimated to 2,226.1 Gg $CO_2$-eq in 2013 and 2,323.5 Gg $CO_2$-eq in 2014. The Solid Waste Disposal emissions are most significant accounting for 94.4% of the total waste emissions in 2014. Emissions from Biological Treatment of Solid Waste have been, for the first time, introduced for the period from 2012 to 2014 as a result of data availability. The emissions from Incineration and Open Burning of Waste represent 1.4% of the total Waste emissions. The remaining 4.2% of Waste emissions come from Wastewater Treatment and Discharge (domestic and industrial).

$CH_4$ emissions constitute 97.6% of the total emissions (in $CO_2$-eq) from the Waste sector in 2014. Emissions of $CO_2$ gases from the Waste sector in Macedonia occur only as a result of Open burning of waste and account for 0.4% of the sectoral emissions. $N_2O$ emissions represent 2% of the Waste emissions.

**The Precursors and indirect emissions** have been estimated in line with the EMEP/CORINAIR Emission Inventory Guidebook (referenced in IPCC 2006 Guidelines), in a consistent, complete and comparable manner for the entire inventory period 1990 – 2014.The emission trend of the Indirect GHG emissions and the emissions of $SO_2$ in Macedonia are presented in Figure 4. The dominant share have the emissions of $SO_2$, or 48.2% in 2014, followed by CO emissions, 31.1%, $NO_x$ emissions with 11.3% and NMVOC emissions with 9.4%.

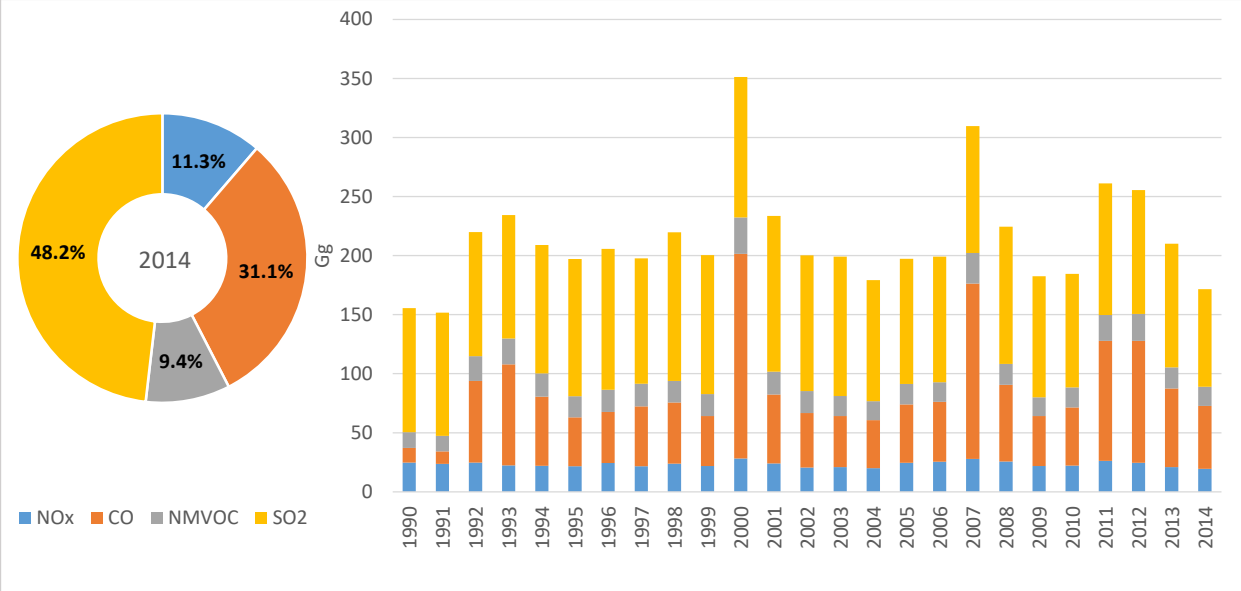



***Figure 4. Emissions of NOx, CO, NMVOC and $SO_2$ in the period 1990 – 2014 (in Gg)***

The assessment of the overall emissions (including AFOLU sector emissions) of the precursors and indirect GHG emissions shows that the Energy sector is the most significant contributor. Namely, in the year 2014, 89.2% from total $NO_x$ emissions originate from the Energy sector, followed by the IPPU sector with 5.8%, AFOLU with 3.0% and Waste sector with 2%. Also, the Energy sector is responsible for 67.1% of the CO emissions, while 15.6% are from the IPPU sector, 12.7% from the Waste sector and 4.6% from the sector AFOLU. When it comes to the emissions of NMVOC, the Energy sector is again most dominant, with 67.2%, while the sector AFOLU contributes with a significant share of 27.9%, followed by the sector IPPU with 4.0% and Waste with 0.9%. Considering the emissions of $SO_2$, the major part, or 89.4%, again originates from the Energy sector, while the IPPU sector contributes with 10.6%.

**The analysis of key categories** that contribute the most to the absolute level of national emissions and removals (level assessment) and to the trend of emissions and removals (trend assessment), is conducted using the Approach 1. According to this approach, key categories are those that, when summed together in descending order of magnitude, add up to 95% of the total level/trend.

According to the level assessment for 2014, the top 5 categories with the highest absolute values of Gg $CO_2$-eq (both emissions and removals) are: Forest Land Remaining Forest Land (35.1%), Energy Industries – Solid Fuels (22.8%), Solid Waste Disposal (11.4%), Road Transportation (8.2%), and Manufacturing Industries and Construction – Liquid Fuels (3.4%).

The trend assessment of source categories is also executed, taking 1990 as base year and 2014 as latest inventory year. The purpose of this trend assessment is to emphasize the categories whose trend is significantly different from the trend of the overall inventory, regardless whether the category trend is increasing or decreasing, or is a sink or source. Unlike the key categories level assessment for 2014, the trend assessment for 1990 and 2014 detects different order of top 5 key categories, as follows: Solid Waste disposal (23.5%), Road Transportation (19.7%), Energy Industries (7.5%), Other Sectors – Liquid Fuels (5.7%), and Energy Industries - Liquid Fuels (3.6%).

**The uncertainty analysis** for the first time is conducted using **both methods**, Approach 1 (Error Propagation method) and Approach 2 (which is actually an implementation of the Monte Carlo method), for **all sectors** of the inventory for 2012, 2013 and 2014. The first approach is already implemented in the IPCC Inventory Software, but for the second approach, a separate model was developed in MATLAB for the purpose of this inventory, which directly uses the database from the Inventory Software.

When using the Error Propagation method for calculating the uncertainty for each sector separately, the obtained results indicate that the AFOLU sector has the highest uncertainty. Immediately after this sector is the sector Waste. A characteristic of these two sectors is that uncertainty in certain subcategories reaches over 40%. On the other hand, the sector with the lowest uncertainty is the Energy sector of about 4%. This sector is followed by the IPPU sector, where the Metal Industry has the utmost uncertainty of about 9.8%.

The opportunity in the Monte Carlo method to insert uncertainty for each input variable separately, especially in the AFOLU and Waste sectors, changes the obtained results compared to the Error Propagation method. According to this Approach, by far the largest uncertainty is in the Waste sector, which exceeds 27% in all the three analyzed years. This sector is followed by the AFOLU sector, where the greatest uncertainty is in the Livestock subcategories of about 16%. On the other hand, Energy again has the lowest uncertainty, followed by the IPPU sector.

Comparing the results from both approaches, by subcategory, it can be concluded that there are no significant differences in the obtained results for the Energy and IPPU sectors. However, there are major differences in the other two sectors, due to the inability to accurately set uncertainty to all variables in the IPCC Inventory Software, i.e. the fact that all the uncertainties should be reduced to only two values (for activity data and emission factor).

The Macedonian approach towards **QA/QC activities** in the national GHG inventory process is based on the in-depth analyses of the current practices of the inventory compilation in the country and the relevant international best practices. The resulting **QA/QC plan** was presented within the FBUR. It is applied in the same manner over the Inventory process of the SBUR, with an extension of QA activities within the energy sector. This QA/QC plan has proved effective in achieving QA/QC objectives, and as such is planned to be implemented for the inventory processes under forthcoming National Communications on Climate Change and Biennial Update Reports.

The Macedonian inventory process meets the necessary technical conditions for ensuring sustainability, since:

- A strong focus is put on documenting essential information in a concise format;
- Activities and tasks are standardized and clear procedures stipulated;
- Roles and responsibilities of all players are clearly defined.

In this regard, worth mentioning are the training materials on GHG inventory preparation developed by the GHG inventory team. These materials are rather country-specific, and being based on personal experience gathered and lessons learned during the GHG inventory preparation in Macedonian conditions, would provide clear guidance for new comers in the process.

Finally, in this report, **good practices, improvements and recommendations for future inventories** are outlined by sector, regarding activity data collection, level of disaggregation, consistency and quality of the activity data, as well as application of more sophisticated methods for emissions estimates.

# 1 Introduction

Macedonia, as a Non-Annex I Party to the UNFCCC, has been developing Inventory of the anthropogenic emissions by sources and removals by sinks of GHGs emitted to or removed from the atmosphere since 2000 as a part of its National Communications on Climate Change and Biennial Update Reports. Up to now, three National Communications (2003, 2008 and 2014) and the First Biennial Update Report (2015) have been delivered to the UNFCCC.

The first National GHG Inventory was developed under the First National Communication (FNC) for the period from 1990 – 1998 and under the Second National Communication (SNC), this period was revised and extended to cover the years 1999 – 2002. In the Third National Communication (TNC), the GHG inventory considered the time-frame 2003 – 2009. In these reports, the inventory was developed in accordance with the 1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories and the 2000 IPCC Good Practice Guidance. In the First Biennial Update Report (FBUR), the inventory was compiled using the IPCC Inventory Software, in compliance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The series was updated to consider the period 2010 – 2012 and additionally, the entire previous series of data from 1990 to 2009 were revised according to the requirements of the IPCC Inventory Software.

The inventory activities under the SBUR are built on the work done in the FBUR, in line with the IPCC 2006 Guidelines. Therefore, the data have been revised and updated as necessary and the emission trend was expanded by developing the GHG inventory for 2013 and 2014, in the IPCC Inventory Software (version 2.17 – Rev 1, from November 22, 2016).

The inventory covers five main sectors: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU) and Waste, disaggregated by categories and subcategories. It includes a database the following GHGs: $CO_2$, $CH_4$, $N_2O$, PFCs and HFCs, as well as precursors and indirect emissions from: CO, NOx, NMVOC and $SO_2$. The emission of $SF_6$ is not estimated for Macedonia due to unavailability of activity data.

Most of the activity data used for preparation of national inventory are taken from official national documents such as: statistical yearbooks, energy balances, sectoral reports and MAKSTAT database from the State Statistical Office (SSO), various strategies and reports from relevant institutions, such as Ministry of Environment and Physical Planning (MOEPP), Ministry of Agriculture, Forestry and Water Economy (MAFWE) etc. and various international databases such as UN projections for population and GDP and FAOstat.

An overview of the trends of overall GHG emissions and removals by sinks in Macedonia is given in Chapter 2. The GHG emissions and removals for each sector are elaborated in details from Chapter 3 to Chapter 6. The detailed information on precursors and indirect emissions are provided in Chapter 7.

The analysis of key categories that contribute the most to the absolute level of national emissions and removals (level assessment) and to the trend of emissions and removals (trend assessment), was also conducted. The five most significant categories (including both emissions sources and removals in absolute values) identified in Macedonia for 2014 are: Forest Land Remaining Forest Land, Energy Industries – Solid Fuels, Solid Waste Disposal, Road Transportation and Manufacturing Industries and Construction – Liquid Fuels. A detailed key category analysis is presented in Chapter 8.

In this report, for the first time both methods, Error Propagation method (Approach 1) and the Monte Carlo method (Approach 2) for uncertainty analysis are applied for each sector of the inventory for 2012, 2013 and 2014. The first approach is already implemented in the IPCC Inventory Software, but for the second approach, a separate model was developed in MATLAB

for the purpose of this inventory, which directly uses the database from the Inventory Software. The results from both approaches and their comparison are elaborated more in Chapter 9.

Additionally, the training materials prepared in the framework of the FBUR were revised and updated for each sector. These training materials contain a step-by-step process for completing inventory tables, explanations of good practices and sources of data and emission factors.

The Macedonian approach towards QA/QC activities in the national GHG inventory process is based on the in-depth analyses of the current practices of the inventory compilation in the country and the relevant international best practices. The resulting QA/QC plan was presented within the FBUR. It is applied in the same manner over the Inventory process of the SBUR, with an extension of QA activities within the energy sector. Detailed information on the QA/QC procedures is provided in Chapter 10.

Summing up, the national inventory process (Figure 5) includes the following key players:

- **Ministry of Environment and Physical Planning**, responsible for supervising the national inventory process and reporting the emissions to UNFCCC and also for other international reporting;
- **GHG Inventory Development Team**, composed of MASA team and external sectoral experts responsible for preparing the GHG inventory in four different sectors (Energy, IPPU, AFOLU and Waste) and calculation of Precursors and indirect emissions;
- **Data Suppliers**, with State Statistical Office being the most important data source;
- **Verification Team,** which includes experts working on Quality Control, as well as experts working on Quality Assurance. The last is also ensured by multilayer structure involving CTA, NCCC and GSP.

The preparation of the national GHG inventory is project based, supported by Global Environment Facility (GEF) and United Nations Development Program (UNDP). The estimated emissions in the inventory are publicly available at http://www.unfccc.org.mk/Default.aspx?LCID=244.

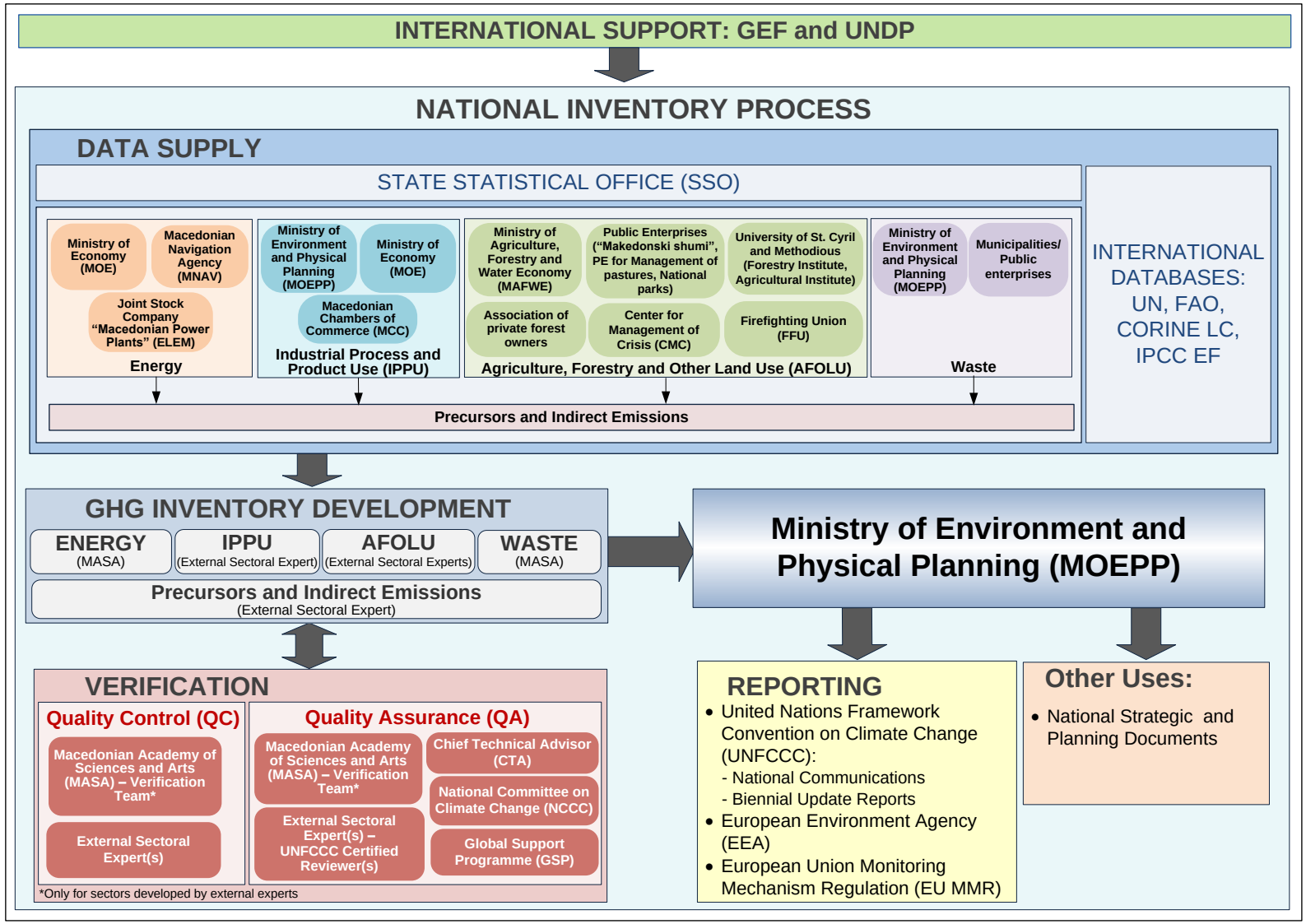



***Figure 5. National inventory process***

# 2 Emission trends

This section gives an overview of the trends of the GHG emissions and removals by sinks in Macedonia. The GHG Inventory for the purpose of the FBUR covered the period 1990 – 2012 and in the SBUR the inventory for years 2013 and 2014 has been compiled. In addition, revision and update (where necessary) of the inventory data have been made. In this inventory the GHG emission for the period 2012 - 2014 are reported. Additionally, the emissions for 2003 and 2008 are given, as years in which the previous National Communications (FNC and SNC) were submitted to UNFCCC, while the submission year for the TNC was 2014 and it is covered with the reported period. More detailed information on the GHG emissions and removals for each sector are provided in the subsequent sections (Chapter 3 to Chapter 6). The inventory covers the GHGs $CO_2$, $CH_4$, $N_2O$, PFCs and HFCs and precursors and indirect emissions of: CO, $NO_x$, NMVOC and $SO_2$. The precursors and indirect emissions are separately presented and elaborated by sectors in Chapter 7. The emission of $SF_6$ is not estimated for Macedonia due to unavailability of activity data.

## 2.1 Methodologies

The Greenhouse gas inventory was prepared following the 2006 IPCC National GHG Inventory Guidelines, using the latest IPCC Inventory Software version available at the time of the preparing the Inventory (v. 2.17.6170.18196 from November 22, 2016). According to the 2006 Guidelines, the GHG emissions and removals estimates are divided into following main sectors:

- Energy
- Industrial Processes and Product Use (IPPU)
- Agriculture, Forestry and Other Land Use (AFOLU)
- Waste
- Other (e.g., indirect emissions from nitrogen deposition from non-agriculture sources)

Each sector comprises individual categories and subcategories, so the national inventory was developed at subcategory level.

In the IPCC Guidelines, methods are divided into three tiers: Tier 1 is for the “default method”, which is the simplest and is usually applied when no country-specific emission factors are available; Tier 2 method uses the same procedure as Tier 1 methods, but incorporate emission factors and/or parametric activity data that are specific to the country or at least one of its regions and Tier 3 is reserved for country-specific methods (models, censuses, and others). In the preparation of Macedonia’s National Inventory, the Tier 2 method was applied for $CO_2$ emission factors for lignite, residual fuel oil and natural gas for Fuel combustion activities in Energy sector. Tier 2 was also used in IPPU sector for emission factors in Mineral industry, for cement production and in Metal industry, for Iron and steel production and Ferroalloys production. The Waste sector is another sector with Tier 2 application, through IPCC FOD method and taking into account the country-specific activity data on waste disposal at solid waste disposal sites (SWDS) and the historical data on GDP and population. For the other sectors the default method, Tier 1, was used. The methods applied in the preparation of this national GHG inventory under SBUR, are summarized in A II.2, Table 82.

To facilitate aggregate reporting of GHG values, expressed as carbon dioxide equivalents ($CO_2$-eq), as indicated in Decision 17/CP.8 the global warming potentials (GWPs) values provided in the IPCC SAR (temporal horizon 100 years) were used (see Table 1).

***Table 1. Global warming potential values used in the preparation of the GHG Inventory (100 year time horizon)***

| Gas | $CO_2$ equivalent |
|---|---|
| **$CO_2$** | 1 |
| **$CH_4$** | 21 |
| **$N_2O$** | 310 |
| **HFC-125** | 2,800 |
| **HFC-143a** | 3,800 |
| **HFC-134a** | 1,300 |
| **HFC-32** | 650 |
| **HFC-227ea** | 2,900 |
| **$CF_4$** | 6,500 |
| **$C_2F_6$** | 9,200 |

*Source: IPCC Second Assessment Report (SAR), 1996*

## 2.2 Aggregate GHG emissions

The aggregate GHG emissions and removals (net emissions) in 2014 are estimated to 9,023 Gg $CO_2$-eq (including the FOLU sector) (Table 2 and Figure 6). Figure 6 shows the time–series of emissions and removals, including the net emissions (in $CO_2$-eq), from 1990 to 2014. There are significant fluctuations in the net emissions in 2000, 2007, 2008 and 2012, where increased emissions can be noticed in the FOLU sector (instead of removals) as a result of the intensified forest fires/wildfires.

***Table 2. GHG emissions and removals by sector (in Gg $CO_2$-eq)***

| Sector | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Energy | 8,887.7 | 9,026.7 | 9,450.6 | 8,419.4 | 7,957.5 |
| Industrial Processes and Product Use | 845.2 | 1,132.1 | 776.4 | 923.1 | 921.6 |
| Agriculture (without FOLU) | 1,071.6 | 1,072.3 | 1,019.4 | 989.2 | 1,001.8 |
| FOLU | -3,757.9 | 1,351.0 | 1,914.8 | -1,837.0 | -3,181.1 |
| Waste | 1,550.7 | 1,765.5 | 2,146.8 | 2,226.1 | 2,323.4 |
| **Total (incl. FOLU) – Net emissions** | **8,597.3** | **14,347.7** | **15,308.0** | **10,720.7** | **9,023.2** |
| **Total (excl. FOLU)** | **12,355.2** | **12,996.7** | **13,393.3** | **12,557.7** | **12,204.3** |

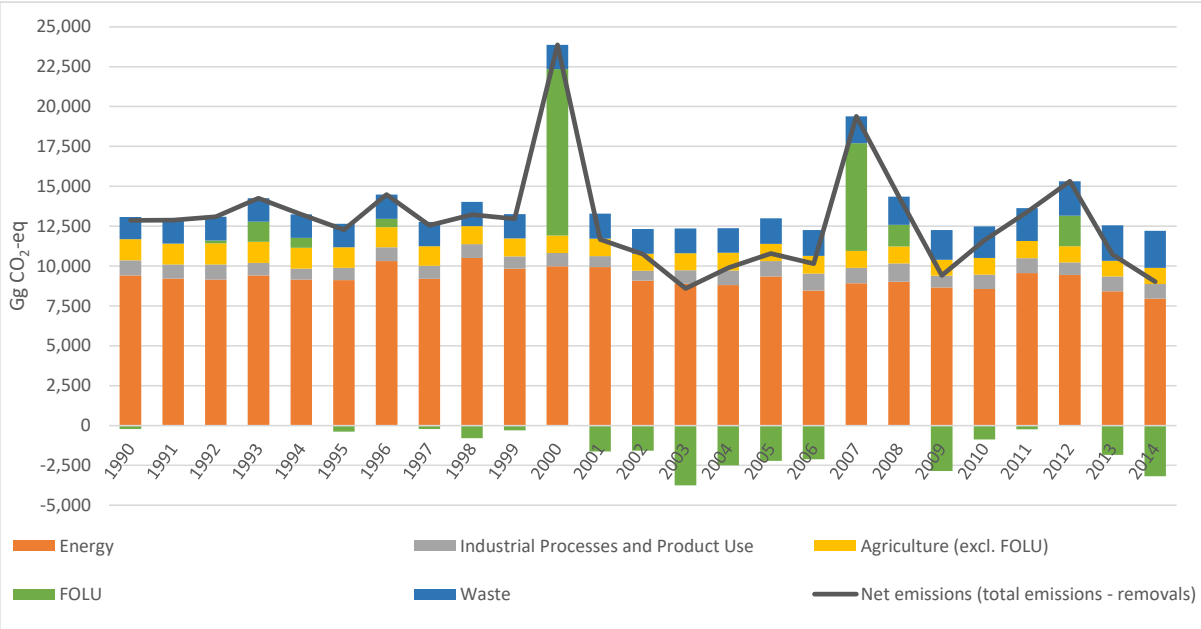


***Figure 6. GHG emissions and removals by sector (in Gg $CO_2$-eq)***

If the removals from FOLU sector are not accounted for, then the total GHG emissions in 2014 are 12,204 Gg $CO_2$-eq (Figure 7). The greatest share of emissions is from the Energy sector, accounting for 65.2% in 2014, followed by the Waste sector with 19% share, Agriculture (excluding FOLU) with 8.2% and IPPU sector with 7.6%. The dominant share of emissions for the Energy sector is evident throughout the whole time series.

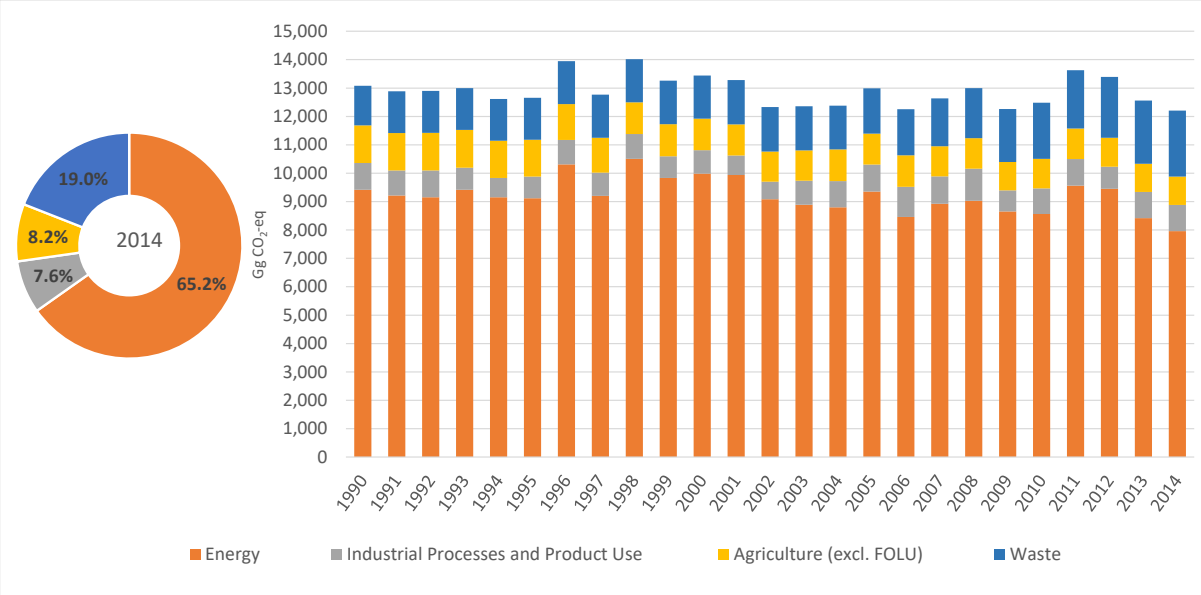



***Figure 7. Total GHG emissions by sector, excluding FOLU sector (in Gg $CO_2$-eq)***

## 2.3 GHG emissions by gas

Analyzing the GHG emissions by gas (excluding FOLU sector), it is evident that across the series the most dominant are the $CO_2$ emissions (Table 3 and Figure 8). Their share accounts for 69.3% in 2014, followed by the $CH_4$ emissions with 25.6%, then $N_2O$ emissions with 3.6% and all F-gasses with 1.5%.

***Table 3. GHG emissions by gas (in $CO_2$-eq)***

| Gas | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| $CO_2$ (incl. FOLU) | 5,554.5 | 10,832.4 | 11,766.2 | 7,097.0 | 5,272.7 |
| $CO_2$ (excl. FOLU) | 9,312.4 | 9,481.4 | 9,851.4 | 8,934.0 | 8,453.8 |
| $CH_4$ | 2,475.0 | 2,640.3 | 2,989.9 | 3,018.0 | 3,125.6 |
| $N_2O$ | 424.6 | 484.7 | 449.2 | 439.0 | 441.5 |
| HFCs | 89.8 | 390.1 | 96.7 | 165.2 | 183.5 |
| PFCs | 53.4 | 0.2 | 6.0 | 1.4 | 0.0 |
| $SF_6$ | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total (incl. FOLU) - Net emissions** | **8,597.3** | **14,347.7** | **15,308.0** | **10,720.7** | **9,023.2** |
| **Total (excl. FOLU)** | **12,355.2** | **12,996.7** | **13,393.3** | **12,557.7** | **12,204.3** |

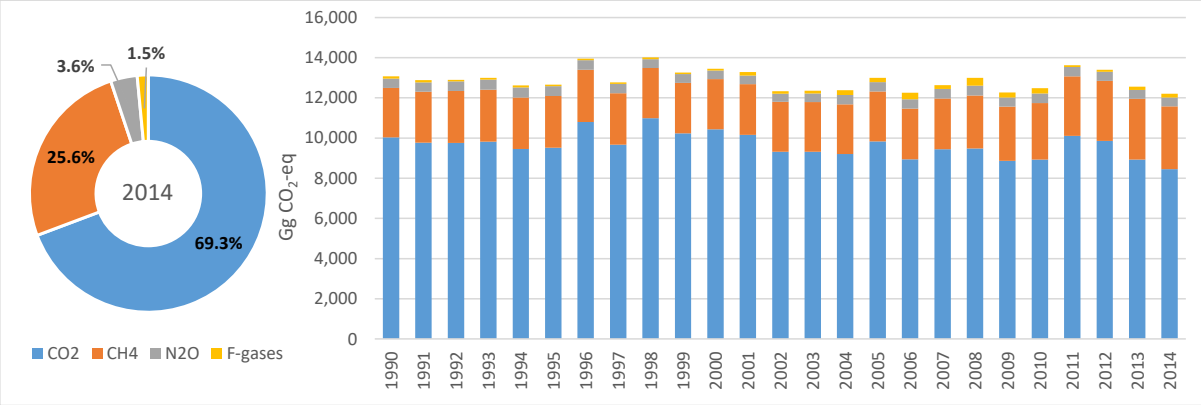



***Figure 8. Total GHG emissions by gas, excluding FOLU (in Gg $CO_2$-eq)***

In spite of the small share of the F-gases in the total emissions, only HFCs and PFCs are reported in the inventory (Table 3). The $SF_6$ is not estimated for Macedonia due to unavailability of activity data. As can be seen in Figure 9, the emissions of HFCs start in the year 2000 with some fluctuations over the time-series, depending on the activities in the IPPU sector, while the emissions of the PFCs are considerably decreasing after 2003.

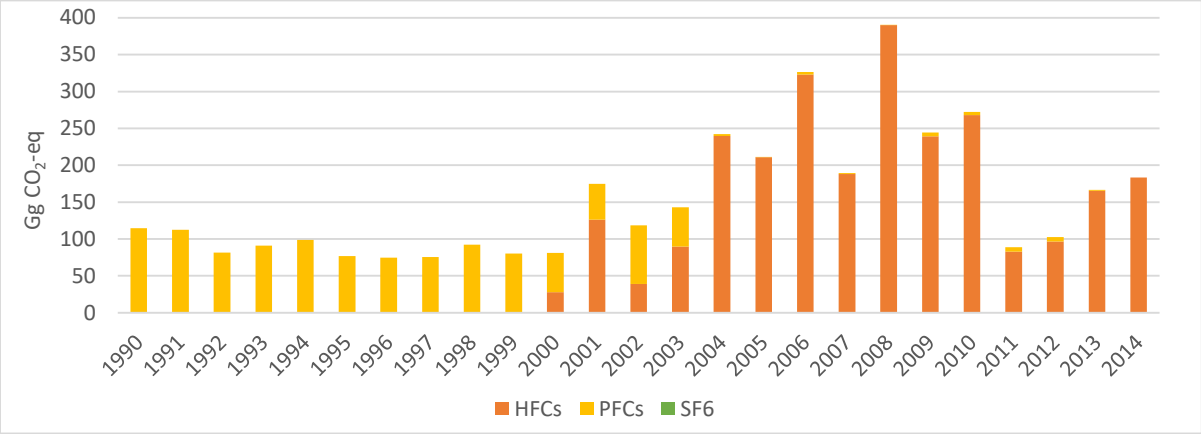



***Figure 9. Emissions of F-gasses (in Gg $CO_2$-eq)***

# 3 Energy

## 3.1 Overview

The energy sector in Macedonia is mainly based on fossil fuels (Figure 10). Their share in the gross inland consumption was 86% in 2003, but was reduced to 81% and 79% in 2013 and 2014, respectively. At the same time, the energy produced from renewable energy sources remains constant at 11% of the total energy production. The rest of the gross inland consumption is covered by the electricity import, which increased from 3% in 2003 to 10% in 2014. On the other hand, the gross inland consumption in 2014 (2,628 ktoe) is lower for 3% compared to the consumption in 2003 and 2013 (2,710 ktoe). In the reported years the highest consumption is recorded in 2008, 3,012 ktoe, and after this year the energy consumption is reducing, so in 2014 is almost 13% lower, compared to 2008.

Historically, the most dominant fuel in Macedonia is coal, which has accounted for about 50% of the gross inland consumption, followed by crude oil and oil products with 33%. In 2014, coal (predominantly lignite) consumption was about 41% (1,074 ktoe), while the consumption of the oil products was 34% (900 ktoe) of the gross inland consumption (Figure 10).

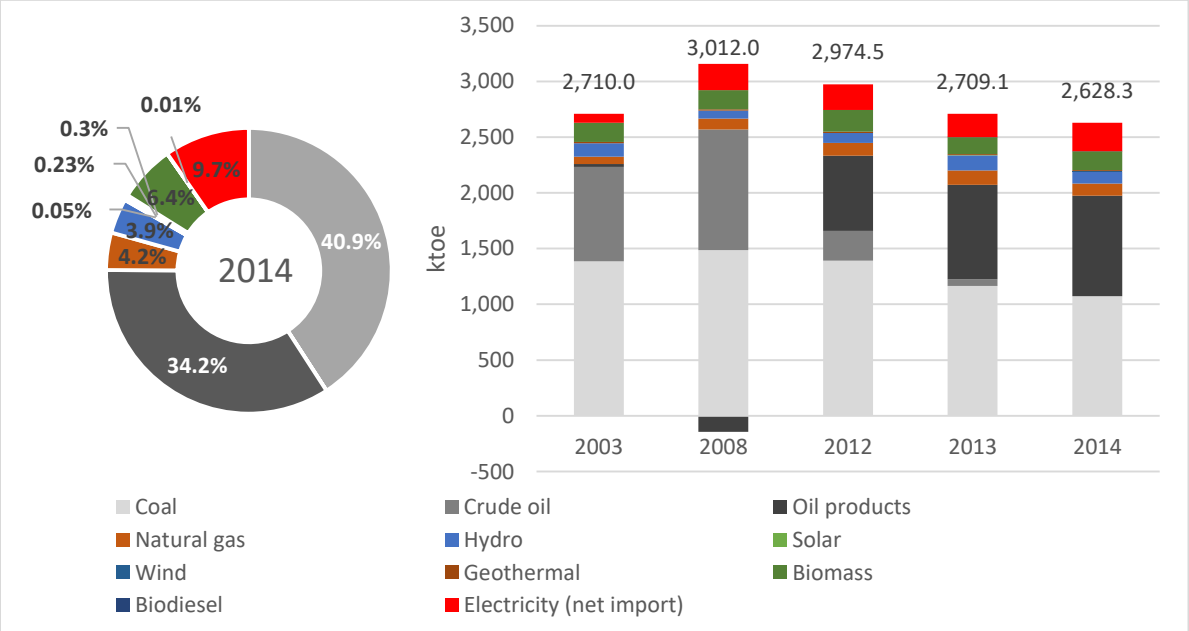



***Figure 10. Gross inland consumption (in ktoe)***

The final energy consumption does not follow the same trend line as the gross inland consumption (Figure 11). The highest consumption of 1,888 ktoe, in the reported period, is recorded in 2012. Moreover, the numbers show that the consumption in 2014 is only 1% lower compared to 2013, but it is higher for 8% competed to the consumption in 2003. In 2014, petroleum products account for the largest share of final energy consumption (48%), while electricity is next (32%), followed by biomass with 10%, coal with 6% and heat and natural gas with 2% each.

In order to calculate the efficiency of the energy system the ratio of final energy consumption per gross inland consumption should be calculated. It is obvious that the efficiency of the

energy system has increased, for example in the period 2013-2014 the final energy consumption has decreased for 1% while the gross inland consumption for 3%. In other words, from 61% in 2003, it increased to nearly 67% and 68%, in 2013 and 2014, respectively. In the developed European countries - in particular, the European member states of the Organization for Economic Cooperation and Development (OECD) this ratio is 70% (in 2012).

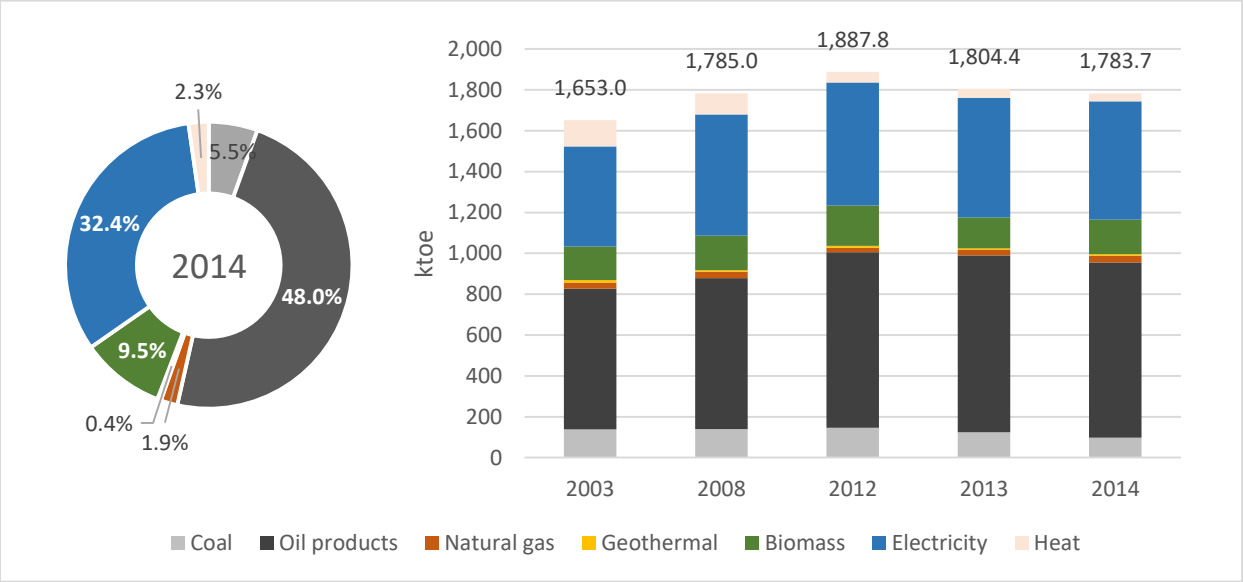



***Figure 11. Final energy consumption (in ktoe)***

Electricity together with biomass are very important commodities for Macedonia, as domestic resources. In 2014, the electricity available for final energy consumption accounted for 6,730 GWh (578.5 ktoe). Although, in the reported years, the consumption of electricity has increased for 18%, it is evident that in the last two years there is a negative trend and it has decreased for 4%.

The installed capacity for electricity production is mainly composed of thermal power plants, 69% in 2003 and 47% in 2014 (Figure 12). They are followed by hydropower plants with 31% in 2003 and 36% in 2014. Technologies such as PV, wind and combined heat and power plants have also been deployed during the reported years and their shares in 2014 were 1%, 2% and 14% of the total installed capacity, respectively.

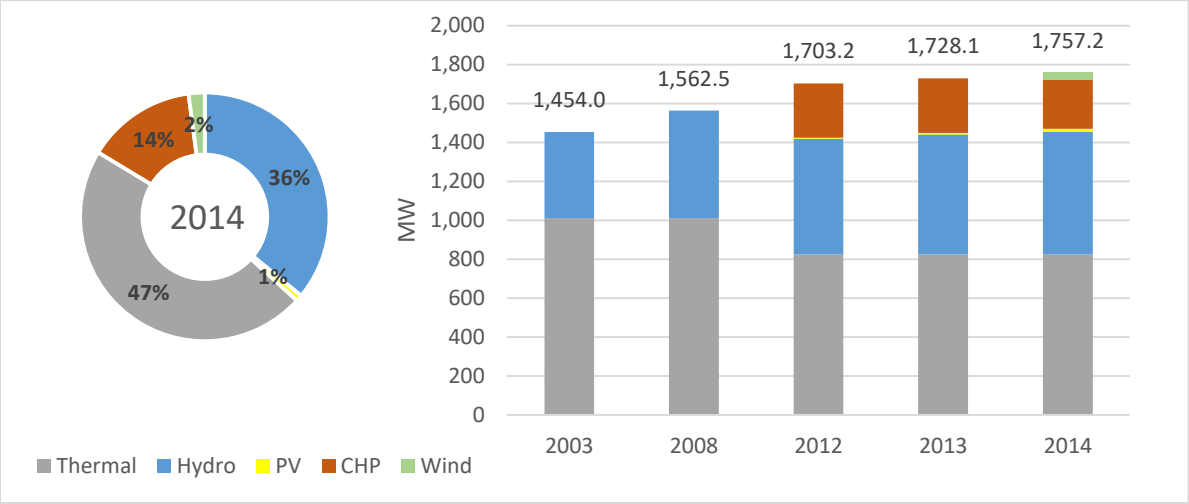



***Figure 12. Total installed capacity for electricity production (in MW)***

Considering these installed capacities, the electricity is mainly produced in the thermal power plants, i.e. 68% in 2003 and 44% in 2014 (Figure 13), followed by the production from hydropower plants, which is 19% in 2003 and 15% in 2014. Although, 14% of the installed capacity in Macedonia is from CHPs, their production in 2014 accounts for only 2%. Electricity net import has significant share and was about 37% in 2014.

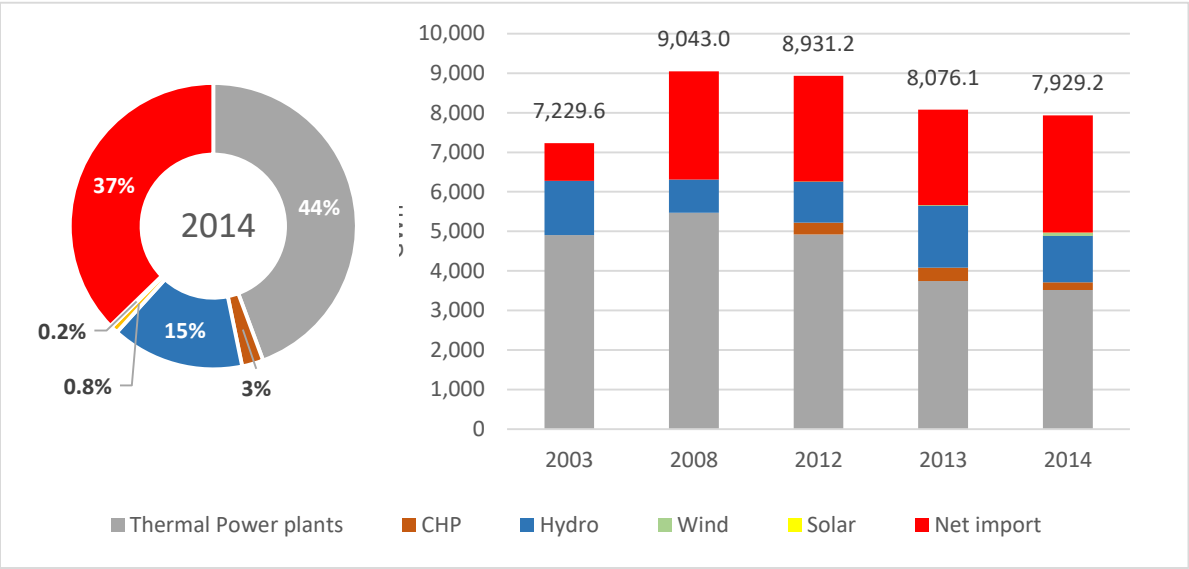



***Figure 13. Electricity production and net import (in GWh)***

## 3.2 Emission trends – Reference approach

In this chapter, the emissions have been calculated using the Reference approach, which is a top-down and straightforward approach. It has been applied using the apparent fuel consumption figures to account for the fuel flows into and out of the country. The estimated $CO_2$ emissions and the apparent fuel consumption for the reporting years, are presented in Table 4. Analysing the results in the table, it is evident that in the recent years the total apparent consumption is declining, and it is 10.4% less in 2013 and 15.1% less in 2014, compared to 2012. Considering the fuel type, it can be seen that relative to 2012, the gaseous fuel consumption has increased by 13.1% in 2013 and decreased by 3.2% in 2014, while the consumption of solid fuels has decreased for 16.5% in 2013 and for 22.9% in 2014. The liquid fuel consumption is also reduced for 3.7% in 2013 and 4.3% in 2014 in comparison to 2012. The changes in fuel consumption have resulted in reduction of the total $CO_2$ emissions, for 11.6% in 2013 and 16.6% in 2014, relative to 2012.

***Table 4. Apparent fuel consumption (in TJ) and $CO_2$ emissions (in Gg) – Reference approach***

| | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Apparent consump. (TJ) | $CO_2$ Emissions (Gg) | Apparent consump. (TJ) | $CO_2$ Emissions (Gg) | Apparent consump. (TJ) | $CO_2$ Emissions (Gg) | Apparent consump. (TJ) | $CO_2$ Emissions (Gg) | Apparent consump. (TJ) | $CO_2$ Emissions (Gg) |
| Liquid Fuels | 32,223.4 | 2,334.7 | 39,599.2 | 2,872.8 | 36,632.6 | 2,737.6 | 35,268.0 | 2,648.0 | 35,074.4 | 2,634.5 |
| Solid Fuels | 62,565.9 | 6,183.0 | 63,659.8 | 5,942.7 | 58,347.3 | 6,229.3 | 48,744.4 | 5,213.4 | 44,959.2 | 4,811.0 |
| Gaseous Fuels | 2,782.0 | 153.2 | 4,049.7 | 223.0 | 4,791.5 | 263.9 | 5,419.9 | 298.5 | 4,638.3 | 255.4 |
| Other Fossil Fuels | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Peat | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Total** | **97,571.3** | **8,670.8** | **107,308.6** | **9,038.5** | **99,771.3** | **9,230.8** | **89,432.3** | **8,159.8** | **84,672.0** | **7,700.9** |

## 3.3 Emission trends – Sectoral approach

The Sectoral approach of the inventory for the Energy sector accounts for the GHG emissions released as a result of Fuel combustion activities, as well as the fugitive emissions from extraction of solid fuels and transmission and distribution of liquid and gaseous fuels. The emissions from Fuel combustion activities are derived from several categories:

- Energy Industries
- Manufacturing Industries and Construction,
- Transport,
- Other Sectors (Commercial/Institutional, Residential and Agriculture/Forestry/Fishing),
- Non-Specified

The entire Energy sector emissions by category can be observed in Figure 14. A decreasing emission trend can be seen, i.e. the emissions in 2014 have 5.5% lower values compared with the ones in 2013 and 15.8% compared with 2012. This is due to reduced electricity production from the Energy Industries, replaced mainly with electricity import.

As can be seen, most of the GHG emissions come from the category Energy Industries (59.7% in 2014), then from the Transport (20.5%) and Manufacturing Industries and Construction (14.2%). The other two categories together account for 3.8% of the total emissions in 2014 and the remaining 1.8% are Fugitive emissions. It is noticeable that in the last two reporting

years the share of Energy Industries has reduced, in comparison with the years 2003, 2008 and 2012, when the share of this category was 69.6%, 67.5% and 64.2%, respectively.

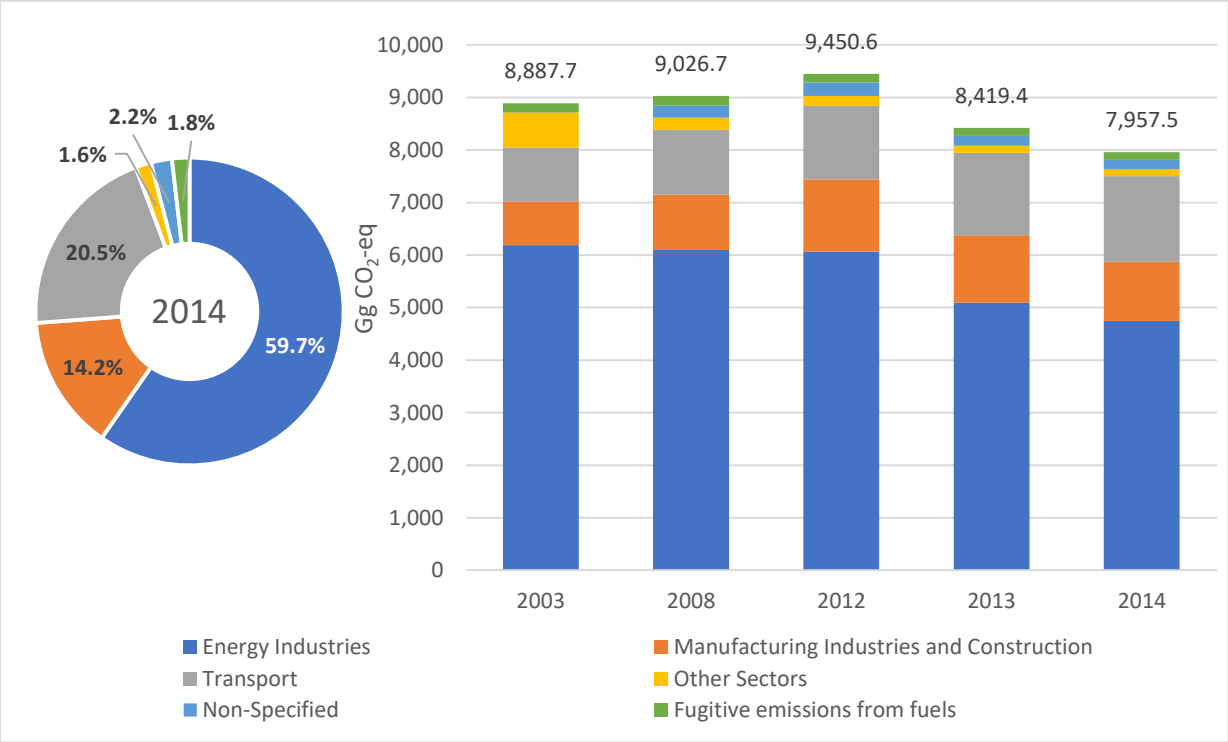



***Figure 14. GHG emissions in Energy sector, by category (in Gg $CO_2$-eq)***

In Table 5, concrete values of the GHG emissions in Energy sector, by category (in Gg $CO_2$-eq) are presented.

***Table 5. GHG emissions in Energy sector, by category (in Gg $CO_2$-eq)***

| Categories / Категории | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Energy/Енергетика** | **8,887.7** | **9,026.7** | **9,450.6** | **8,419.4** | **7,957.5** |
| **Fuel Combustion Activities / Активности при кои се согорува гориво** | **8,712.8** | **8,845.8** | **9,285.9** | **8,268.8** | **7,811.6** |
| Energy Industries / Енергетски индустрии | 6,187.2 | 6,095.1 | 6,065.8 | 5,096.5 | 4,746.9 |
| Manufacturing Industries and Construction / Производствени индустрии и градежништво | 836.8 | 1,053.2 | 1,373.9 | 1,277.9 | 1,126.1 |
| Transport / Транспорт | 1,019.5 | 1,236.0 | 1,402.4 | 1,575.0 | 1,631.9 |
| Other Sectors / Други сектори | 669.4 | 234.1 | 187.9 | 128.3 | 131.2 |
| Non-Specified / Неспецифицирани | 0.0 | 227.4 | 255.9 | 191.1 | 175.6 |
| **Fugitive emissions from fuels / Фугитивни емисии** | **174.9** | **180.9** | **164.7** | **150.6** | **145.9** |
| Solid Fuels / Цврсти горива | 174.5 | 180.4 | 164.6 | 150.5 | 145.9 |
| Oil and Natural Gas / Нафта и природен гас | 0.4 | 0.5 | 0.1 | 0.0 | 0.0 |

Furthermore, the overall GHG emissions in Energy sector by gas (in Gg of $CO_2$-eq) for the reporting years, as well as their share in 2014 are given together in Figure 15. Perceiving the left part of the chart, one can easily notice that almost all of the Energy sector GHG emissions in 2014 are actually $CO_2$ emissions (96.8%), and $CH_4$ and $N_2O$ emissions amount to only 2.5% and 0.7%, respectively.

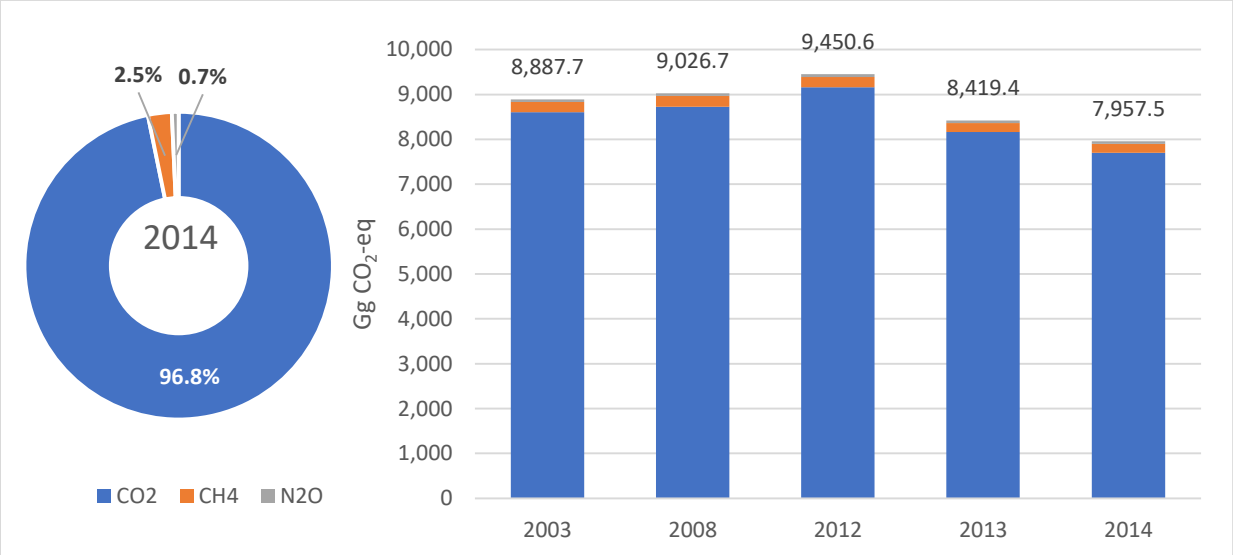



***Figure 15. GHG emissions in Energy sector, by gas (in Gg of $CO_2$-eq)***

### 3.3.1 Energy industries

The largest Energy Industries in Macedonia are the thermal power plants. Lignite (as a dominant domestic power source), residual fuel oil and natural gas are the main energy sources in the country. Gas/Diesel Oil (road diesel, heating and other gasoil) and wood/wood waste (biomass) are used as fuels as well (in the category Other Energy Industries).

This category is the highest contributor to the overall emissions from the Energy sector accounting for 59.7% of the Energy sector emissions in 2014.

Subcategories covered by this category are:

- Electricity Generation
- Combined Heat and Power Generation (CHP)
- Heat Plants
- Other Energy Industries

The Electricity Generation happen to be the biggest contributor within the category with 95.5% of the emissions in 2014 as well as within the Energy sector as a whole with 57.1% in 2014. Figure 16 indicates a declining trend, i.e. the emissions from the subcategory in 2014 have lower share of 5.3% compared to 2013 and 20.4% compared to 2012.

On the other hand, the other subcategories have a share of 4.2% of the emissions in 2014. They also experience a declining trend throughout the reporting years.

In 2014, the total emissions of the category are 6.9% lower compared to 2013, and 21.7% compared to 2012.

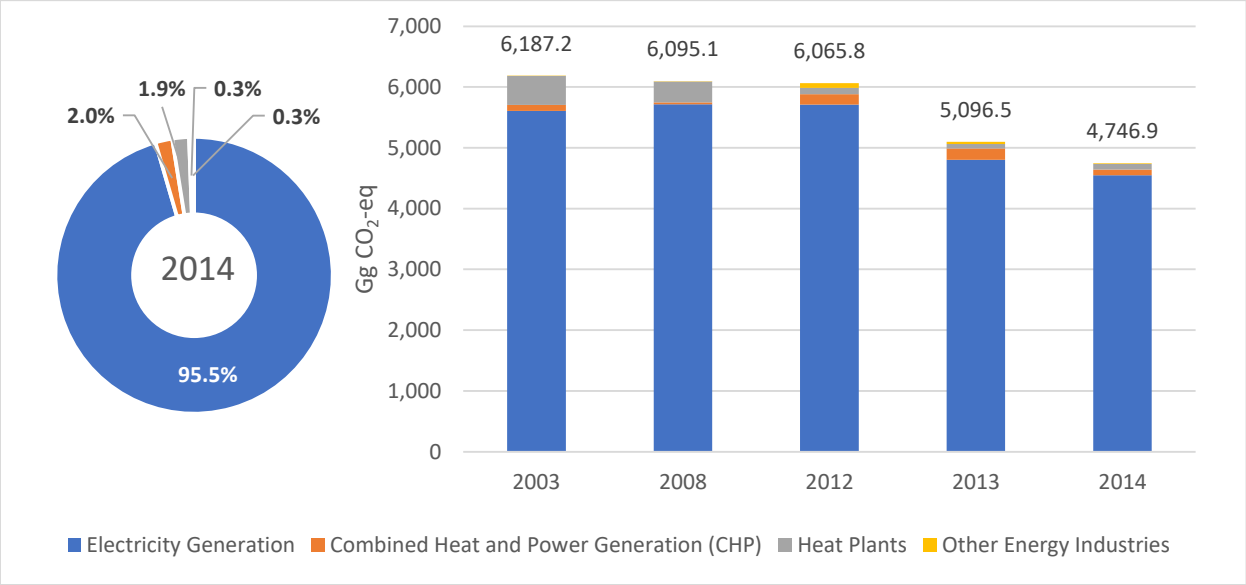



***Figure 16. GHG emissions in Energy Industries (in Gg $CO_2$-eq)***

In Table 6, the GHG emissions in Energy Industries by gas can be found. The emissions of $CH_4$ and $N_2O$ in this category are very low (less than 0.5% of the total emissions in Energy Industries).

***Table 6. GHG emissions in Energy Industries, by category and by gas (in Gg $CO_2$-eq)***

| Categories | 2003 | | | 2008 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| **Energy Industries / Енергетски индустрии** | **6,157.5** | **1.7** | **27.9** | **6,064.6** | **1.6** | **28.8** | **6,039.6** | **1.3** | **24.9** | **5,074.6** | **1.1** | **20.7** | **4,726.4** | **1.0** | **19.4** |
| **Main Activity Electricity and Heat Production / Главна активност производство на електрична и топлинска енергија** | **6,151.2** | **1.7** | **27.9** | **6,060.4** | **1.6** | **28.8** | **5,962.4** | **1.3** | **24.7** | **5,040.1** | **1.1** | **20.6** | **4,712.6** | **1.0** | **19.4** |
| Electricity Generation / Производство на електрична енергија | 5,577.8 | 1.2 | 26.2 | 5,685.8 | 1.4 | 28.0 | 5,683.5 | 1.2 | 24.4 | 4,780.1 | 1.0 | 20.4 | 4,526.5 | 1.0 | 19.3 |
| Combined Heat and Power Generation (CHP) / Комбинирано производство на топлинска и електрична енергија | 99.3 | 0.0 | 0.3 | 30.0 | 0.0 | 0.1 | 170.7 | 0.1 | 0.2 | 188.0 | 0.1 | 0.2 | 93.5 | 0.0 | 0.1 |
| Heat Plants / Топлани | 474.0 | 0.5 | 1.3 | 344.7 | 0.3 | 0.7 | 108.2 | 0.1 | 0.2 | 72.1 | 0.0 | 0.1 | 92.6 | 0.0 | 0.1 |
| **Manufacture of Solid Fuels and Other Energy Industries / Производство на цврсти горива и други енергетски индустрии** | **6.4** | **0.0** | **0.0** | **4.2** | **0.0** | **0.0** | **77.2** | **0.1** | **0.2** | **34.5** | **0.0** | **0.1** | **13.8** | **0.0** | **0.0** |
| Other Energy Industries / Други енергетски индустрии | 6.4 | 0.0 | 0.0 | 4.2 | 0.0 | 0.0 | 77.2 | 0.1 | 0.2 | 34.5 | 0.0 | 0.1 | 13.8 | 0.0 | 0.0 |

### 3.3.2 Manufacturing industries and construction

Manufacturing Industries and Construction as an Energy category had a portion of 14.2% in the overall Energy sector emissions in 2014. The fuels used in this category consist of: coking coal, other bituminous coal, lignite, liquefied petroleum gases, residual fuel oil, natural gas, wood/wood waste (biomass and wood wastes, wood briquettes and pellets), sub-bituminous coal, petroleum coke, and gas/diesel oil (road diesel, and heating and other gasoil).

The category itself includes the following subcategories:

- Iron and Steel
- Non-Ferrous Metals
- Chemicals
- Pulp, Paper and Print
- Food Processing, Beverages and Tobacco
- Non-Metallic Minerals
- Machinery
- Mining (excluding fuels) and Quarrying
- Textile and Leather
- Non-specified Industry

The total emissions by subcategories are illustrated in Figure 17. The top three most intensive subcategories are: Iron and Steel (58.6% of the emissions in 2014), Non-Metallic Minerals (24.7% of the emissions in 2014) and Food Processing, Beverages and Tobacco (5.5% of the emissions in 2014). Worth to note is that 100% of the emissions in 2003 come from the Non-Specified Industry because in the inventory database the data from the SSO are entered under one subcategory (Non-Specified Industry), even though in the Energy Balances they are disaggregated by different subcategories. This issue will be considered and corrected in the further revisions of the GHG inventory series.

If the declining trend of the total category emissions is quantified, one can calculate 11.9% when comparing 2014 with 2013, and 18% when comparing 2014 with 2012. The GHG emissions by gas in this category are presented in Table 7.

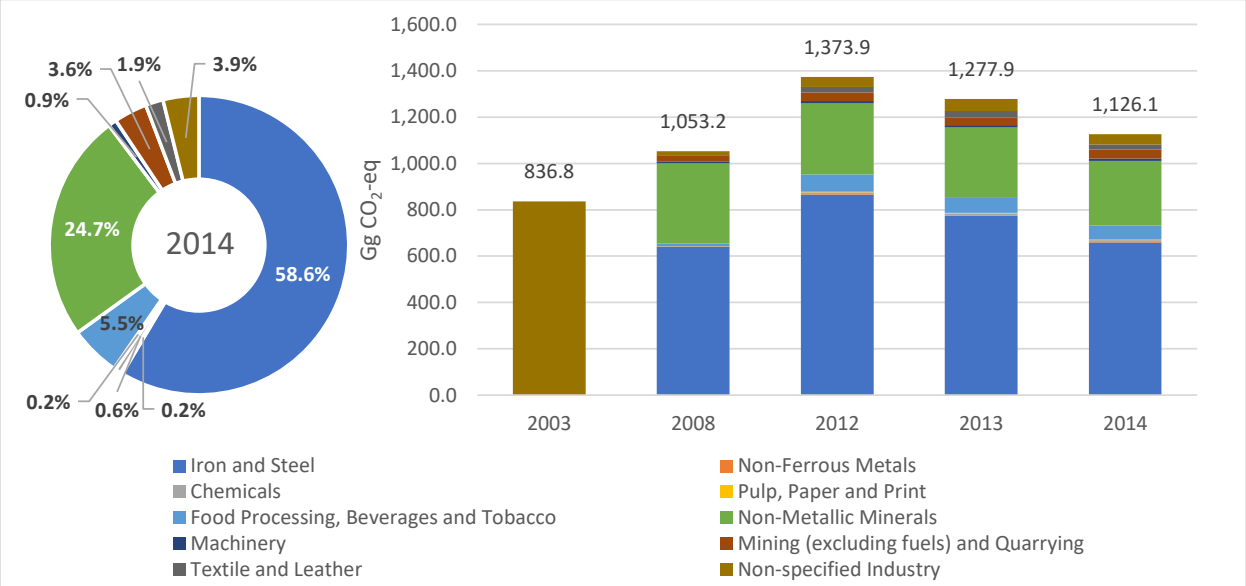



***Figure 17. GHG emissions in Manufacturing Industries and Construction (in Gg $CO_2$-eq)***

***Table 7. GHG emissions in Manufacturing Industries and Construction, by category and by gas (in Gg $CO_2$-eq)***

| Categories / Категории | 2003 | | | 2008 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| **Manufacturing Industries and Construction / Производствени индустрии и градежништво** | **832.3** | **1.3** | **3.1** | **1,048.6** | **1.3** | **3.3** | **1,367.1** | **2.0** | **4.8** | **1271.8** | **1.8** | **4.3** | **1,120.6** | **1.6** | **3.9** |
| Iron and Steel / Железо и челик | 0.0 | 0.0 | 0.0 | 636.3 | 0.9 | 2.2 | 860.2 | 1.5 | 3.5 | 769.8 | 1.2 | 2.9 | 656.0 | 1.0 | 2.4 |
| Non-Ferrous Metals / Обоена металургија | 0.0 | 0.0 | 0.0 | 2.1 | 0.0 | 0.0 | 2.7 | 0.0 | 0.0 | 2.7 | 0.0 | 0.0 | 2.4 | 0.0 | 0.0 |
| Chemicals / Хемиска индустрија | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 8.0 | 0.0 | 0.0 | 7.7 | 0.0 | 0.0 | 7.1 | 0.0 | 0.0 |
| Pulp, Paper and Print / Целулоза, хартија и печатење | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.7 | 0.0 | 0.0 | 2.1 | 0.0 | 0.0 | 2.3 | 0.0 | 0.0 |
| Food Processing, Beverages and Tobacco / Прехранбена индустрија, пијалаци и тутун | 0.0 | 0.0 | 0.0 | 13.2 | 0.0 | 0.0 | 73.8 | 0.1 | 0.2 | 64.4 | 0.2 | 0.4 | 60.8 | 0.2 | 0.4 |
| Non-Metallic Minerals / Неметални минерали | 0.0 | 0.0 | 0.0 | 344.0 | 0.3 | 0.9 | 305.7 | 0.2 | 0.6 | 303.7 | 0.2 | 0.6 | 277.2 | 0.2 | 0.5 |
| Machinery / Машини | 0.0 | 0.0 | 0.0 | 6.4 | 0.0 | 0.0 | 10.2 | 0.0 | 0.0 | 9.3 | 0.0 | 0.0 | 10.1 | 0.0 | 0.0 |
| Mining (excluding fuels) and Quarrying / Вадење на руди (без горива) и камен | 0.0 | 0.0 | 0.0 | 27.6 | 0.0 | 0.1 | 36.8 | 0.0 | 0.1 | 33.9 | 0.0 | 0.1 | 40.2 | 0.0 | 0.1 |
| Textile and Leather / Текстилна индустрија и кожарство | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 23.9 | 0.1 | 0.2 | 27.4 | 0.1 | 0.2 | 21.3 | 0.1 | 0.2 |
| Non-Specified Industry / Неспецифицирана индустрија | 832.3 | 1.3 | 3.1 | 18.1 | 0.0 | 0.1 | 43.2 | 0.1 | 0.2 | 50.8 | 0.1 | 0.2 | 43.2 | 0.1 | 0.2 |

### 3.3.3 Transport

The Transport category participated with 20.5% in the overall Energy sector emissions in 2014. Regarding the fuels, gas/diesel oil (road diesel), motor gasoline, liquefied petroleum gases (LPG), aviation gasoline and natural gas are used.

There are three subcategories actively contributing to the emissions: Road Transportation, Railways and Domestic Aviation (Figure 18). Road Transportation releases almost all of the emissions (99.43% in 2014). The Railways emissions are 0.56% in 2014, and the Domestic Aviation emissions are close to zero (0.01%).

Unlike the other categories and Energy sector as a whole, the emissions from the Transport show an increasing trend as shown in Figure 18. In 2014 there were 3.6% more emissions than in 2013, and 16.4% more than 2012.

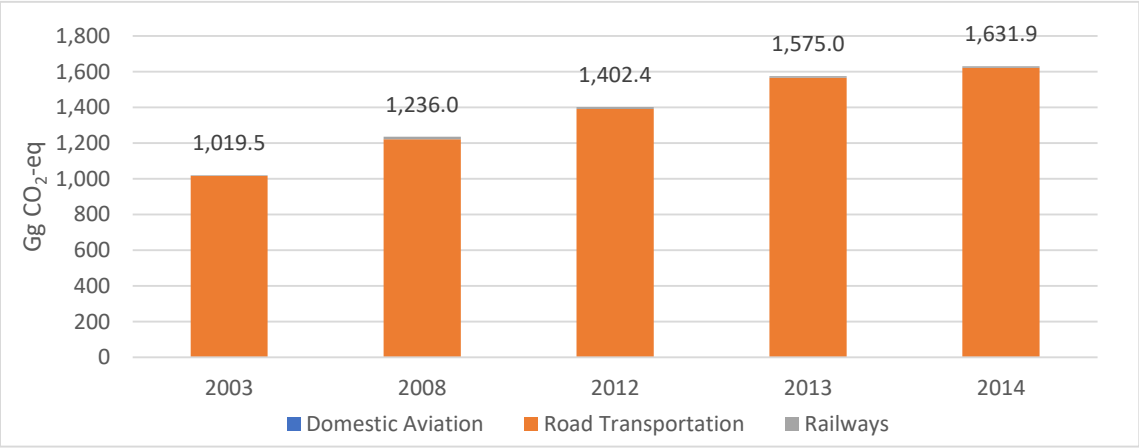



***Figure 18. GHG emissions in Transport (in Gg $CO_2$-eq)***

Table 8 gives an insight in Transport GHG emissions by categories and by gasses, in Gg $CO_2$-eq.

***Table 8. GHG emissions in Transport, by category and by gas (in Gg $CO_2$-eq)***

| Categories / Категории | 2003 | | | 2008 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| **Transport / Транспорт** | **998.9** | **5.6** | **15.0** | **1210.6** | **7.2** | **18.1** | **1,374.8** | **6.4** | **21.3** | **1,544.5** | **6.8** | **23.7** | **1,600.6** | **6.8** | **24.5** |
| **Civil Aviation / Воздушен сообраќај** | **0.8** | **0.0** | **0.0** | **0.9** | **0.0** | **0.0** | **0.1** | **0.0** | **0.0** | **0.4** | **0.0** | **0.0** | **0.2** | **0.0** | **0.0** |
| Domestic Aviation / Домашна авијација | 0.8 | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| **Road Transportation / Патен сообраќај** | **994.9** | **5.6** | **14.6** | **1197.9** | **7.2** | **16.7** | **1364.8** | **6.4** | **20.1** | **1536.1** | **6.8** | **22.7** | **1592.2** | **6.8** | **23.6** |
| **Railways / Железнички сообраќај** | **3.2** | **0.0** | **0.4** | **11.8** | **0.0** | **1.4** | **9.8** | **0.0** | **1.2** | **8.0** | **0.0** | **1.0** | **8.2** | **0.0** | **1.0** |

### 3.3.4 Other sectors

This category emitted 1.6% of the overall Energy sector emissions in 2014 and covers the GHG emissions from energy consumption in two subcategories, Residential and Agriculture/Forestry/Fishing/Fish Farms. Their GHG emissions are presented in Figure 19. For the second subcategory, only stationary emissions are estimated. Up until 2005 the emissions from Commercial/Institutional subcategory are elaborated under this category and from 2006 the emissions of this subcategory are included within the Non-Specified subcategory (to be consistent with the subcategories reported in the Energy Balances from SSO).

In this category fuels such as: lignite, liquefied petroleum gases, motor gasoline, residual fuel oil, wood/wood waste (biomass and wood wastes, wood briquettes and pellets), gas/diesel oil (road diesel, heating and other gasoil) and natural gas are utilized.

In 2014, 69.2% of the emissions came from the Residential subcategory and the rest (30.8%) from the Agriculture/Forestry/Fishing/Fish Farms. The GHG emissions in 2014 were 2.2% higher than in 2013, but 30.2% lower than 2012. The total GHG emissions from Other Sectors in Gg $CO_2$-eq, are listed in Table 9.

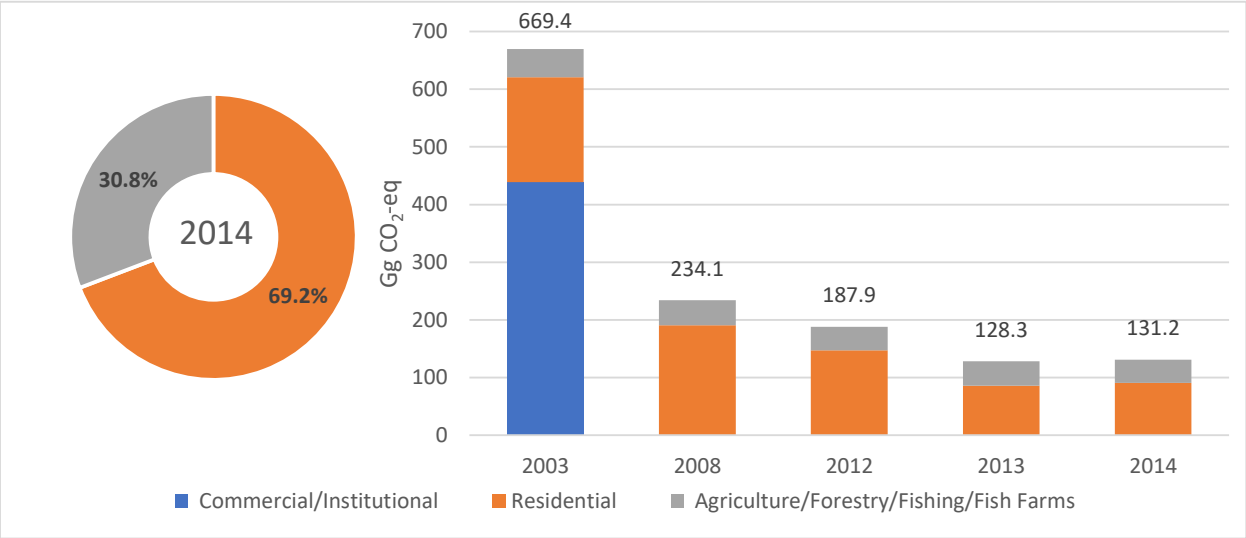



***Figure 19. GHG emissions in Other Sectors (in Gg $CO_2$-eq)***

***Table 9. GHG emissions in Other Sectors, by category and by gas (in Gg $CO_2$-eq)***

| Categories / Категории | 2003 | | | 2008 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| **Other Sectors / Други сектори** | **613.4** | **46.0** | **10.0** | **182.7** | **42.8** | **8.6** | **130.1** | **48.1** | **9.6** | **83.5** | **37.4** | **7.4** | **82.2** | **40.8** | **8.1** |
| Commercial/Institutional / Комерцијален/Институционален сектор* | 434.1 | 3.1 | 1.5 | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| Residential / Домаќинства | 131.1 | 42.4 | 8.4 | 140.3 | 42.1 | 8.4 | 90.3 | 47.7 | 9.5 | 42.2 | 36.5 | 7.2 | 42.9 | 40.0 | 7.9 |
| Agriculture/Forestry/Fishing/ Fish Farms / Земјоделство/Шумарство/ Рибарство/Рибници | 48.1 | 0.4 | 0.2 | 42.4 | 0.6 | 0.2 | 39.8 | 0.4 | 0.2 | 41.3 | 0.9 | 0.2 | 39.4 | 0.8 | 0.2 |
| Stationary / Стационарни | 48.1 | 0.4 | 0.2 | 42.4 | 0.6 | 0.2 | 39.8 | 0.4 | 0.2 | 41.3 | 0.9 | 0.2 | 39.4 | 0.8 | 0.2 |

*IE – Included Elsewhere*
**From 2006 the emissions are reported in Non-specified sector*

### 3.3.5 Non-specified

The last category from the Fuel Combustion Activities is Non-Specified, having a share of 2.2% of the Energy sector GHG emissions in 2014. The following fuels are being combusted: Lignite, Liquefied Petroleum Gases, Residual Fuel Oil, Natural Gas, Wood/Wood Waste (Biomass), Gas/Diesel Oil (Road Diesel and Heating and Other Gasoil). The GHG emissions are depicted in Figure 20.

The category contributes to the overall Energy sector with declining trend. In 2014 there is a decrease of 8.1% compared to 2013 and 31.4% compared to 2012.

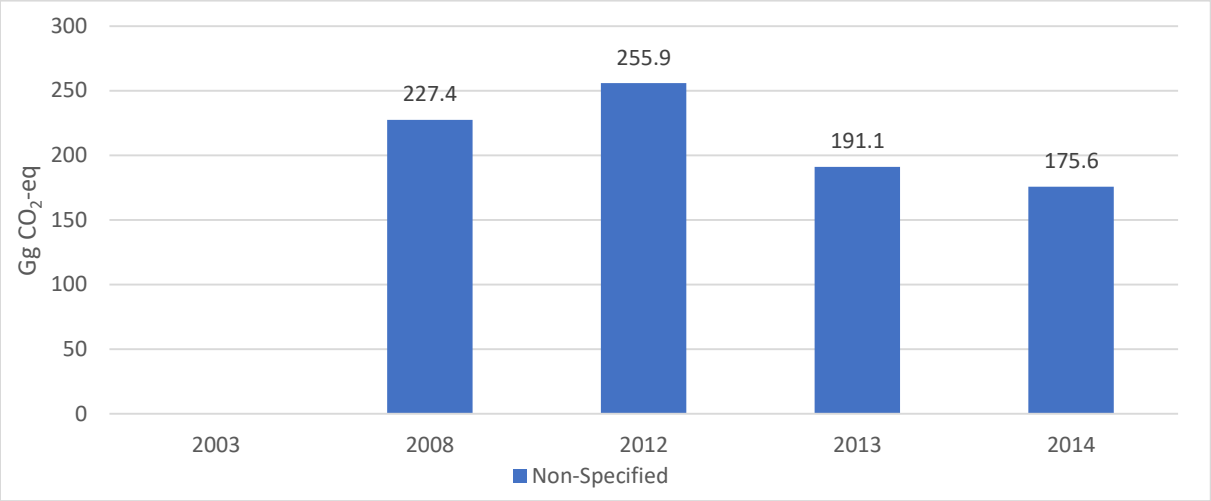



***Figure 20. GHG emissions in Non-Specified category (in Gg $CO_2$-eq)***

The GHG emissions from the Non-Specified category are presented in Table 10.

In contrast to the previous category, the emissions in 2003 are missing, because they are comprised within the Other Sectors (Commercial/Institutional category).

***Table 10. GHG emissions in Non-specified category, by gas (in Gg $CO_2$-eq)***

| Categories / Категории | 2003 | | | 2008 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| **Non-Specified / Неспецифицирани*** | **IE** | **IE** | **IE** | **222.7** | **3.7** | **1.1** | **251.3** | **3.5** | **1.1** | **188.3** | **2.1** | **0.7** | **172.6** | **2.3** | **0.7** |
| Stationary / Стационарни | IE | IE | IE | 222.7 | 3.7 | 1.1 | 251.3 | 3.5 | 1.1 | 188.3 | 2.1 | 0.7 | 172.6 | 2.3 | 0.7 |

*IE – Included Elsewhere*
**Up until 2005 the emissions are reported in Other sectors – Commercial/Institutional*

### 3.3.6 Fugitive emissions from fuels

In Macedonia, fugitive emissions originate from coal mining and handling within surface mines (mining and post-mining seam gas emissions), oil refining and natural gas venting. Direct GHG emissions arising from fugitive emissions from fuels are actually $CH_4$ emissions. The fugitive emissions contributed with 1.8% in the overall Energy sector emissions in 2014. Almost all of them came from solid fuels (coal mining) or 145.9 Gg $CO_2$-eq in 2014, i.e. the fugitive

emissions from oil and natural gas are below 0.1 Gg $CO_2$-eq. How the fugitive emissions from fuels have changed over the years shows the Figure 21.

As presented, the fugitive emissions from fuels experience a declining trend. In 2014 they were 3.1% lower than in 2013, and 11.4% lower than in 2012. The fugitive emissions from fuels by gasses in Gg $CO_2$-eq are given in Table 11.

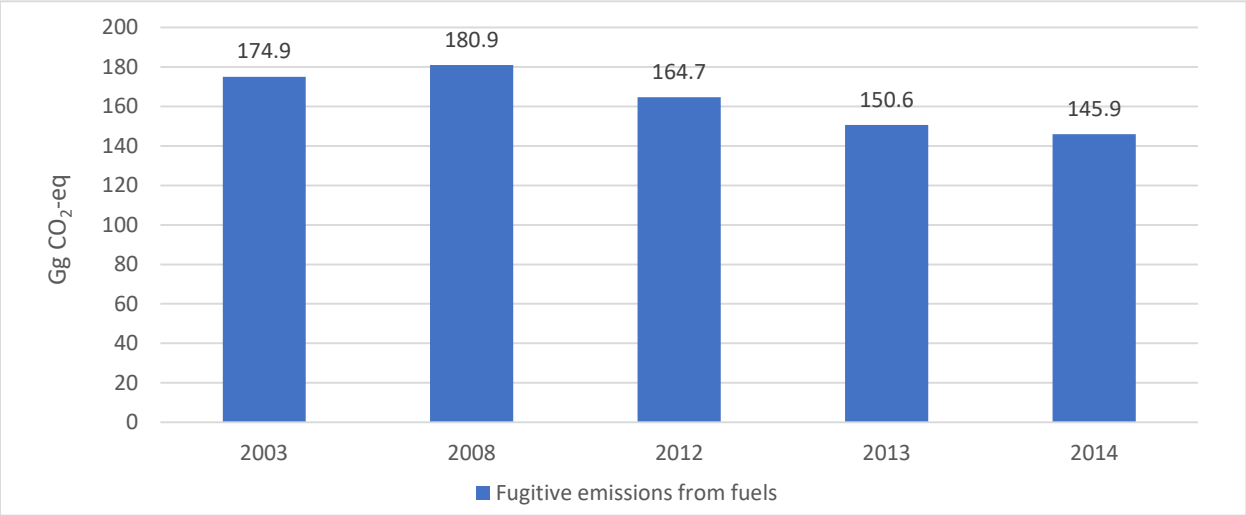



***Figure 21. Fugitive emissions from fuels (in Gg $CO_2$-eq)***

***Table 11. Fugitive emissions from fuels (in Gg $CO_2$-eq)***

| Categories / Категории | 2003 | | | 2008 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| **Fugitive emissions from fuels / Фугитивни емисии од горива** | **NA** | **174.9** | **NA** | **NA** | **180.9** | **NA** | **NA** | **164.7** | **NA** | **NA** | **150.6** | **NA** | **NA** | **145.9** | **NA** |
| **Solid Fuels / Цврсти горива** | **NA** | **174.5** | **NA** | **NA** | **180.4** | **NA** | **NA** | **164.6** | **NA** | **NA** | **150.5** | **NA** | **NA** | **145.9** | **NA** |
| Coal mining and handling / Ископување на јаглен и ракување | NA | 174.5 | NA | NA | 180.4 | NA | NA | 164.6 | NA | NA | 150.5 | NA | NA | 145.9 | NA |
| Surface mines / Површински рудници | NA | 174.5 | NA | NA | 180.4 | NA | NA | 164.6 | NA | NA | 150.5 | NA | NA | 145.9 | NA |
| Mining / Ископување на руда | NA | 163.6 | NA | NA | 169.1 | NA | NA | 154.3 | NA | NA | 141.1 | NA | NA | 136.8 | NA |
| Post-mining seam gas emissions / Емисии од јагленовите пластови после ископување | NA | 10.9 | NA | NA | 11.3 | NA | NA | 10.3 | NA | NA | 9.4 | NA | NA | 9.1 | NA |
| **Oil and Natural Gas / Нафта и природен гас** | **NA** | **0.4** | **NA** | **0.0** | **0.5** | **NA** | **0.0** | **0.1** | **NA** | **0.0** | **0.0** | **NA** | **0.0** | **0.0** | **NA** |

*NA – Not Applicable*

### 3.3.7 MEMO Items: International aviation

The contributions from the International Aviation are almost insignificant. They amount to 0.5% in the overall Energy sector emissions in 2014. Jet kerosine is used as fuel. The GHG emissions are illustrated in Figure 22.

According to Figure 22, the emissions have increased throughout the period 2012-2014. In 2014, the emissions are 16.9% higher than in 2013, and 44.5% than in 2012.

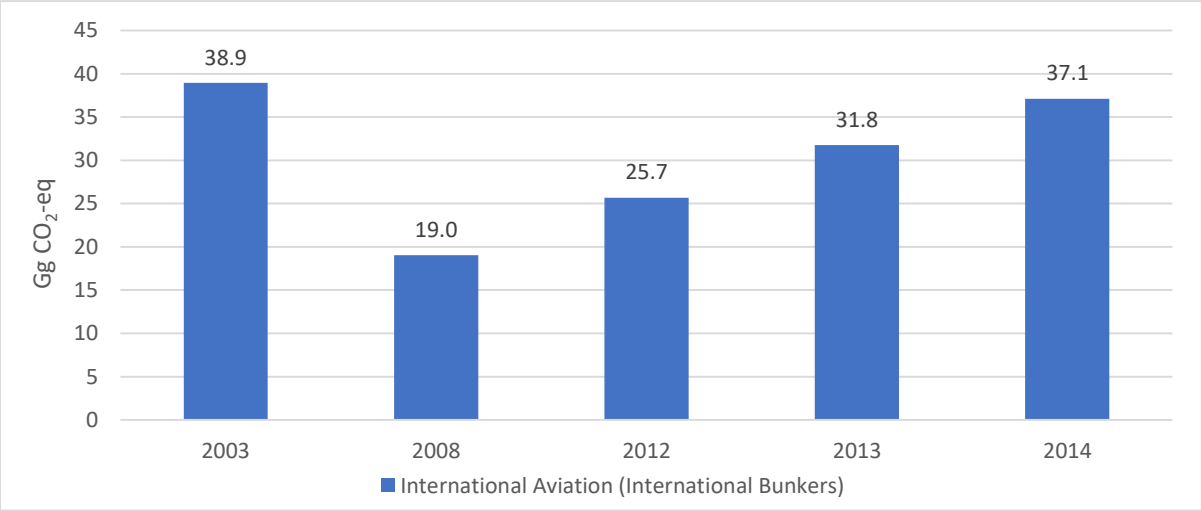



***Figure 22. GHG emissions from International aviation (in Gg $CO_2$-eq) – MEMO Items***

The total International Aviation GHG emissions by gasses in Gg $CO_2$-eq are presented in Table 12.

***Table 12. GHG emissions from International aviation, by gas (in Gg $CO_2$-eq) – MEMO Items***

| Categories/Категории | 2003 | | | 2008 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| **Memo Items / Мемо ставки** | | | | | | | | | | | | | | | |
| **International Bunkers / Меѓународни бункери** | **38.6** | **0.0** | **0.3** | **18.9** | **0.0** | **0.2** | **25.5** | **0.0** | **0.2** | **31.5** | **0.0** | **0.3** | **36.8** | **0.0** | **0.3** |
| International Aviation / Меѓународна авијација | 38.6 | 0.0 | 0.3 | 18.9 | **0.0** | 0.2 | 25.5 | **0.0** | 0.2 | 31.5 | **0.0** | 0.3 | 36.8 | **0.0** | 0.3 |

*NA – Not Applicable*

## 3.4 Comparison of Reference and Sectoral approach

It is considered a good practice to compare the results of the two approaches in order to assess possible flaws in the evaluation. Therefore, Table 13 summarizes the total apparent consumption and $CO_2$ emissions estimated using the Reference Approach, the energy consumption and $CO_2$ emissions obtained from the Sectoral Approach, as well as the calculated differences.

The total differences in energy consumption and $CO_2$ emissions are smaller than 5% for all reported years. Furthermore, the differences from 2012 up to 2014 are smaller than 1%.

***Table 13. Comparison of Sectoral and Reference Approach – total consumption and $CO_2$ emissions for all reported years***

| | Reference Approach | | Sectoral Approach | | Differences | |
|---|---|---|---|---|---|---|
| Year | Apparent consumption (TJ) | $CO_2$ Emissions (Gg) | Energy Consumption (TJ) | $CO_2$ Emissions (Gg) | Energy Consumption (%) | $CO_2$ Emissions (%) |
| 2003 | 97,571.3 | 8,670.8 | 96,006.1 | 8,602.1 | 1.630 | 0.799 |
| 2008 | 107,308.6 | 9,038.5 | 102,498.6 | 8,729.2 | 4.693 | 3.543 |
| 2012 | 99,771.3 | 9,230.8 | 98,858.8 | 9,162.8 | 0.923 | 0.742 |
| 2013 | 89,432.3 | 8,159.8 | 89,443.7 | 8,162.7 | -0.013 | -0.035 |
| 2014 | 84,672.0 | 7,700.9 | 84,677.0 | 7,702.4 | -0.006 | -0.019 |

## 3.5 Methodology and emission factors

The choice of Tier for each calculation of the GHG emissions from the Energy sector was determined by the accessibility of the corresponding national data. In this inventory report the following Tiers have been used:

- Tier 1: data on the amount of fuel combusted in the source category; default emissions factor
- Tier 2: data on the amount of fuel combusted in the source category; a country-specific emissions factor for the source category and fuel for $CO_2$ emissions

The $CO_2$ emissions from the combustion of lignite, residual fuel oil and natural gas have been calculated using the Tier 2 methodology.

In the FBUR, the lignite emission factor was calculated as a weighted sum of the emission factors of the two thermal main power plants on lignite in the country (REK Bitola and REK Oslomej), where the weighting coefficients were taken to be the shares of the total lignite consumption. The calculations were based on the carbon content of the lignite (results obtained from laboratory test). Due to lack of data on the carbon content of lignite for 2013 and 2014, the country-specific emission factor of lignite calculated for 2012 was used to estimate the $CO_2$ emissions in 2013 and 2014 as well.

Macedonia imports natural gas of Russian origin. In the framework of the FBUR the carbon emission factor of the natural gas used in the country was calculated using the carbon content and the net calorific value (NCV) from the Russian Natural Gas specification. The same emission factor used in the Macedonia's FBUR inventory database (from the IPCC Inventory Software) was used in this report.

The country specific emission factor has also been calculated for residual fuel oil, using the same data on carbon content as in the FBUR, obtained from the OKTA refinery, and the NCV of residual fuel oil for each year (based on the Energy Balances from SSO).

The State Statistical Office issues annual Energy balances with information on fuel consumption both in natural units and kilotonnes of oil equivalent (ktoe). These data were used to calculate the NCV of each fuel in a certain year. It should be noted that the variations of a certain fuel's NCV from one sector to another were taken into account.

When compared to the FBUR, the Energy balances used for the SBUR have provided a more disaggregated data set. Namely, similar fuels, which in the older issues of the Energy balances had been grouped together, are given separately. This indicates a higher resolution approach

of the State Statistical Office, but it also indicates that certain fuels have become significant enough to be reported independently.

For instance, the Energy balances issued until 2011 contained a category named Diesel and Heating Oil, which is now separated into the categories:

- Road Diesel and
- Heating & Other fueloil

Although in the IPCC Inventory Software both of the above-mentioned categories are reported as Gas/Diesel Oil, different NCVs are used. The same concept applies to biomass. In the Energy balances issued since 2012, it has been reported in the following two categories:

- Biomass
- Wood wastes, Wood briquettes and Pellets

In order to take advantage of the disaggregation in this National Inventory Report, the category Biomass is reported in TJ under Wood/Wood Wastes in the IPCC Inventory Software. Additionally, Wood wastes, Wood briquettes and Pellets are also reported as Wood/Wood Wastes and the amount of fuel is entered in Gg.

The emission factors used to estimate the GHG emissions are given in Table 14.

***Table 14. Emission factors used for Energy sector***

| Emission factor | FBUR | SBUR | Comment |
|---|---|---|---|
| **Energy Industries** | CS, DF | CS, DF | CS same as NIR-FBUR[1]<br>DF from 2006 IPCC Guidelines |
| **Manufacturing Industries and Construction** | CS, DF | CS, DF | CS same as NIR-FBUR<br>DF from 2006 IPCC Guidelines |
| **Transport** | DF | DF | DF from 2006 IPCC Guidelines |
| **Other Sectors** | CS, DF | CS, DF | CS same as NIR-FBUR<br>DF from 2006 IPCC Guidelines |
| **Non-Specified** | CS, DF | CS, DF | CS same as NIR-FBUR<br>DF from 2006 IPCC Guidelines |
| **Fugitive emissions from fuels** | DF | DF | DF from 2006 IPCC Guidelines |

*DF=Default Factor, CS= Country Specific*

## 3.6 Data sources

The main data sources for the Energy sector are the Energy balances from the State Statistical Office as the most relevant institution for gathering accurate information (Table 15)

***Table 15. Data sources for Energy sector***

| | Documents | Data provider |
|---|---|---|
| **Energy sector** | Energy balance, Final data 2012<br>Energy balance, Final data 2013<br>Energy balance, Preliminary data 2014 | SSO |

[1]Available at: http://unfccc.org.mk/content/FBUR/National%20Inventory%20Report%20FBUR.pdf

# 4 Industrial processes and production use

## 4.1 Overview

The industrial production in Macedonia has slowed down after the economic transition period in the '90s. Many industrial plants in the country have either lowered the volume of manufacturing or entirely shut down. However, there are several industries where production stayed stable or increased over time that constitute the largest contributors of GHG emissions in the IPPU sector. Most of the GHG emissions come from mineral industry, in particular from production of cement and the metal industry or in particular from steel and ferroalloys production. Over the reported period, the overall emissions from this sector are somewhat stable, however the participation of different categories fluctuates during the entire time-series and the distinguished years reported in this biennial update report.

The rest of the greenhouse emissions in the country come from usage of substitutes for ozone-depleting substances (ODS) for refrigeration and air-conditioning. All of the ODS alternatives are imported in the country either pure or as a blend. There is no industrial facility for production of ODS in Macedonia and all of the emissions are result of filling, usage or destruction of the equipment that contains such gases.

## 4.2 Emission trends

The emissions in Macedonia from the IPPU sector come either from the manufacturing industries or the usage of ODS substitutes for refrigeration and air-conditioning. The metal industry is the main contributor with dominant level of emissions from the ferroalloy production. This category is followed by the mineral industry where most of the emissions come from cement production. The rest of the emissions are a result of ODS substitutes usage in the country. Only small portion of emissions come from the chemical industry sector as there are no significant factories that produce chemicals.

The level of the overall greenhouse emissions from this sector is consistent throughout the entire period of 1990-2014 The emissions in 2013 amount 923.1 $CO_2$-eq or 9.1% and in 2014 amount 921.6 $CO_2$-eq or 7.6% of the national emissions (excluding FOLU) (Table 16). However, it should be noted that emissions from manufacturing industries follow generally decreasing trend, while emissions from product use follow increasing trend over the observed years.

From the Figure 23 it can be seen that the greenhouse emissions from the IPPU sector are consisted of several fluctuations that result from various economic factors that impact production volumes in different industries. A major spike of emissions is observed in 2008 right before the Global Economic Crisis spread in Europe during 2009 as the markets were still optimistic and spending was encouraged. The emissions from ODS substitutes usage in the country increases until 2008 when they reach their pick, following a sharp decline and stabilizing by the end of the time series. The overall emissions from the entire IPPU sector in 2013 and 2014 are somewhat stable with a negligible decrease of -0.16% in 2014.

***Table 16. GHG emissions from the IPPU sector, by category (in Gg $CO_2$-eq)***

| Categories / Категории | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Industrial Processes and Product Use /Индустриски процеси и користење на производи** | **845.2** | **1132.1** | **776.4** | **923.1** | **921.6** |
| **Mineral Industry / Минерална индустрија** | **318.6** | **369.3** | **283.0** | **301.9** | **285.6** |
| Cement production / Производство на цемент | 299.6 | 357.3 | 266.6 | 284.9 | 267.9 |
| Lime production / Производство на вар | 5.5 | 0.0 | NO | NO | NO |
| Glass Production / Производство на стакло | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Other Process Uses of Carbonates / Други процеси што користат карбонати | 13.4 | 12.0 | 16.4 | 17.1 | 17.7 |
| Ceramics / Керамика | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| Other Uses of Soda Ash / Друго користење на сода бикарбонат | 2.1 | 2.2 | 2.2 | 2.2 | 2.2 |
| Other / Друго | 11.2 | 9.7 | 14.1 | 14.7 | 15.3 |
| **Chemical Industry / Хемиска индустрија** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** |
| Soda Ash Production / Производство на сода бикарбонат | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Metal Industry / Метална индустрија** | **436.8** | **372.7** | **396.7** | **455.9** | **452.5** |
| Iron and Steel Production / Производство на железо и челик | 53.1 | 46.3 | 67.0 | 70.0 | 73.0 |
| Ferroalloys Production / Производство на феролегури | 232.3 | 326.2 | 323.0 | 384.3 | 379.5 |
| Aluminium production / Производство на алуминиум | 59.5 | 0.2 | 6.7 | 1.6 | NO |
| Lead Production / Производство на олово | 7.1 | NO | NO | NO | NO |
| Zinc Production / Производство на цинк | 84.9 | NO | NO | NO | NO |
| **Non-Energy Products from Fuels and Solvent Use / Не-енергетски производи од горива и користење на разредувачи** | **NO** | **NO** | **NO** | **NO** | **NO** |
| **Electronics Industry / Индустрија за електроника** | **NO** | **NO** | **NO** | **NO** | **NO** |
| **Product Uses as Substitutes for ODS / Користење на производи како замена за супстанци кои го оштетуваат озонот** | **89.8** | **390.1** | **96.7** | **165.2** | **183.5** |
| Refrigeration and Air Conditioning / Уреди за разладување | 89.8 | 390.1 | 96.7 | 165.2 | 183.5 |
| Refrigeration and Stationary Air Conditioning / Фрижидери и стационарно ладење | 89.8 | 390.1 | 96.7 | 165.2 | 183.5 |
| Mobile Air Conditioning / Мобилни клима уреди | IE | IE | IE | IE | IE |
| Foam Blowing Agents / Дување на пена | IE | IE | IE | IE | IE |
| Fire Protection / Заштита од пожар | IE | IE | IE | IE | IE |
| Aerosols / Аеросоли | IE | IE | IE | IE | IE |
| Solvents / Разредувачи | IE | IE | IE | IE | IE |
| Other Applications / Други примени | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Other Product Manufacture and Use / Друго** | **NO** | **NO** | **NO** | **NO** | **NO** |
| **Other / Друго** | **NO** | **NO** | **NO** | **NO** | **NO** |

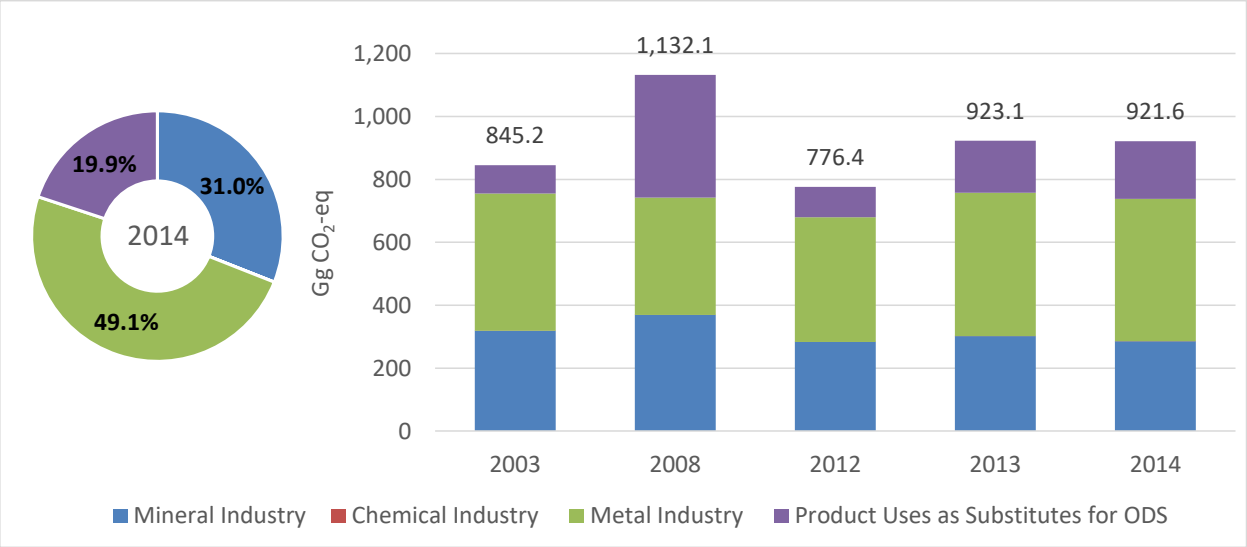



***Figure 23. GHG emissions from the IPPU sector, (in Gg $CO_2$-eq)***

In 2014, the $CO_2$ emissions accounted for 79.88% of the overall greenhouse emissions from IPPU. The HFCs were second highest contributor and accounted for 19.91% of the total emissions. $CH_4$ emissions were negligible and accounted only for 0.21% of the greenhouse emissions from this sector. The emissions segregated by gas are presented in Table 17.

***Table 17. GHG emissions from the IPPU sector, by gas (in Gg $CO_2$-eq)***

| Categories / Категории | 2003 | | | 2008 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| **Industrial Processes and Product Use / Индустриски процеси и користење на производи** | **700.8** | **1.17** | **NO** | **739.5** | **2.37** | **NO** | **672.0** | **1.78** | **NO** | **754.4** | **1.94** | **NO** | **736.2** | **1.91** | **NO** |
| Mineral Industry / Минерална индустрија | 318.6 | NO | NO | 369.3 | NO | NO | 283.0 | NO | NO | 301.9 | NO | NO | 285.6 | NO | NO |
| Chemical Industry / Хемиска индустрија | 0.01 | NO | NO | 0.01 | NO | NO | 0.01 | NO | NO | 0.01 | NO | NO | 0.01 | NO | NO |
| Metal Industry / Метална индустрија | 539.1 | 1.17 | NO | 370.2 | 2.37 | NO | 388.9 | 0.41 | NO | 452.5 | 1.70 | NO | 450.6 | 2.61 | NO |
| Non-Energy Products from Fuels and Solvent Use / Не-енергетски производи од горива и користење на разредувачи | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Electronics Industry / Индустрија за електроника | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Product Uses as Substitutes for ODS / Користење на производи како замена за супстанци кои го оштетуваат озонот | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other Product Manufacture and Use / Друго | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other / Друго | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

| Categories / Категории | 2003 | | | 2008 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HFC | PFC | $SF_6$ | HFC | PFC | $SF_6$ | HFC | PFC | $SF_6$ | HFC | PFC | $SF_6$ | HFC | PFC | $SF_6$ |
| **Industrial Processes and Product Use / Индустриски процеси и користење на производи** | **89.8** | **53.4** | **NO,NE** | **390.1** | **0.2** | **NO,NE** | **96.7** | **6.0** | **NO,NE** | **165.2** | **1.4** | **NO,NE** | **183.5** | **NO** | **NO,NE** |
| Mineral Industry / Минерална индустрија | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE |
| Chemical Industry / Хемиска индустрија | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE |
| Metal Industry / Метална индустрија | NO | 53.4 | NO,NE | NO | 0.2 | NO,NE | NO | 6.0 | NO,NE | NO | 1.4 | NO,NE | NO | NO | NO,NE |
| Non-Energy Products from Fuels and Solvent Use / Не-енергетски производи од горива и користење на разредувачи | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE |
| Electronics Industry / Индустрија за електроника | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE |
| Product Uses as Substitutes for ODS / Користење на производи како замена за супстанци кои го оштетуваат озонот | 89.8 | NO | NO,NE | 390.1 | NO | NO,NE | 96.7 | NO | NO,NE | 165.2 | NO | NO,NE | 183.5 | NO | NO,NE |
| Other Product Manufacture and Use / Друго | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE |
| Other / Друго | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE | NO | NO | NO,NE |

## 4.3 Mineral industry

### 4.3.1 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 sulphate (gypsum or anhydrite), into hydraulic (typically Portland) cement. There is only one cement production factory in the country. Marlstone is used as basic mineral raw material and is obtained from the open-cast mine, located within the factory. Marlstone, as a non-metallic mineral raw material, is a basic component in the production of clinker, i.e., cement. Apart from the marlstone, other components are also used to form fly ash for the manufacturing of clinker.

The emissions from the cement production are influenced by the volume of industrial activity and are generally following increasing trend throughout the entire observed period. The cement manufacturing is following a declining trend in the last two years, and it is considerably lower in comparison to 2008 when the production volume was estimated to be 852 kt of cement produced to 686 kt cement in 2014. The production of cement in the country accounted for 30.9% in 2013 of the greenhouse emissions from the IPPU sector and 29.1% in 2014. In 2013 the emissions from this category amount 302.0 Gg $CO_2$–eq and in 2014 it amounts 285.6 Gg $CO_2$–eq. There is a slight decline of 6.0% in the emissions in 2014 in comparison to 2013.

### 4.3.2 Lime production

The production of lime involves a series of steps similar to those used in the production of cement clinker. The calcium oxide is formed by heating limestone in shaft or rotary kilns at high temperatures to decompose the carbonates. Dolomite and dolomitic (high magnesium) limestones may also be processed at high temperature to obtain dolomitic lime and in that process release $CO_2$. The production of lime involves a series of steps, including the quarrying of raw materials, crushing and sizing, calcining the raw materials to produce lime, and (if required) hydrating the lime to calcium hydroxide.

The emissions from lime production are influenced by the volume of industrial activity and are following generally decreasing trend in the period 1990-2009. There is no evidence that lime production occurred in the country in 2013 and 2014.

### 4.3.3 Glass production

The major glass raw materials which emit $CO_2$ during the melting process are limestone, dolomite and soda ash. 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.

As there is no substantial production of glass in the country, the overall emissions from this category gravitate around 0 Gg $CO_2$-eq/year. In both, 2013 and 2014 the greenhouse emissions are considerably low. Due to the inexistence of official data as a result of the low volume of glass production, the activity data for the last years is calculated using extrapolation. Therefore, the decreasing trend of these emissions might not be representative to the existing circumstances in the country.

### 4.3.4 Other process uses of carbonates

In Macedonia, there are emissions from process uses of carbonates such as soda ash use and limestone use that are not accounted for in the other categories in the mineral industry sector. Also GHG emissions result from ceramics production including the production of bricks and roof tiles, vitrified clay pipes, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware (household ceramics), sanitary ware, technical ceramics, and inorganic bonded abrasives. Most ceramic products are made from one or more different types of clay (e.g., shales, fire clay and ball clay) that are collected and crushed in successive grinding operations. The $CO_2$ emissions result from the calcination of the raw material (particularly clay, shale, limestone, dolomite and witherite) and the use of limestone as a flux.

The currently operating ceramic plants in Macedonia are producing mostly bricks, roof and wall tiles and other ceramic products.

The $CO_2$ emissions from ceramic production are estimated to be 0.1 Gg $CO_2$-eq in 2013 and 0.1 Gg $CO_2$-eq in 2014.

Soda ash is used in a variety of applications, including, glass production, soaps and detergents, flue gas desulphurization, chemicals, pulp and paper and other common consumer products. Soda ash production and consumption (including sodium carbonate, $Na_2CO_3$) results in the release of $CO_2$. In Macedonia there are several factories that use soda ash as a feedstock in the manufacturing process. The $CO_2$ emissions from soda ash consumption are generally following stable trend and in the last two years were estimated to be 2.2 Gg $CO_2$-eq.

Limestone ($CaCO_3$) and dolomite ($CaMgCO_3$) 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 are reported under that industry sector and not under the sector of Limestone and Dolomite Use. In this category are inventoried only the other uses of limestone and dolomite which produce $CO_2$ emissions.

The $CO_2$ emission trend from limestone use is tightly related to the industrial activity within steel production industry. The first half of the time series has a decreasing trend, followed by sharp and steady increase in the period 2000-2007. In 2008 is observed sudden decline of emissions due to the global financial crisis which is further followed by slow increase of emissions as the country's production bounced back. In 2013 the emissions from limestone use amount 14.7 Gg $CO_2$–eq and in 2014 they amount 15.3 Gg $CO_2$–eq. There is a 4.1% increase in emissions between 2013 and 2014 which is a direct consequence of increased steel production where limestone is primarily used.

## 4.4 Chemical industry

There is almost no production of chemicals in Macedonia. There is evidence for certain amounts of soda ash production in the country that is reported under this sector.

### 4.4.1 Soda ash production

Sodium carbonate or soda ash is a widespread white crystal material that is used in many industries as a feedstock for production of glass, detergents, paper etc. $CO_2$ is emitted during production of this substance and its volume is dependent of the performed manufacturing process.

Several major spikes are observed in the emission trend during the first years of the 1990-2014 time series. These fluctuations are due to the variance in the production rate. However, there is high uncertainty in these data due to inefficiencies of the data collection system in the statistical office as well as the lack of reports on production data for the second half of the time series.

## 4.5 Metal industry

### 4.5.1 Iron and steel production

Steel production in Macedonia mainly relies on electricity. The economic activity in this area 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% 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.

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.

The trend of the $CO_2$ emissions from steel production follows downfall trend in the first portion of the time series preceded by stable rise in the second half. As the industrial productivity is directly related to political and economic events in the region, the fluctuations can be partially described as consequences of these occurrences. On the several outstanding decreases/increases of the $CO_2$ emissions can be observed as a direct consequence of decrease/increase of industrial activity. In 2008, a sharp decrease of emissions is observed due to the economic turmoil as a result of the global financial crisis that affected the steel production all around the world including Macedonia. Afterwards the level of emissions from this category gradually increased with the increased volume outputs as the global economy stabilized. In 2013, the greenhouse gas emissions amount 70.0 Gg $CO_2$-eq or 7.6% of the entire IPPU sector and in 2014 the emissions amount 73.0 Gg $CO_2$-eq or 7.9% of the overall emissions in the sector.

### 4.5.2 Ferroalloys production

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. This process results in both $CO_2$ and $CH_4$ emissions.

The trend of the GHG emissions from ferroalloy production is fluctuating over the observed period. As the industrial productivity is directly related to the political and economic events in the region, the fluctuations can be partially described as consequences of these occurrences. . In 2013, the greenhouse gas emissions amount 384.3 Gg $CO_2$-eq or 41.6% of the entire IPPU sector and in 2014 the emissions amount 379.5 Gg $CO_2$-eq or 41.2% of the overall emissions in the sector. The emissions between these two years decreased for 1.2% due to the decline in the production volume of ferroalloys in the country.

### 4.5.3 Aluminum production

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). The $CO_2$ 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 GHG 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, there was only one industrial plant that had a complete process for the production of aluminium alloys, profiles, pipes and structures. 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 GHG emissions from the aluminium production are influenced by the volume of industrial activity and are following downfall trend in the period 1990-2003. Due to the closure of the only industrial plant that produced aluminium, the emissions in 2013 are negligible and there is no evidence of aluminium production in 2014.

### 4.5.4 Lead production

There are two primary processes for the production of rough lead bullion from lead concentrates. Primary production from mined lead ore is of course the original source of all lead, but secondary production, where it is recovered from recycled products or from residues arising from the production process is of enormous importance. Lead in Macedonia was produced until 2003 in a lead and zinc smelter that used to produce under IST (Imperial Smelt Technology). However, there were alarming issues regarding the pollutions with the releasing of heavy metals and sulfur. This problem was the most visible in the year 2000 when the production in the two lead mines was terminated, which have one of the highest quality lead – zinc mineral in the world, with the concentration of sulfur in the mineral below 35%. About 60% of the minerals for production came from domestic mines and the remaining part was imported. The unresolved environmental issues of this facility were the major reason for termination of the production in 2003.

The $CO_2$ emissions from the lead production are influenced by the volume of industrial activity. As the industrial plant that was producing lead ceased its operations in 2003 there are no emissions from this category in 2013 and 2014.

### 4.5.5 Zinc production

The zinc production in Macedonia is performed with pyrometallurgical process involving the use of an Imperial Smelting Furnace, which allows for the simultaneous treatment of lead and zinc concentrates. The process results in the simultaneous production of lead and zinc and the release of non-energy $CO_2$ emissions. The metallurgical coke/coal reductant used in this process must be allocated to lead and zinc production in order to perform an emission calculation without double counting. Zink in the country was produced until 2003 using IST (Imperial Smelt Technology). The $CO_2$ emissions from the lead production are influenced by the volume of industrial activity in the period 1990-2003. As the industrial plant that was producing zink ceased its operations in 2003 there are no emissions from this category in 2013 and 2014.

## 4.6 Product uses as substitutes of ozone depleting substances

Hydrofluorocarbons (HFCs) and, to a very limited extent, perfluorocarbons (PFCs), are serving as alternatives to ozone depleting substances (ODS) being phased out under the Montreal Protocol. HFCs and PFCs are not controlled by the Montreal Protocol because they do not contribute to depletion of the stratospheric ozone layer. In Macedonia these gasses are mainly used for refrigeration and air conditioning. The HFCs and their blends are controlled by the Ministry of Environment and Physical Planning since 2000. Data for the period from 2000-2010 are based on issued import permits. Data from 2011-2014 is actual import taken from the EXIM system. All importers since 2011 should apply on-line through the www.exim.gov.mk system to obtain a valid import permit. The EXIM procedure applies for all refrigerants and it is very simple to monitor the real import.

The HFC emissions from this sector followed an increasing trend until 2008, following a decline in the subsequent year and stabilization of the emissions around 165.3 CO2-eq in 2013 and 182.5 $CO_2$-eq in 2014.

## 4.7 Methodology and emission factors

The estimation of the greenhouse gases from all the categories in the IPPU sector was done in accordance to the 2006 IPCC guidelines (Tier 1, Tier 2) and with the usage of the IPCC Inventory Software.

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 and the 2006 IPCC Guidelines as well as data from peer-reviewed papers and other publications, including National Inventory Reports (NIRs) from other countries with similar circumstances relevant for this sector. The emission factors were compared to those used in the previous biennial report and national communications and are presented in the Table 18. Furthermore, country-specific emission factors were calculated for the subcategories of Cement Production, Steel Production and Ferro-alloy Production. These emission factors are given in the publication entitled *'National $CO_2$ and non-$CO_2$ emission factors for key sectors under IPCC and CORINAIR methodologies'*[2].

[2] Available at: http://www.unfccc.org.mk/content/Documents/INVENTORY/EFs%20EN.pdf

***Table 18. Emission factors used for IPPU sector***

| Emission factor | FBUR | SBUR | Comment |
|---|---|---|---|
| **Industrial Processes and Product Use** | CS, DF | CS, DF | |
| **Mineral Industry** | CS, DF | CS, DF | |
| Cement production | CS | CS | Data for calculating EF gathered from Titan-Usje |
| Lime production | DF | DF | DF from 2006 IPCC guidelines |
| Glass Production | DF | DF | DF from 2006 IPCC guidelines |
| Other Process Uses of Carbonates | DF | DF | DF from 2006 IPCC guidelines |
| Ceramics | DF | DF | DF from 2006 IPCC guidelines |
| Other Uses of Soda Ash | DF | DF | DF from 2006 IPCC guidelines |
| Other | DF | DF | DF from 2006 IPCC guidelines |
| **Chemical Industry** | DF | DF | |
| Soda Ash Production | DF | DF | DF from 2006 IPCC guidelines |
| **Metal Industry** | CS, DF | CS, DF | |
| Iron and Steel Production | CS | CS | Data for calculating EF gathered from MAKSTIL |
| Ferroalloys Production | CS | CS | Data for calculating EF gathered from FENI, Jegunovce Ferroalloys and Skopski Leguri |
| Aluminium production | DF | DF | DF from 2006 IPCC guidelines |
| Lead Production | DF | DF | DF from 2006 IPCC guidelines |
| Zinc Production | DF | DF | DF from 2006 IPCC guidelines |
| **Product Uses as Substitutes for Ozone Depleting Substances** | DF | DF | |
| Refrigeration and Air Conditioning | DF | DF | DF from 2006 IPCC guidelines |
| Refrigeration and Stationary Air Conditioning | DF | DF | DF from 2006 IPCC guidelines |

*DF=Default, CS= Country Specific*

## 4.8 Data sources

The data for preparation of the greenhouse gases inventory for the IPPU sector was generally collected from three main sources: the State Statistical Office, the Ministry of Environment and Physical Planning or directly from the industrial plants (Table 19). In addition to the data provided by these main sources, other international databases were used to crosscheck the data or to fill in the gaps in the time series, such as the UN industrial production statistics, the World Steel Association Statistics archive and the Eurostat PRODCOM database.

***Table 19. Data sources for IPPU sector***

| | Documents | Data provider |
|---|---|---|
| **Mineral Industry** | | |
| Cement production | SSO Yearbook 2013<br>SSO Yearbook 2015<br>SSO Yearbook 2016 | Usje-Titan - direct correspondence; SSO |
| Lime production | | SSO |
| Glass Production | | SSO |
| Other Process Uses of Carbonates | | SSO |
| Ceramics | | SSO |
| Other Uses of Soda Ash | | SSO |
| Other | | SSO |
| **Chemical Industry** | | |
| Soda Ash Production | SSO Yearbook 2013<br>SSO Yearbook 2015<br>SSO Yearbook 2016 | SSO |
| **Metal Industry** | | |
| Iron and Steel Production | SSO Yearbook 2013<br>SSO Yearbook 2015<br>SSO Yearbook 2016 | SSO |
| Ferroalloys Production | | SSO |
| Aluminium production | | SSO |
| Lead Production | | SSO |
| Zinc Production | | SSO |
| **Product Uses as Substitutes for Ozone Depleting Substances** | | |
| Refrigeration and Air Conditioning | HCFC Management Phase out Plan- Report | MOEPP |
| Refrigeration and Stationary Air Conditioning | HCFC Management Phase out Plan- Report | MOEPP |

# 5 Agriculture, forestry and other land use

## 5.1 Overview

The AFOLU sector is covering activities in Livestock production; Land use in particular Forest land, Cropland, Grassland, Wetland, Settlements and other land; Aggregate sources and non-$CO_2$ emissions sources on land; and other.

Activities related to livestock production emit $CH_4$ and $N_2O$. The $CH_4$ emissions is caused by enteric fermentation during herbal digestion in ruminants. Additionally, during the metabolic processes occur emissions of $N_2O$, but also nitrous oxide is emitted as a result of manure storage and processing (management). National livestock population has decreasing tendency in all species, mainly as a result of socio-economic change in last decades. However, livestock is emitting about 50% of the total emission of GHG (in $CO_2$-eq.) in AFOLU (excluding Forest land). About 80% of GHG emissions due to livestock production activities are $CH_4$ as a consequence of enteric fermentation in cattle.

Out of the total area of about 2.5 mil. ha, agricultural land covers an area of approximately 1.13 mil. ha. More than 0.5 mil. ha of the agricultural land is arable land, while the rest of more than 0.6 mil. ha are pastures. Forests and Forest land covers area of round 1.3 mil. ha and the rest of the area is other land use type. Forests are characterized with great species diversity, but low quality and small annual growth. More than 70% of the forests are coppice, 90% are deciduous and almost 90% are state owned. The most dominant species is beech, and then various oak species. Total wood reserve is estimated on around 70 mil $m^3$, and total annual growth is around 1.7 mil $m^3$. Very large part of the land considered as forest, are Mediterranean type of forest, characterized with small trees and bushes.

It should be noted that certain categories of land use, like pastures and forests and forest land, according statistical data exhibits significant changes in the period of 2009 onwards. The total area under pastures increases for more than 150,000 ha, while the total area of forest land in the period 2010-2015 increases for more than 100,000 ha.

The emissions and removals in the category Land are mainly a result of activities and changes in Forest Land (fuel wood, afforestation and forest fires etc.) and conversion from one to another land use type of agricultural land. According to the statistical data, there is an increasing of area under forests of more than 20,000 ha for the period 2013-2014 compared to 2010. Still, there are significant inconsistencies of data related to land under forests, depending to the source of data. In order to achieve more accurate overview of areas under certain categories of land use, it is highly recommended to establish a sustainable system for performing of continuous long term inventory of Forest and and all other sectors within category Land. However, sector forestry can be considered as a significant sink of $CO_2$ which vary from year to year.

The other land use categories under the category Land, like: Cropland, Grassland, Wetlands, settlements and Other Land, contribute to the emission of $CO_2$-eq which is due to the conversion of land use categories. The $CO_2$-eq emissions are mainly from Cropland, accounting for 466.7 Gg $CO_2$-eq in 2003, followed by Grassland with 344.1 Gg $CO_2$-eq, or in total 906.0 Gg $CO_2$-eq for all categories of land, excluding Forest land. However, there is a significant decreasing of the emission of $CO_2$-eq in all categories of land use (excluding Forest land) for more than 60% in last decade. It should be noted that emissions of $CO_2$-eq in Land category are result of conversion from one to another land use category. For better estimation of areas under different types of land use, creation of system for continuous monitoring of land use change is a must, as in the case of forest areas. Soil is another significant sink of GHG which is closely related to soil management and fertilization practices.

## 5.2 Emission trends

Agriculture, including Livestock and other land use are emitters of GHGs beside Forest land (forestry) where sinks of GHGs occurred (Table 20). In some years, when forest fires were more intensive than usual, forestry was also an emitter. The forest fires were the reason of varying emission trends over the years, and the difference in total AFOLU emission trends (e.g. -847.8 Gg $CO_2$-eq in 2013 vs. -2,179.3 Gg $CO_2$-eq in 2014). Emissions of $CO_2$ equivalent in other categories are decreasing over years, mainly due to lower volume of productive activities.

***Table 20. GHG emissions and removals from AFOLU sector, by category (in Gg $CO_2$-eq)***

| | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **AFOLU / ЗШДКЗ** | **-2,686.3** | **2,423.4** | **2,934.1** | **-847.8** | **-2,179.3** |
| **Livestock / Сточарство** | **761.8** | **714.2** | **692.6** | **666.4** | **673.7** |
| **Land / Земјиште** | **-3,741.6** | **1,376.5** | **1,936.4** | **-1,814.8** | **-3,181.1** |
| Forestl and / Шумско земјиште | -4,647.6 | 865.0 | 1,665.0 | -2,097.0 | -3,471.2 |
| Cropland / Обработливи површни | 466.7 | 219.7 | 114.9 | 120.6 | 123.8 |
| Grassland / Пасишта | 344.1 | 237.3 | 125.9 | 130.0 | 134.9 |
| Settlements / Населени места | 90.1 | 45.5 | 24.2 | 25.0 | 25.9 |
| Other Land /Друго земјиште | 5.1 | 9.0 | 6.5 | 6.6 | 5.5 |
| **Aggregate sources and non-$CO_2$ emissions sources on land / Збирни извори и извори на емисии на други гасови од земјиштето кои не се $CO_2$** | **309.8** | **358.2** | **326.8** | **322.8** | **328.2** |
| Urea application / Примена на уреа | 4.9 | 4.5 | 5.7 | 5.7 | 5.7 |
| Direct $N_2O$ emissions from managed soils / Директни $N_2O$ емисии од обработени почви | 192.4 | 226.7 | 198.2 | 196.0 | 197.7 |
| Indirect $N_2O$ emissions from managed soils / Индиректни $N_2O$ емисии од обработени почви | 70.4 | 84.5 | 72.0 | 71.3 | 72.0 |
| Indirect $N_2O$ emissions from manure management / Индиректни $N_2O$ емисии од шталско ѓубре | 27.3 | 29.9 | 27.9 | 26.8 | 27.3 |
| Rice cultivations / Површини под ориз | 14.8 | 12.6 | 22.9 | 22.9 | 25.4 |
| **Other / Друго** | **-16.2** | **-25.5** | **-21.6** | **-22.2** | **0.0** |
| Harvested Wood Products / Искористена дрвна маса | -16.2 | -25.5 | -21.6 | -22.2 | 0.0 |

The GHG emissions and removal in AFOLU sector are presented in Figure 24. The proportions of GHG emissions as $CO_2$ equivalent in the categories other than Forest land are almost identical in 2013 and 2014. Most of the emissions (52.1%) were due to Livestock production activities, followed by Aggregate sources and non-$CO_2$ emissions with over 25.4%, while grassland and cropland contributed with 10.4% and 9.6%, respectively. Settlements account for 2% of the emissions and other land less than 0.4%. While emissions from Livestock had slow decreasing tendency, the emissions related to Cropland and Grassland activities were decreasing rapidly over years. The decreasing tendencies were mainly due to lower volume of productive activities.

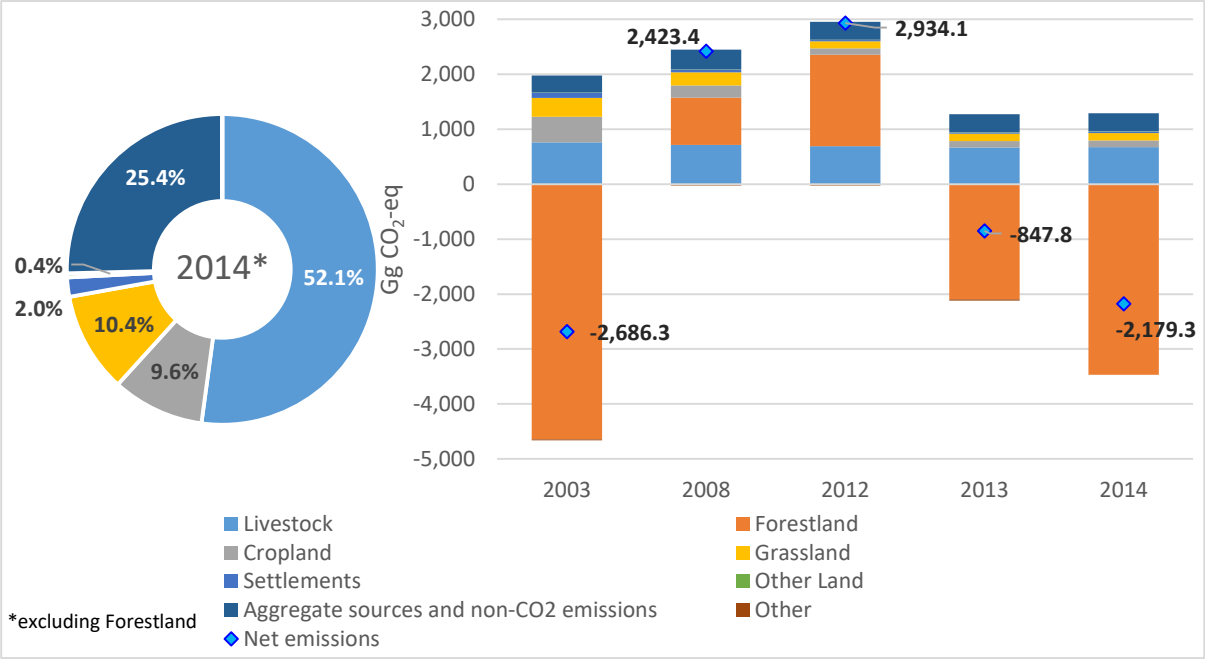



***Figure 24. GHG emissions (and removals) from AFOLU sector (in Gg CO2-eq)***

## 5.3 Livestock

GHG emissions as consequences of livestock production activities are depending of species specific production system, type of production and intensity. In some species like other cattle, sheep, goat and horses predominant production systems are with low to moderate intensity. However, small part of dairy cows, and majority of swine and poultry production system is very intensive where emissions from manure management can be closely monitored. Still, there is no sufficient data to describe national typical farm profile. Hence, for the BUR needs, default emission factors were used.

### 5.3.1 Emissions from livestock activities

Dairy cows and other cattle are emitting the majority of GHGs in livestock production. Sheep and goats (ruminants), horses, swine and poultry contribute significantly less to the sector's emissions.

In total $CH_4$ emissions were 29.8 Gg and 30.2 Gg in 2013 and 2014 (Table 21). It the both years, about 83% of $CH_4$ emissions were due to enteric fermentation, and the rest (17%) as a result of manure management. $CH_4$ from enteric fermentation was mainly emitted by cattle 81.5% (dairy cows contributed in the emissions with over 75% of cattle emissions), followed by sheep with 14.8%. Other species contributed remarkably lower to enteric methane emissions.

In manure management $CH_4$ emissions, cattle contributed with 75% and pigs with 21%. Other livestock species had lower contribution due to specific system, most of the times sheep, goats and horses are keep on pasture.

$N_2O$ emissions were solely due to manure management. The emissions in 2013 were 0.129 Gg while in 2014 0.131 Gg (Table 21). The main emitters were cattle manure with 78%, followed by sheep manure with 11% and swine manure with almost 9%. Similarly to $CH_4$ emissions, dairy cows were the largest contributor with 56% of annual $N_2O$ emissions in Livestock.

In the assessment emissions of $CH_4$ and $N_2O$ were transferred into $CO_2$ equivalents (Table 21 and Figure 25). The $CH_4$ emissions were 626.4 Gg $CO_2$-eq and 633.1 Gg $CO_2$-eq in 2013 and 2014. The emissions of $N_2O$ over the years are rather stable around 41 Gg $CO_2$-eq. The emissions due to livestock activity in 2013 were 666.4 Gg $CO_2$-eq, while in 2014, 673.7 Gg $CO_2$-eq. This increase of about 1% in 2014 was due to increase of the number of cattle for over 3,000 heads.

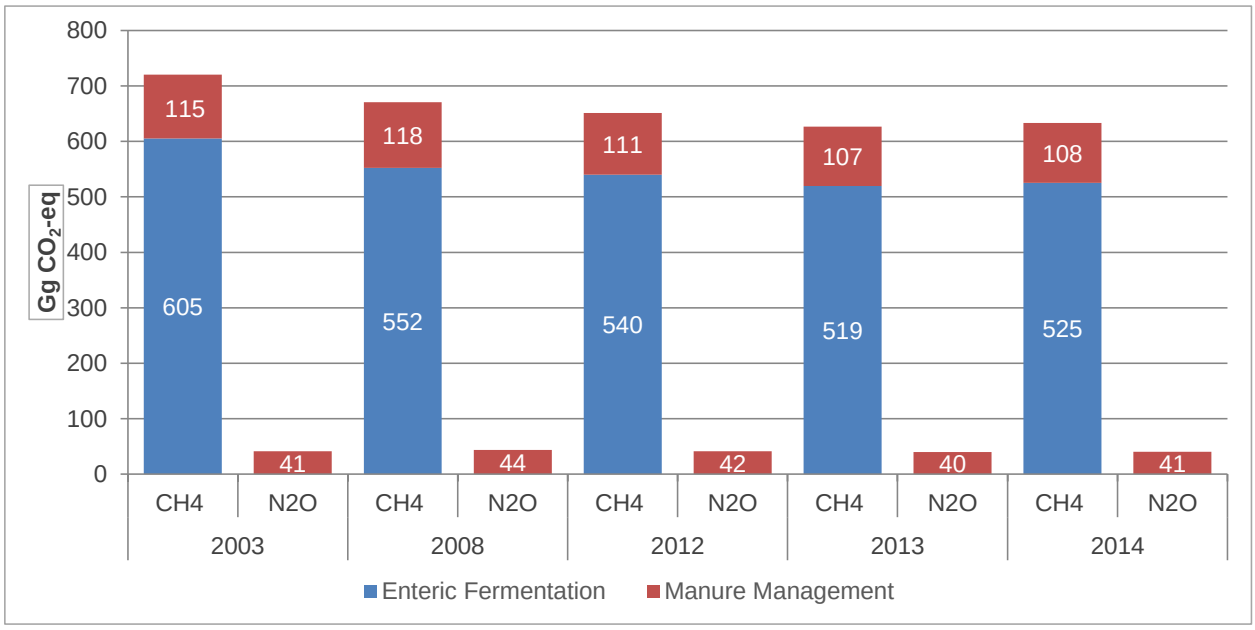



***Figure 25. Emissions of $CH_4$ and $N_2O$ (in Gg $CO_2$-eq) from Enteric Fermentation and Manure Management***

***Table 21 Emissions of $CH_4$ and $N_2O$ (in Gg) due to activities in livestock production***

| Categories<br>Категории | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $CH_4$ | $N_2O$ | $CH_4$ | $N_2O$ | $CH_4$ | $N_2O$ | $CH_4$ | $N_2O$ | $CH_4$ | $N_2O$ |
| **Enteric Fermentation<br>Ентерична ферментација** | **28.82** | **NA** | **26.30** | **NA** | **25.72** | **NA** | **24.73** | **NA** | **25.01** | **NA** |
| - Cattle / Говеда | 21.67 | NA | 20.75 | NA | 21.17 | NA | 20.16 | NA | 20.39 | NA |
| *- Dairy Cows / Млечни крави* | *15.92* | NA | *14.60* | NA | *15.94* | NA | *15.29* | NA | *15.39* | NA |
| *- Other Cattle / Други говеда* | *5.75* | NA | *6.15* | NA | *5.23* | NA | *4.86* | NA | *5.00* | NA |
| - Sheep / Овци | 6.20 | NA | 4.08 | NA | 3.66 | NA | 3.66 | NA | 3.70 | NA |
| - Goats / Кози* | IE | NA | 0.67 | NA | 0.32 | NA | 0.38 | NA | 0.41 | NA |
| - Horses / Коњи | 0.77 | NA | 0.56 | NA | 0.39 | NA | 0.37 | NA | 0.35 | NA |
| - Swine / Свињи | 0.18 | NA | 0.25 | NA | 0.18 | NA | 0.17 | NA | 0.17 | NA |
| **Manure Management<br>Управување со добиточно ѓубре** | **5.49** | **0.13** | **5.63** | **0.14** | **5.29** | **0.13** | **5.10** | **0.13** | **5.14** | **0.13** |
| - Cattle / Говеда | 4.11 | 0.10 | 3.90 | 0.10 | 4.03 | 0.11 | 3.84 | 0.10 | 3.88 | 0.10 |
| *- Dairy Cows / Млечни крави* | *3.22* | *0.07* | *2.95* | *0.07* | *3.22* | *0.08* | *3.09* | *0.07* | *3.11* | *0.07* |
| *- Other Cattle / Други Говеда* | *0.89* | *0.03* | *0.95* | *0.04* | *0.81* | *0.03* | *0.75* | *0.03* | *0.78* | *0.03* |
| - Sheep / Овци | 0.19 | 0.02 | 0.12 | 0.02 | 0.11 | 0.01 | 0.11 | 0.01 | 0.11 | 0.01 |
| - Goats / Кози* | IE | IE | 0.02 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 |
| - Horses / Коњи | 0.07 | NA | 0.05 | NA | 0.04 | NA | 0.03 | NA | 0.03 | NA |
| - Swine / Свињи | 1.07 | 0.01 | 1.48 | 0.02 | 1.06 | 0.01 | 1.06 | 0.01 | 1.06 | 0.01 |
| - Poultry / Живина | 0.05 | 0.00 | 0.04 | 0.00 | 0.04 | 0.00 | 0.04 | 0.00 | 0.04 | 0.00 |
| **Total emissions / Вкупно емисии** | **34.31** | **0.13** | **31.93** | **0.14** | **31.01** | **0.13** | **29.83** | **0.13** | **30.15** | **0.13** |
| **Total emissions (Gg $CO_2$-eq.)<br>Вкупно емисии (Gg $CO_2$ екв.)** | **720.45** | **41.35** | **670.47** | **43.72** | **651.11** | **41.51** | **626.40** | **39.99** | **633.14** | **40.51** |
| **Total annual emissions (Gg $CO_2$-eq) /<br>Вкупни годишни емисии (Gg $CO_2$ екв)** | **761.80** | | **714.19** | | **692.62** | | **666.40** | | **673.65** | |

** Until 2006 the goat is included in the sheep category, IE-Included Elsewhere, NA- Not Applicable*

## 5.4 Land

The category Land contents Forest land, Cropland, Grassland, Settlements and Other land. Nevertheless, some of the categories are significant contributor to GHG emissions, but other like Forest land can be major $CO_2$ sink. For this report need, they were deeply analyzed separately.

### 5.4.1 Forest land

In this report, the revision of the forestry sector data from the FBUR report was made on several levels, explained in more details in the following sub-chapters.

#### 5.4.1.1 Total Forest area

Data for the total forest area were taken from the Statistical Yearbooks (State Statistical office), Forestry management plans (PE "Makedonski sumi", other subjects that manage forests, the Ministry of Agriculture, Forestry and Water Economy - MAFWE) and the Faculty of Forestry (different experts). A difference can be observed between the data from the institutions, mainly due to the different update year, but having in mind that there is no legal obligation to record the area annually, it is difficult to track the annual changes. Most of the data are collected on 10 year cycle, there is no forest inventory done and there are really sporadic data that can be used with modern technology (like satellite images) to make evidence of the changes. For the period 2010-2014, extended data for forestry land were found in the State statistical office (SSO) data, and a comparison was made with the data from Forestry sector (MAFWE, PE "Makedonski sumi" and other subjects managing other forests) and the satellite images from CORINE (Coordination of Information on the Environment) Land Cover (CLC). Slight differences were found between the data and it was decided to use the SSO data for that period. For the period 2000-2009, the SSO data collected and reported the data for several categories in the forestry, so less detailed data were used for this period.

#### 5.4.1.2 Areas by different tree species

The data for tree species composition in the forests was also used from SSO. Again, a comparison was made with the data from the Forestry management plans from MAFWE, PE "Makedonski sumi" and other subjects that manage the forests, and no significant changes were noticed in, so the same data were used as in the previous report. In addition, the forestry area by types of forests was modified, and there two new categories of Forest land were added, degraded forests and transitional forest land, for which different emission and removal factors were chosen from the IPCC Inventory Software. In the previous reports the data for those categories of Forest land were not taken into consideration. In this report, the two new categories were defined in the IPCC Inventory Software, by entering their area, growing stock and the emission and sink factors, different from other forest categories. Since there are no data available for those categories prior to 2010, the series cover only for the last 5 years.

#### 5.4.1.3 Above ground biomass growth

Revising the previous reports, it was noticed that the average annual above ground biomass growth factors (in tonnes dry matter per ha per year) used previously are not compatible with the national factors, actually they were too high to be used for Macedonian forests. Therefore, the above ground biomass growth factor for conifer, deciduous and mixed categories of forests was changed and two new categories were introduced in this report, using the data from actual Forestry management plans, provided by the experts from Ss Cyril and Methodius University - Faculty of Forestry, Department of Forest Management. These corrections of the growing stock level have been reflected to the whole series of the forestry sector, and can be recognized as an improvement of the inventory for the Forest land. The old and new

implemented above ground biomass growth factors for different forest categories are shown in Table 22.

***Table 22. Average annual above ground biomass growth level for Forest categories (in t d.m./ ha/yr)***

| Forest category | FBUR above ground biomass growth | SBUR above ground biomass growth |
|---|---|---|
| **Coniferous** | 4 | 5 |
| **Deciduous** | 4 | 2 |
| **Mixed forest** | 4 | 2.5 |
| **Transitive forest land** | – | 0.5 |
| **Degraded forest** | – | 0.9 |

#### 5.4.1.4 Land converted to Forest land

Since there are no data on annual level for changes in land use, the satellite images from CORINE Land Cover were used (see Chapter 5.7.2). The changes that were acknowledged for 6 year period were interpolated on annual bases and added to the actual land use change data given in the SSO reports. This was the first try to actually use modern technologies, such as satellite images, in this sector. Land use changes from forestry are shown in Table 23.

***Table 23. Forest land area (ha)***

| | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Forest land Remaining Forest land | 955,294 | 947,377 | 1,045,540 | 1,046,458 | 1,040,702 |
| Land converted to Forest land | 11,369 | 4,805 | 2,547 | 2,631 | 2,709 |
| **Total** | **966,663** | **952,182** | **1,048,087** | **1,049,089** | **1,043,411** |

#### 5.4.1.5 Forest for commercial use and firewood

Analyzing the previous inventory report under FBUR, it was noticed that in the worksheet, extraction of firewood was double counted in tables Loss of carbon from wood removals and Loss of carbon from fuel wood removals. This was corrected, and the series has been updated.

#### 5.4.1.6 Burned forest area

The data for the category Loss of carbon from disturbances was updated with combined data from the State Statistical Office, subjects that manage forests, MAFWE and Centre for crisis management. Significant differences were found for some years between the data from different sources, and the most appropriate one, according to the expert judgment, were used in this report.

#### 5.4.1.7 Emission trends

Emissions in Macedonia from forestry sector are product of the fuelwood consumption as well as the forest fires. The most constant producer of $CO_2$ emissions are the households that use fuelwood for heating. Forest fires are the second emitter of $CO_2$, but they are not constant, and their contribution varies greatly from year to year, depending on their number and the area that they cover, as well as the species composition in the burned areas. There are several years (2000, 2007, 2008, and 2012) where due to the large burned area, forestry sector instead of removing, contributed with increase of the GHG emissions in the country. The emissions/removals from Forest land for the reported years are given in Figure 26.

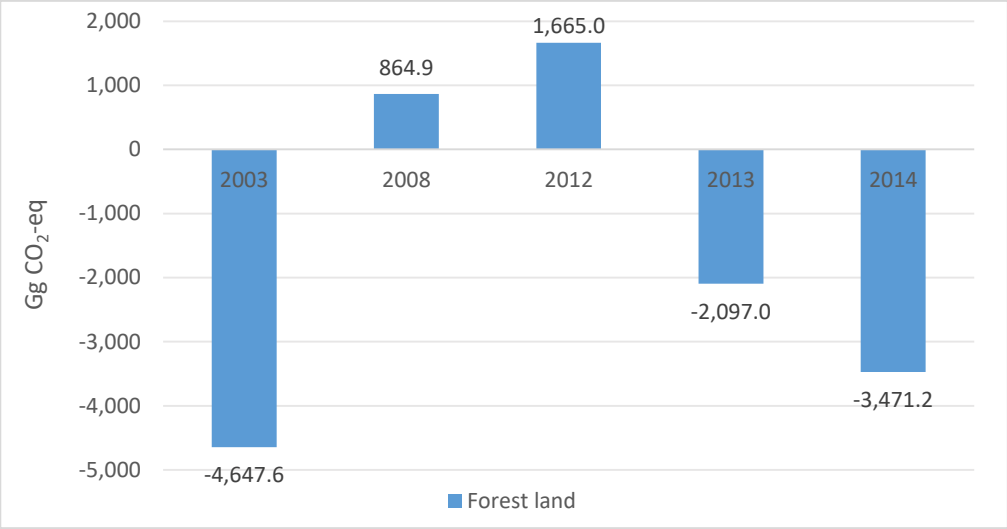



***Figure 26. GHG emissions and removals from Forest land (in Gg $CO_2$-eq)***

## 5.4.2 Cropland

The cropland in this report is considered as "cultivated land" according the State Statistical Office. The definitions of cultivated land as presented in "Statistical Yearbook of Republic of Macedonia (2016)" refers to land area under cultivation, used for growing field crops, perennial plants and grasses, and where cultivation, harvesting and other agricultural activities are performed, producing an annual yield. The cultivated area consists of arable land and gardens, orchards, vineyards and meadows. Arable land refers to land area where crop production takes place and which is sown with field crops: cereals, industrial crops, vegetables and fodder crops. Moreover, this includes and Fallow and uncultivated arable land. The fruit-bearing trees and grape-vines refer to trees and vines which by their physiological ripeness are ready to bear fruit under normal conditions for vegetation, regardless of whether they bore fruit or not in the reference year.

Therefore, the cropland area is basis for crop production, including vegetables, fruits and grape. These sectors are very important in national economy and some of them are important export products (tobacco and tobacco products, grape wine and wine, vegetable and processed vegetable etc.).

### 5.4.2.1 Total Cropland

The cropland in the country highly fluctuated from more than 650 thousand hectares in middle of 90's. The last 5-years period the cropland area stabilized to close to 515 thousand hectares with fluctuation of just several thousand hectares from year to year.

Moreover, we disaggregate the cropland area to annual crops area, perennial crops area and rice area in order to prepare to use the Tier2 approach when national emission factors will be developed. However, after intensive literature review it was concluded that there are no data available for determination of the national emission factors for various crops and cultivation practices in the present. Therefore, if intention of using the Tier2 methodology will be established as national priority in assessment of the GHG emissions in the crop production category the intensive investing in research related to determination of national emission factors is required.

#### 5.4.2.2 Rice growing area

The rice growing land fluctuated with strong drop in the middle of 90's from almost 9000 hectares in year 1990 to 1,296 ha in year 1995. This was result of severe dry period in the 90's and particularly proclamation of the drought as national disaster in year 1993. After this drop the quick growth in the rice planted land started but this trend changed with the significant drop in year 2001. After that rice was planted on about 2-3,000 ha. In last 5-years period there is evident trend of increase of the land planted with rice and again reached more than 5,000 ha in 2014.

#### 5.4.2.3 Perennial crops area

The land planted with perennial crops is estimated as sum of the land planted with orchards and vine grape planted land. The data source is same as previous, from the special publication Field crops, orchards and vineyards (period 2007-2014) and the "Statistical Yearbook of Republic of Macedonia", for the period 1990 – 2006.

#### 5.4.2.4 Land converted to Cropland

The conversions from one to other land use type presented in this report were prepared specially for this activity by the expert team, because there is no data available in the country. These land changes are important source of $CO_2$ emissions in the AFOLU sector, particularly when some other land type is converted into cropland. Due to decrease of agricultural activities and significant area of unused agricultural land in the country these changes are reduced in the last period.

#### 5.4.2.5 Cropland Remaining Cropland

The cropland area that remain as a cropland in each year was calculated, as a difference between the total cropland area and the total land use changes from other land use types (the results obtained from the conversion analyses conducted by CORINE Land Cover temporal analyses).

#### 5.4.2.6 Emission trends

The emissions from the Cropland is mainly caused by land use changes. The Cropland that remains as Cropland is carbon neutral and some emissions that are quite low in comparison with other sectors are due to conversion of the land use types to cropland. The land use changes are estimated for the period from year 2000-2014 and only this period can be analyzed. The emissions from Cropland are decreasing in time, due to decreasing of agricultural activities and significant portion of non-cultivated agricultural land (abonded, fallowed). The emissions in the years reported is highest in year 2003 with 466.7 Gg $CO_2$-eq. The minimal emissions are recorded in year 2012 with 114.9 Gg $CO_2$-eq, There is slight increase of emissions in year 2013 and 2014 with 120.6 and 123.8 Gg $CO_2$-eq, respectively. The GHG emissions for the reported years is given in Figure 27.

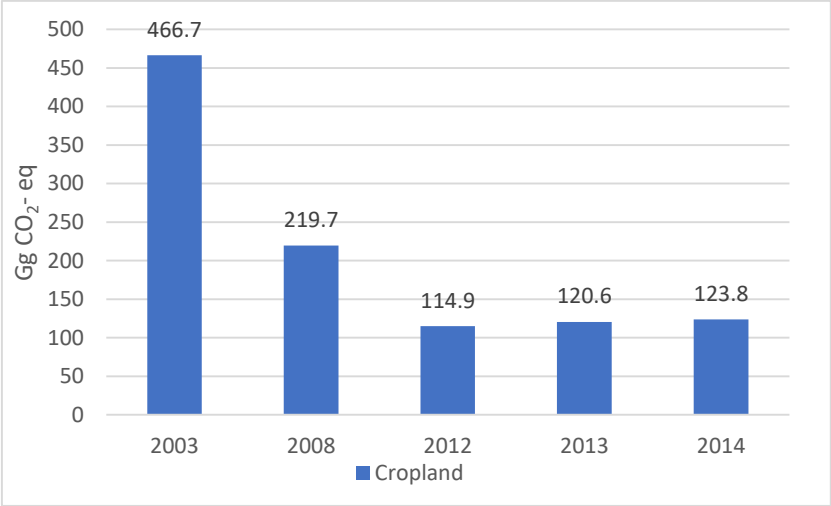



***Figure 27. GHG emissions from Cropland (in Gg $CO_2$-eq)***

### 5.4.3 Grassland

The Grassland in this report is considered as pasture land according to the State Statistical Office. The pastures together with the cultivated land represent the total agricultural land in the country. Unlike cultivated land the pastures are natural grassland that is permanent and there is not regular soil cultivation, fertilization, and other agricultural practices usually associated with cultivated land. While cropland in the country is managed by private farmers and enterprises the grassland is managed by the Public Enterprise for Pasture Management. The pastures are mainly located on the higher elevation above the forest line and parcels are big and managed by the state. Small portion of pasture land is privately owned.

Therefore, the grassland area is basis for sheep breeding. This sectors is very important in national economy and lamb meat is important export product. Unfortunately, the number of sheep in the country is reduced and size of the herd as well. Not all sheep are transferred during the summer on highland pastures and these are underutilized.

#### 5.4.3.1 Total Grassland

The Grassland in the country highly fluctuated. The minimal recorded Grassland is in 1999 with about 483,000 hectares and maximal recorded area is in 2012 of about 756,000 hectares. In the last 3-years period reported (2012-2014) the Grassland is stabilized to slightly above 750,000 hectares, what is among highest recorded in historical series analyzed.

Same as for the Cropland there is no sources available for determination of the national emission factors for various grassland and different management practices at the present. Hence, Tier1 methodology was applied and some preparation was made or using Tier2, such as introducing the land conversions from and to grassland.

#### 5.4.3.2 Land converted to Grassland

In order to determine changes from different land use type to grassland, a temporal analyses of the available CLC maps for Macedonia was conducted. The highest portion of conversion is the forest converted to grassland, as well as grassland converted to forest, so it can be concluded that forest and grassland exchange areas. Also, there is important land use change between cropland and grassland. For the period 1990 to 1999 it was not possible to provide even rough estimation of the land use changes on annual level, so this period remains same as presented in FBUR.

#### 5.4.3.3 Grassland remaining Grassland

The Grassland area that remain as a Grassland in each year was calculated as a difference between the total grassland area presented in data sources and total land use changes from other land use types, obtained from the conversion analyses conducted by CORINE Land Cover temporal analyses.

#### 5.4.3.4 Emission trends

The emissions from the Grassland is mainly caused by land use changes. The Grassland that remains as grassland is carbon neutral. The emissions presented are quite low in comparison with other sectors. The main source of these emissions is land use changes. The land use changes are estimated for the period from year 2000-2014 and only this period can be analyzed. The period of interest (year 2012-2014) shows slight increase of emissions from 125.9 to 134.9 Gg of $CO_2$-eq (Figure 28). Even though we report slight increase of GHG emissions in last 3-years period these emissions are much smaller than emissions in year 2003 with 344.1 Gg $CO_2$-eq. Therefore, as general conclusion we can say that in last 10-years period we have decreasing trend in GHG emissions from the Grassland.

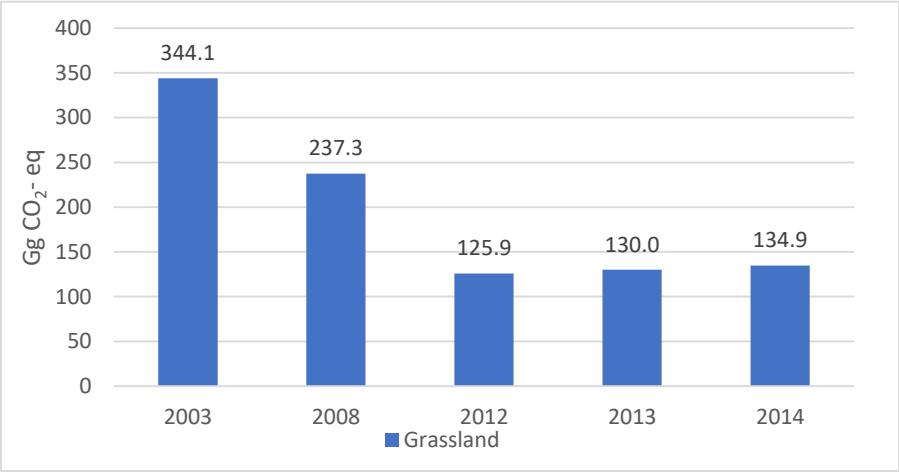



***Figure 28. GHG emissions from Grassland (in Gg $CO_2$-eq)***

### 5.4.4 Wetlands

The Wetlands are not reported by SSO and it was not possible to find data on Wetlands in the country. In this report, Wetlands data set was produced from CORINE Land Cover maps for year 2000, 2006 and 2012.

The Wetlands in the country are present on limited areas and these are small areas flooded by water during the remains of the reclaimed wetlands during the period of 50's and 60's of the last century. In that period the big land reclamation projects for drying the wetlands and drainage of the waterlogged soils were conducted in order to solve malaria problem, to create new fertile land for agriculture or to protect soils from waterlogging during the wet period of the year. The drainage systems were developed on the 82,195 ha. So, nowadays the wetlands are distributed on about 2000 ha.

#### 5.4.4.1 Total Wetland

Data for the total Wetland were developed from the CLC maps. Therefore, the category Wetland, according to the CLC nomenclature, was used to derive data for wetlands in Macedonia. The only category of the wetlands in Macedonia according CLC is Inland wetlands, particularly Inland marshes. So, only this category was used to estimate wetland

area in the country. In order to fill years 2001-2005 and 2007-2014 regression analyses was used to estimate wetlands when CLC data is not available. The used regression was linear.

#### 5.4.4.2 Land converted to Wetland

Changes from different land use type to wetland were also using the CLC maps for Macedonia. The highest portion of conversion is the forest converted to wetland. The wetlands are mostly converted to cropland. For the period 1990 to 1999 it was not possible to provide even rough estimation of the land use changes on annual level, so this period remains same as presented in FBUR.

#### 5.4.4.3 Wetland remaining Wetland

The Wetland area that remain as a Wetland in each year was calculated as a difference between the total wetland area presented in the data sources and the total land use changes from other land use types, obtained from the conversion analyses conducted by CORINE Land Cover temporal analyses.

### 5.4.5 Settlements

The land occupied by artificial structures, particularly Settlements is not reported by State Statistical Office and it was not possible to find data on this land use category in any of the reliable data sources in the country. In this report, the Settlement data set was obtained from CORINE Land Cover maps.

The Settlements in this report are considered as CLC land class continuous urban-fabric and discontinuous urban-fabric. Therefore, the Settlements area is land covered by urban and industrial infrastructure.

#### 5.4.5.1 Total Settlements

Due to big mapping unit and big width of the linear objects in CLC maps, the numerous villages from disaggregated type are probably not considered as urban area. The applied methodology is not best fitting to the area covered by small infrastructure as result of applied coarse scale, but this was the best data source available at the moment. Moreover, this augments the need of classification of the land use on annual basis conducted by some of the national institutions and applying methodology that will better fit national circumstances as small size of some urban areas, existence of the complex of urban/agricultural land etc. Also, this will solve problem of annual data for land use changes, using real data, not estimations based on regression analyses. Such capacities exist in the country and it is matter of mobilization of the experts that can conduct such analyses on regular basis. This is of importance for land degradation convention and can provide reliable data on soil sealing in the country. So, it is highly recommended to put high priority and empower this issue in future.

Finally, CLC category Settlements was used to derive data for settlements in Macedonia. Particularly, following CLC categories Continuous urban-fabric and Discontinuous urban-fabric. In order to fill years 2001-2005 and 2007-2014 a regression analyses was used to estimate settlements when CLC data is not available. The used regression was linear.

#### 5.4.5.2 Land converted to Settlements

The conversions from one land type to Settlements was estimated using the same approach as for the other land types (using CLC maps)

#### 5.4.5.3 Settlements remaining Settlements

The Settlements area that remain as a Settlements in each year was calculated as a difference between the total Settlements area and the total land use changes from other land use types, obtained from the conversion analyses conducted by CORINE Land Cover temporal analyses.

#### 5.4.5.4 Emission trends

The emissions from the Settlements is mainly caused by land use changes. The Settlements that remain as Settlements is carbon neutral and some emissions that are quite low in comparison with other sectors are due to conversion of the land use types to Settlements. The land use changes are estimated for the period from year 2000-2014 and only this period can be analyzed. From the beginning of the analyzed period (year 2003 to 2014) there is trend of reduction of the GHG emissions from Settlements land use type. However it was noticed slight increasing trend in last 3-year period (2012 to 2014), when emissions increased from 24.2 to 25.9 Gg $CO_2$-eq, but this increase is almost negligible when these values are compared with emissions in year 2003 of 90.1 Gg $CO_2$-eq (Figure 29).

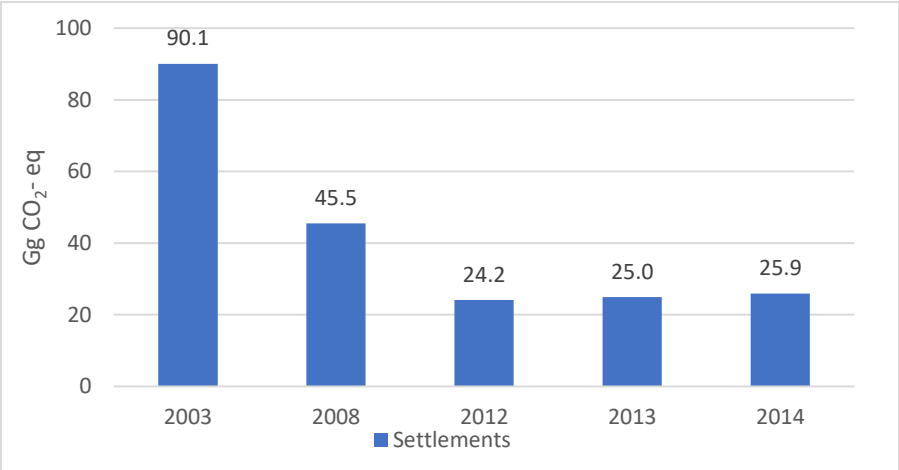



***Figure 29. GHG emissions from Settlements (in Gg $CO_2$-eq)***

### 5.4.6 Other land

The land that is occupied by some other land use type than Forest Land, Cropland, Wetland and Settlements is reported as Other land. Such category does not exist in the documents provided by State Statistical Office, or any other national document. However, there is class other land in CLC, but it is not same other land as needed in this analysis. Therefore, the other land class was calculated as a difference between the total territory of Macedonia and sum of the land use classes Forest Land, Cropland, Wetland and Settlements.

The other land in this report was considered all lend that do not belong to the land use classes: Forest Land, Cropland, Wetland and Settlements.

#### 5.4.6.1 Total Other land

Data for the total other land was developed as mathematical difference between territory of Macedonia and land use classes: Forest Land, Cropland, Wetland and Settlements.

#### 5.4.6.2 Land converted to Other land

The conversions from one land type to other land was estimated using the same approach as for the other land types (using CLC maps)

#### 5.4.6.3 Other land area remaining Other land

The Other land area that remain as Other land in each year was calculated as a difference of the total other land area and the total land use changes from other land use types, obtained from the conversion analyses conducted by CORINE Land Cover temporal analyses.

#### 5.4.6.4 Emission trends

The emissions from the other land is mainly caused by land use changes. The other land that remains as other land is carbon neutral and some emissions that are very low in comparison with other sectors are due to conversion of the land use types to other land. The land use changes are estimated for the period from year 2000-2014 and only this period can be analyzed. The GHG emissions from other land use class in year 2013 is 6.6 Gg CO2-eq, while in year 2014 is slightly lower with 5.5 Gg $CO_2$-eq. It is big decrease in comparison with the emissions in year 2008 (9.0 Gg $CO_2$-eq). Anyhow, this decrease, even though it seems big, is almost not very important due to low emissions from this land use class (Figure 30).

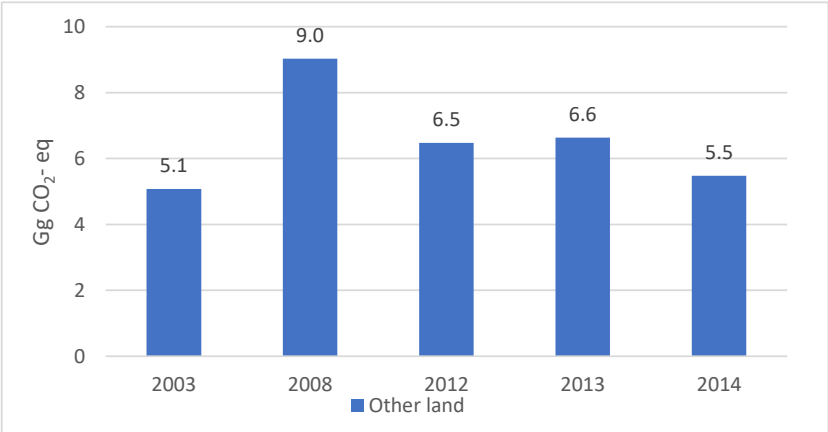



***Figure 30. GHG emissions from Other land (in Gg $CO_2$-eq***

## 5.5 Aggregate sources and non-$CO_2$ emissions sources on land

The Land category, despite the $CO_2$ emissions and/or sinks, is characterized with non-$CO_2$ emissions, particularly as a result of biomass burning, $N_2O$ emissions from managed soils, including indirect $N_2O$ emissions from additions of N to land due to deposition and leaching, and emissions of $CO_2$ following additions of liming materials and urea-containing fertilizer.

Liming as a process of changing soil structure is not used in Macedonia. Hence, it is not a part of the report, since there are no emissions occurring from this process.

The emissions considered here are from different sources as urea application, direct $N_2O$ emissions from managed soils, indirect $N_2O$ emissions from managed soils, indirect $N_2O$ emissions from manure management and methane emissions from rice cultivation.

Managed soils are all soils on land, including Forest land, which is managed according management common for the land use classes the soils are used for.

The emissions from these sources, despite direct $N_2O$ emissions from managed soils, are not very high, but when aggregated they are much higher than direct $CO_2$ emissions from any of the land use classes. In the years 2013 and 2014 the emissions are 322.8 Gg $CO_2$-eq and 328.1 Gg $CO_2$-eq, respectively (Table 24 and Figure 31).

***Table 24. GHG emissions from Aggregate sources and non-$CO_2$ emissions sources on land (in Gg $CO_2$-eq)***

| Categories / Категории | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Aggregate sources and non-$CO_2$ emissions sources on land / Збирни извори и извори на емисии на други гасови од земјиштето кои не се $CO_2$** | **309.8** | **358.2** | **326.8** | **322.8** | **328.2** |
| Urea application / Примена на уреа | 4.9 | 4.5 | 5.7 | 5.7 | 5.7 |
| Direct $N_2O$ emissions from managed soils / Директни $N_2O$ емисии од обработени почви | 192.4 | 226.7 | 198.2 | 196.0 | 197.7 |
| Indirect $N_2O$ emissions from managed soils / Индиректни $N_2O$ емисии од обработени почви | 70.4 | 84.5 | 72.0 | 71.3 | 72.0 |
| Indirect $N_2O$ emissions from manure management / Индиректни $N_2O$ емисии од шталско ѓубре | 27.3 | 29.9 | 27.9 | 26.8 | 27.3 |
| Rice cultivations / Површини под ориз | 14.8 | 12.6 | 22.9 | 22.9 | 25.4 |

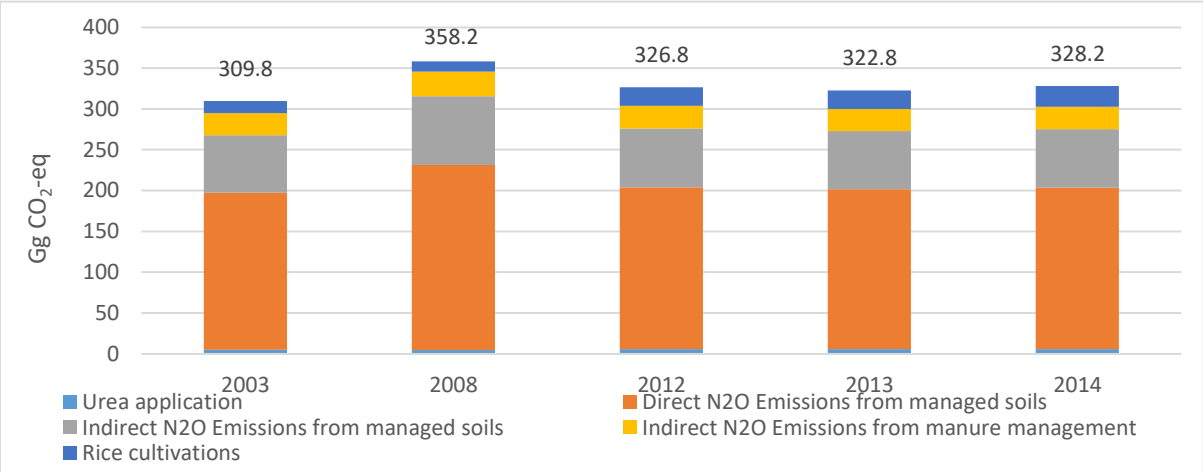



***Figure 31. GHG emissions from Aggregate sources and non-$CO_2$ emissions sources on land (in Gg $CO_2$-eq)***

## 5.5.1 Urea application

Adding urea to soils during fertilization leads to a loss of $CO_2$ that was fixed in the industrial production process. Urea ($CO(NH_2)_2$) is converted into ammonium ($NH_4^{+2}$), hydroxyl ion ($OH^-$ ), and bicarbonate ($HCO3^-$), in the presence of water and urease enzymes. Similar to the soil reaction following addition of lime, bicarbonate that is formed evolves into $CO_2$ and water.

### 5.5.1.1 Emission trends

The emissions from the urea application is mainly caused by use of urea fertilizers on managed agricultural soils. Even though in the last 3-years of the period investigated the value is not changing and is stabilized to 5.7 Gg. In general we can say that emissions from urea applications are slightly increasing by time (Figure 32).

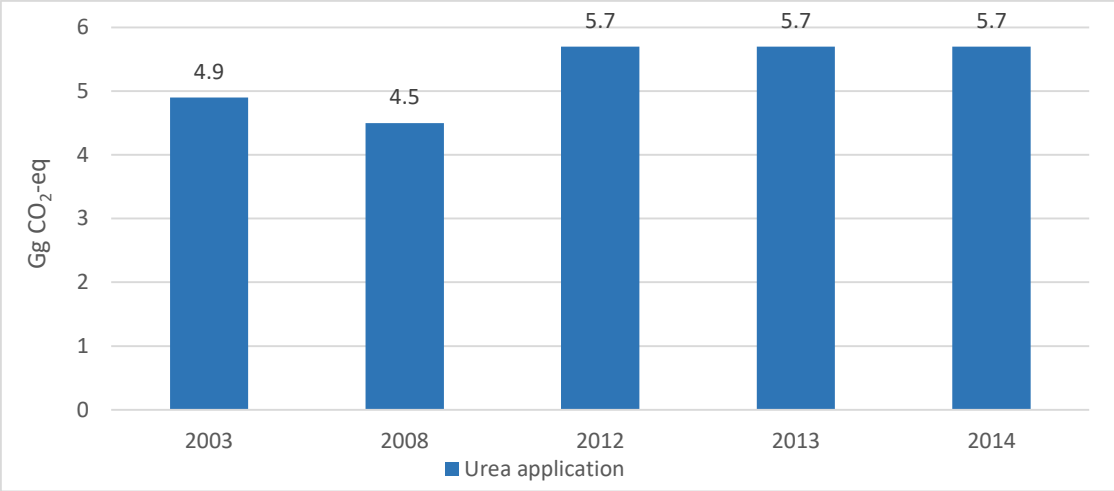



***Figure 32. GHG emissions from Urea applications (in Gg $CO_2$-eq)***

### 5.5.2 Direct $N_2O$ emissions from managed soils

In most soils, an increase in available N enhances nitrification and de-nitrification rates which then increase the production of $N_2O$. Increases in available N can occur through human-induced N additions or change of land-use and/or management practices that mineralize soil organic N.

Nitrous oxide is produced naturally in soils through the processes of nitrification and de-nitrification. Nitrification is the aerobic microbial oxidation of ammonium to nitrate, and de-nitrification is the anaerobic microbial reduction of nitrate to nitrogen gas (N). Nitrous oxide is a gaseous intermediate in the reaction sequence of de-nitrification and a by-product of nitrification that leaks from microbial cells into the soil and ultimately into the atmosphere. One of the main controlling factors in this reaction is the availability of inorganic N in the soil.

This methodology, therefore, estimates $N_2O$ emissions using human-induced net N additions to soils (e.g., synthetic or organic fertilizers, deposited manure, crop residues, sewage sludge), or of mineralization of N in soil organic matter following drainage/management of organic soils, or cultivation/land-use change on mineral soils (e.g. Forest land/Grassland/Settlements converted to Cropland).

#### 5.5.2.1 Emission trends

The direct $N_2O$ emissions from managed soils are mainly caused by use of nitrogen fertilizers on managed agricultural soils in common agricultural practice. According Zhang et al. (2015) the crop yield is closely related to increase of the nitrogen supply, but, maize yield has increased in the USA since 2001 without increasing nationally averaged N input rates, suggesting that the yield improvement has been achieved by adopting more efficient technologies or management practices that shift the yield response curve upwards. The increasing of nitrogen fertilizer use efficiency is one of the possible directions to achieve higher yields with less nitrogen use. This strategy can be valuable practice for reducing $N_2O$ emissions from managed soils.

During the last 2-years of the period investigated the value of the $N_2O$ emissions from managed soils is very stable and estimated to 196.0 Gg $CO_2$-eq in 2013 and 197.7 Gg $CO_2$-eq in 2014 (Figure 33). In general, we can say that the direct $N_2O$ emissions from managed soils are stabile in last period, even though there is some fluctuation in the analyzed time series. Also, we can consider this source of emissions as important emissions source in AFOLU sector.

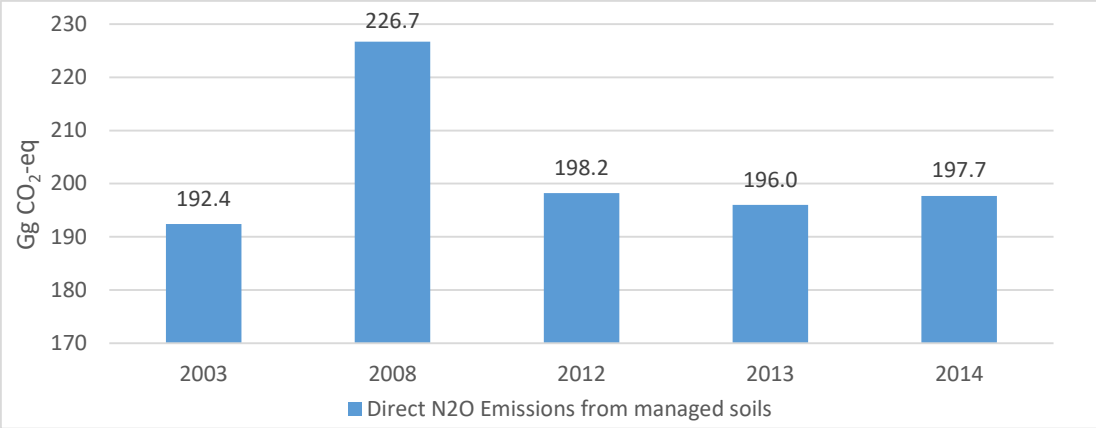



***Figure 33. Direct $N_2O$ emissions from managed soils (in Gg $CO_2$-eq)***

### 5.5.3 Indirect $N_2O$ emissions from managed soils

In addition to the direct emissions of $N_2O$ from managed soils that occur through a direct pathway (i.e., directly from the soils to which N is applied), emissions of $N_2O$ also take place through two indirect pathways.

The first of these pathways is the volatilization of N as $NH_3$ and oxides of N ($NO_x$), and the deposition of these gases and their products $NH_4^+$ and $NO_3^-$ onto soils and the surface of lakes and other waters. The sources of N as $NH_3$ and $NO_x$ are not confined to agricultural fertilizers and manures, but also include fossil fuel combustion, biomass burning, and processes in the chemical industry. Thus, these processes cause $N_xO$ emissions in an exactly analogous way to those resulting from deposition of agriculturally derived $NH_3$ and $NO_x$, following the application of synthetic and organic N fertilizers and /or urine and dung deposition from grazing animals.

The second pathway is the leaching and runoff from land of N from synthetic and organic fertilizer additions, crop residues, mineralization of N associated with loss of soil C in mineral and drained/managed organic soils through land-use change or management practices, and urine and dung deposition from grazing animals. Some of the inorganic N in or on the soil, mainly in the $NO_3$- form, may bypass biological retention mechanisms in the soil/vegetation system by transport in overland water flow (runoff) and/or flow through soil macro pores or pipe drains. Where $NO_3^-$ is present in the soil in excess of biological demand, e.g., under cattle urine patches, the excess leaches through the soil profile. The nitrification and de-nitrification processes transform some of the $NH_4^+$ and $NO_3^-$ to $N_2O$. This may take place in the groundwater below the land to which the N was applied, or in riparian zones receiving drain or runoff water, or in the ditches, streams, rivers and estuaries (and their sediments) into which the land drainage water eventually flows. So, the managed soils can be important source of $N_2O$ trough the indirect emission.

#### 5.5.3.1 Emission trends

The emissions from the indirect $N_2O$ from managed soils is caused not only by use of nitrogen fertilizers and manure, but also some other natural and human induced processes (fossil fuel combustion, biomass burning, some processes in the chemical industry, loss of soil C in mineral and drained/managed organic soils through land-use change or management practices, urine and dung deposition from grazing animals etc. In the last 2-years of the period investigated the value is stabilized to about 72 Gg $CO_2$-eq. In general we can say that indirect $N_2O$ emissions from managed soils used to fluctuate over the time, but in last period they were stable (Figure 34).

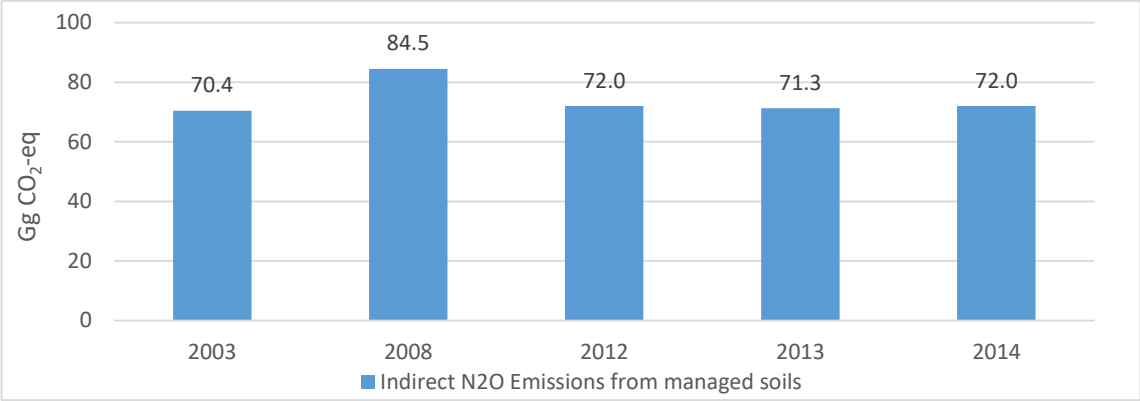



***Figure 34. Indirect $N_2O$ emissions from managed soils (in Gg $CO_2$-eq)***

### 5.5.4 Indirect $N_2O$ emissions from manure management

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and $NO_x$. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure collection and storage depends primarily on time, and to a lesser degree temperature. Simple forms of organic nitrogen such as urea (mammals) and uric acid (poultry) are rapidly mineralized to ammonia nitrogen, which is highly volatile and easily diffused into the surrounding air. Nitrogen losses begin at the point of excretion in houses and other animal production areas (e.g., milk parlors) and continue through on-site management in storage and treatment systems (i.e., manure management systems). Nitrogen is also lost through runoff and leaching into soils from the solid storage of manure at outdoor areas, in feedlots and where animals are grazing in pastures.

#### 5.5.4.1 Emission trends

The indirect $N_2O$ emissions from manure management were mainly caused through on-site management in storage and treatment systems of manure (i.e. manure management systems). During the last 2-years of the period investigated the levels were 26.8 Gg $CO_2$-eq in 2013 and 27.3 Gg $CO_2$-eq in 2014. In general, the indirect $N_2O$ emissions from manure management are stabile by time (Figure 35).

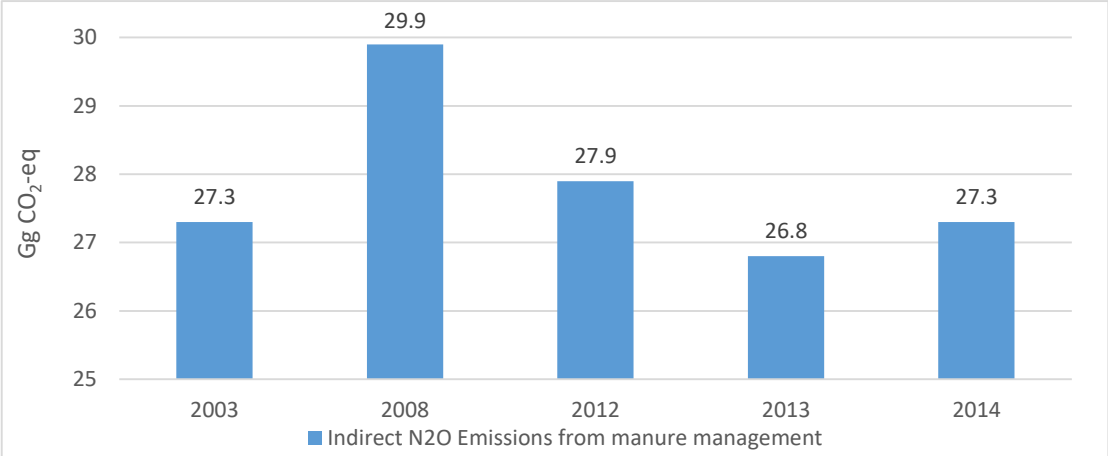



***Figure 35. Indirect $N_2O$ emissions from managed soils from manure management (in Gg $CO_2$-eq)***

### 5.5.5 Rice cultivation

Flooded rice fields are a significant source of atmospheric $CH_4$. The emissions are the net result of opposing bacterial processes, production in anaerobic microenvironments, and consumption and oxidation in aerobic microenvironments, both of which can be found side by side in flooded rice soils.

#### 5.5.5.1 Emission trends

The methane emissions from rice cultivation are caused by rice cultivation practice of growing the rice in flooded basins during the whole season. The methane is result of the anaerobic processes into the flooded soil. The emissions of methane from rice field fluctuated as rice growing area in the country, having the highest values at the beginning of the considered period, than rapidly decrease with the very dry period in the middle 90's and irrigation reforms at the beginning of 2000's. In last period, there is trend of permanent increase of the rice growing area that is followed by increase of the $CH_4$ emissions. During the last 2-years of the period investigated the emissions of methane from rice cultivation were 22.9 Gg $CO_2$-eq in 2013 and 25.4 Gg $CO_2$-eq in 2014 (Figure 36). In general, we can say that emissions from rice cultivation in last period slightly increase by time and if trend of increasing of rice growing area keeps this can be very important source of atmospheric methane.

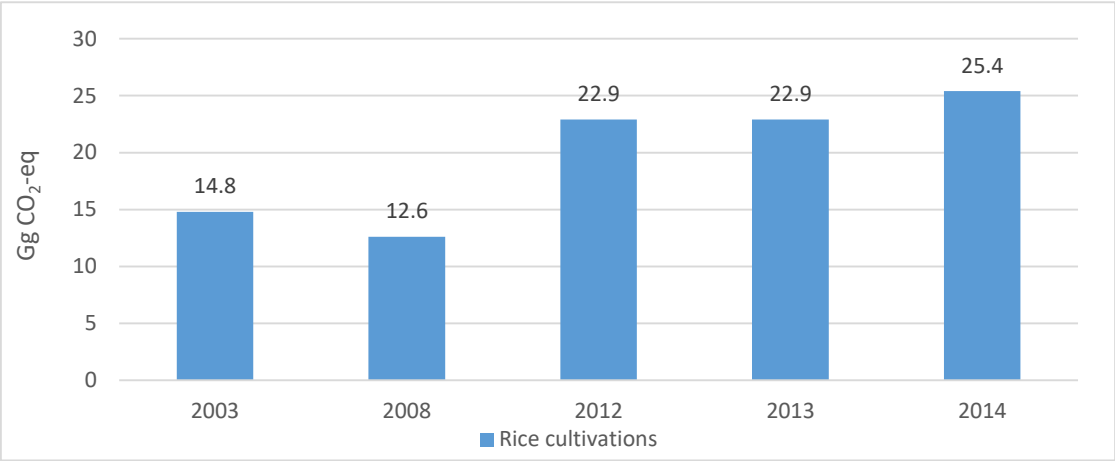



***Figure 36. Emissions of $CH_4$ from rice cultivation (in Gg $CO_2$-eq)***

## 5.6 Methodology and emission factors

### 5.6.1 Livestock

Emissions intensities (emissions per unit of animal product) vary greatly between production units, even within similar production systems. This variability is due to different farming practices and supply chain management. In order to be able to distinguish different systems and practice levels deep descriptive data set is needed. Statistical yearbooks are still not providing such a data. Hence for the inventory Tier1 methodology was used.

In the future in order to apply Tier2 methodology, it is necessary to do assessment, where a typical farm size, system and technology will be modeled. It is of particular importance to do assessment in Cattle, where majority of farms are small size with different production system and purpose is applied. For this report it was not possible to check ratios of different manure systems used in farms with dairy cows and other cattle. Also it is important to access small pig farms, since a half of the pig production is coming from them. On these farms there various

manure management practices, and pig manure management is contributing with 20% in total livestock $N_2O$ emissions.

The emission factors used for GHG emissions inventory in livestock activities under SBUR, are given in Table 25.

***Table 25. Emission factors used for GHG emissions inventory in livestock activities***

| Emission factor | FBUR | SBUR | Comment |
|---|---|---|---|
| **Livestock** | | | |
| **Dairy cows (enteric - $CH_4$)** | 99 kg/head/year | 99 kg/head/year | |
| **Other cattle (enteric- $CH_4$)** | 58 kg/head/year | 58 kg/head/year | |
| **Sheep (enteric- $CH_4$)** | 5 kg/head/year | 5 kg/head/year | 40kg live weight |
| **Sheep < 1 Y (enteric- $CH_4$)** | - | 5 kg/head/year | Sheep < 1 Y with 28kg live weight |
| **Goat (enteric- $CH_4$)** | 5 kg/head/year | 5 kg/head/year | |
| **Horses (enteric- $CH_4$)** | 18 kg/head/year | 18 kg/head/year | |
| **Swine (enteric- $CH_4$)** | 1 kg/head/year | 1 kg/head/year | 180 kg live weight |
| Finishers (enteric- $CH_4$) | - | 1 kg/head/year | Finishers 50 kg live weight |
| **Dairy cows (manure - $CH_4$)** | 20 kg/head/year | 20 kg/head/year | |
| **Dairy cows (manure - $N_2O$)** | 0.35 kg/1000 kg/day<br>18% liquid slurry (40% N loss);<br>67% solid storage slurry (40% N loss);<br>1% daily spread slurry (22% N loss)<br>13% pasture<br>0.005 Direct $N_2O$ - N | 0.35 kg/1000 kg/day<br>18% liquid slurry (40% N loss);<br>67% solid storage slurry (40% N loss);<br>1% daily spread slurry (22% N loss)<br>13% pasture<br>0.005 Direct $N_2O$ - N | |
| **Other cattle (manure- $CH_4$)** | 9 kg/head/year | 9 kg/head/year | |
| **Other cattle (manure- $N_2O$)** | 0.35 kg/1000 kg/day<br>18% liquid slurry (40% N loss);<br>67% solid storage slurry (40% N loss);<br>1% daily spread slurry (22% N loss)<br>13% pasture<br>0.005 Direct $N_2O$ - N | 0.35 kg/1000 kg/day<br>18% liquid slurry (40% N loss);<br>67% solid storage slurry (40% N loss);<br>1% daily spread slurry (22% N loss)<br>13% pasture<br>0.005 Direct $N_2O$ - N | |
| **Sheep (manure- $CH_4$)** | 0.15 kg/head/year | 0.15 kg/head/year | t |
| **Sheep (manure- $N_2O$)** | 0.9 kg/1000 kg/day<br>20% solid storage<br>80% pasture<br>0.005 Direct $N_2O$ - N | 0.9 kg/1000 kg/day<br>20% solid storage<br>80% pasture<br>0.005 Direct $N_2O$ - N | 40 kg live weigh |
| **Sheep < 1 Y (manure- $CH_4$)** | - | 0.15 kg/head/year | Sheep < 1 Y with 28kg live weight |
| **Sheep < 1 Y (manure- $N_2O$)** | - | 0.9 kg/1000 kg/day<br>20% solid storage<br>80% pasture<br>0.005 Direct $N_2O$ - N | Sheep < 1 Y with 28kg live weight |
| **Goat (manure- $CH_4$)** | 0.17 kg/head/year | 0.17 kg/head/year | |
| **Goat (manure- $N_2O$)** | 1.28 kg/1000 kg/day<br>20% solid storage<br>80% pasture<br>0.005 Direct $N_2O$ - N | 1.28 kg/1000 kg/day<br>20% solid storage<br>80% pasture<br>0.005 Direct $N_2O$ - N | |
| **Horses (manure- $CH_4$)** | 1.64 kg/head/year | 1.64 kg/head/year | |
| **Horses (manure- $N_2O$)** | 100% pasture | 100% pasture | |
| **Swine (manure- $CH_4$)** | 6 kg/head/year | 6 kg/head/year | 180 kg live weight |
| **Swine (manure- $N_2O$)** | 0.46 kg/1000 kg/day | 0.46 kg/1000 kg/day | 180 kg live weight |

| Emission factor | FBUR | SBUR | Comment |
|---|---|---|---|
| | 60% Pit storage (25% N loss); 0.002 Direct $N_2O$ – N 40% solid storage (50% N loss); 0.005 Direct $N_2O$ - N | 60% Pit storage (25% N loss); 0.002 Direct $N_2O$ – N 40% solid storage (50% N loss); 0.005 Direct $N_2O$ - N | |
| **Finishers (manure- $CH_4$)** | - | 6 kg/head/year | Finishers 50 kg live weight |
| **Finishers (manure-$N_2O$)** | - | 0.55 kg/1000 kg/day 60% Pit storage (25% N loss); 0.002 Direct $N_2O$ – N 40% solid storage (50% N loss); 0.005 Direct $N_2O$ - N | Finishers 50 kg live weight |
| **Poultry (manure- $CH_4$)** | 0.2 kg/head/year | - | 1.8 kg live weight |
| **Poultry (manure- $N_2O$)** | 0.82 kg/1000 kg/day 100% Poultry litter (50% N loss); 0.001 Direct $N_2O$ - N | - | 1.8 kg live weight |
| **Layers (manure- $CH_4$)** | - | 0.2 kg/head/year | 1.8 kg live weight |
| **Layers (manure- $N_2O$)** | - | 0.82 kg/1000 kg/day 100% Poultry litter (50% N loss); 0.001 Direct $N_2O$ - N | 1.8 kg live weight |
| **Broilers (manure- $CH_4$)** | - | 0.2 kg/head/year | 0.9 kg live weight |
| **Broilers (manure- $N_2O$)** | - | 1.1 kg/1000 kg/day 100% Poultry litter (50% N loss); 0.001 Direct $N_2O$ - N | 0.9 kg live weight, specific factors for broilers were used |
| **Turkey (manure- $CH_4$)** | - | 0.9 kg/head/year | 6.8 kg live weight, specific factors for Turkey were used |
| **Turkey (manure- $N_2O$)** | - | 0.74 kg/1000 kg/day 100% Poultry litter (50% N loss); 0.001 Direct $N_2O$ - N | 6.8 kg live weight, specific factors for Turkey were used |
| **Other (manure- $CH_4$)** | - | 0.2 kg/head/year | 1.8 kg live weight |
| **Other (manure- $N_2O$)** | - | 0.82 kg/1000 kg/day 100% Poultry litter (50% N loss); 0.001 Direct $N_2O$ - N | 1.8 kg live weight |

## 5.6.2 Land

### 5.6.2.1 Forest land

Methodology used for estimation of the emissions is Tier 1, since there are no accurate data on annual level. Improvement has been made by using CORINE Land Cover maps to establish annual land use changes. Also, the annual increment of different types of forests, were changed and used national averages for different categories of forests, provided by the experts from Ss Cyril and Methodius University - Faculty of Forestry, Department of Forest Management. Default emission factors were used from the IPCC Inventory Software (in accordance with 2006 IPCC Guidelines).

### 5.6.2.2 Cropland, Grassland, Wetlands, Settlements and Other Lands

Methodology used for estimation of the emissions from these land use types is Tier 1. Even though some very valuable and important efforts for using Tier 2 were done, the most important challenge is to develop country specific emission factors for various land use types. Our research showed that there is not any scientific/expert paper on determination of the GHG emission factors from various land use types in the country. The serious efforts and investment

in research activities is required in order to develop country specific emission factors associated with different land use types.

## 5.7 Data sources

### 5.7.1 Livestock

In the inventory of the GHG emissions due to livestock activities, the official "Statistical Yearbooks of the Republic of Macedonia" were used (see Table 26). The data provided in Statistical reviews was fully agreed with FAOstat and Eurostat. For the reported years in some livestock species data for different categories was available and it was used in assessment (e.g. sheep, pigs and poultry). In addition, in order to produce trends detailed data since 2007 was used.

***Table 26. Data sources for GHG emissions inventory in Livestock activities***

| | Documents | Data provider |
|---|---|---|
| **Livestock** | Statistical review: Agriculture 5.4.9.03 | SSO, 2009 |
| | Statistical review: Agriculture 5.4.11.03 | SSO, 2011 |
| | Statistical review: Agriculture 5.4.13.01 | SSO, 2012 |
| | Statistical review: Agriculture 5.4.13.03 | SSO, 2013 |
| | Statistical review: Agriculture 5.4.14.03 | SSO, 2014 |
| | Statistical review: Agriculture 5.4.15.03 | SSO, 2015 |

Data for GHG emissions inventory due to activities in Livestock production are given in A II.1.3, Table 66. All numbers of heads are taken directly from sources except for broilers and turkey, where the data were corrected for annual cycles (0.1644 for broilers and 0.3856 for turkey)

### 5.7.2 Land

In the inventory of the GHG emissions, due to different land use and management practices several sources were used. The official "Statistical Yearbooks of the Republic of Macedonia" were the major source of information. In agricultural sector for the period year 2007 and later data from the SSO publication Field crops, orchards and vineyards were used. The data provided in Statistical reviews was fully agreed with FAOstat and Eurostat. Moreover, for forestry sub-sector data sources included Forestry management plans and data from the Ss Cyril and Methodius University - Faculty of Forestry (Table 27). However, some land use classes are not reported in national documents (wetlands, settlements, other land) and for this purpose we used CLC (Table 28, Table 29, Table 30, Table 31, Table 32).

In order to determine changes from one to other land use type, a temporal analyses of the available CORINE Land Cover maps for Macedonia were conducted. The CLC is referring to a European program establishing a computerized inventory on land cover of the 28 EU member states and other European countries. The CLC maps are sourced from European Environmental Agency for the year 2000, year 2006 and year 2012. These years are the only 3 periods that CLC maps are available for territory of Macedonia. The analyses gave us the land use changes in 3 points: year 2000, year 2006 and year 2012. In order to convert these points in annual land use changes we conducted regression analyze, and estimate annual land use changes for the period 2000-2014. Using the same regression for the period 1990 to 1999 did not provide a good base and for this period it was not possible to present even rough estimation of the land use changes on annual level, so this period remains same as presented in FBUR.

The CLC methodology used 44 classes of the 3-level CORINE nomenclature. 38 countries with a total area of 5.8 $Mkm^2$ participate in this initiative. Macedonia is part of this activity since year 2000 and there is time series of 3 maps (as stated above).

Technical parameters of CORINE Land Cover show that mapping scale is 1:100.000 and minimum mapping unit (MMU) is 25 hectares. The minimum width of linear elements is 100 meters. The standard CLC nomenclature includes 44 land cover classes, grouped in a three-level hierarchy. Five main categories are "artificial surfaces", "agricultural areas", "forest and semi-natural areas", "wetlands", "water bodies".

#### 5.7.2.1 Forest land

Data for the preparation of GHG inventory for the Forestry sector was collected from several main sources: State Statistical office, Ministry of Agriculture, Forestry and Water Economy (MAFWE), subjects that manage state and private owned forests, Ss Cyril and Methodius University – Faculty of Forestry, Center for management of crises (CMC), Firefighting union (FFU) of Macedonia, expert opinions and other domestic and international sources. The sources of data for different categories are presented in Table 27. Land use changes from forestry are shown in A II.1.3, Table 67.

***Table 27. Data sources for Forestry sector***

| | Documents | Data provider |
|---|---|---|
| **Forest area** | SSO Yearbooks 2000 – 2015 (Forestry); Forestry management plans | SSO<br>Subjects that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE |
| **Forest types** | SSO Yearbooks 2000 – 2015 (Forestry); Forestry management plans | SSO<br>Subjects that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE |
| **Above ground biomass growth** | Forestry management plans; Actual management plans with different 10 year period<br>Department of Forest growth and yield | Subjects that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE<br><br>Ss Cyril and Methodius University - Faculty of Forestry |
| **LU change** | SSO Yearbooks 2000 – 2015 (Forestry); Own estimation based on temporal analyses of CORINE Land Cover maps for year 2000, 2006 and 2012 | SSO<br>European Environmental Agency/Expert team |
| **Removal from forests** | SSO Yearbooks 2000 – 2015 (Forestry); Monthly and Annual Reports | SSO<br>Subjects that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE |
| **Burned forest area** | SSO Yearbooks 2000 – 2015 (Forestry); Annual reports; Internal documents | Subjects that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE, CMC, FFU |

#### 5.7.2.2 Cropland

Data for the preparation of GHG inventory for the Land use class of cropland was collected from several main sources: State Statistical office as main source of actual land use in the country and European Environmental Agency CORINE Land Cover maps and analysis for land use changes based on these maps conducted by the expert team. The sources of data for different categories are presented in Table 28. The areas that were used in GHG inventory in the category cropland are in A II.1.3, Table 68.

***Table 28. Data sources for Cropland***

| | Documents | Data provider |
|---|---|---|
| **Cropland area** | Field crops, orchards and vineyards (2007-2014) Statistical Yearbook of Republic of Macedonia (1990-2006) | SSO |
| **Permanent crops area** | Own calculation based on: Field crops, orchards and vineyards (2007-2014) and Statistical Yearbook of Republic of Macedonia (1990-2006); sum of area of orchards and grape yards | SSO |
| **Rice growing Area** | Field crops, orchards and vineyards (2007-2014) Statistical Yearbook of Republic of Macedonia (1990-2006) | SSO |
| **Annual crops area** | Own calculation based on: Field crops, orchards and vineyards (2007-2014) and Statistical Yearbook of Republic of Macedonia (1990-2006); cropland area minus permanent crop area minus rice growing area | Expert team |
| **Cropland remaining cropland area** | Own calculation based on: Field crops, orchards and vineyards (2007-2014) and Statistical Yearbook of Republic of Macedonia (1990-2006); cropland area minus areas that are in change from CORINE Land Use changes estimation | Expert team |
| **Conversions (LU changes)** | Own estimation based on temporal analyses of CORINE Land Cover maps for year 2000, 2006 and 2012 | European Environmental Agency/Expert team |

### 5.7.2.3 Grassland

Data for the preparation of GHG inventory for the Land Use category of Grassland was collected from several main sources: State Statistical office as main source of actual land use in the country and European Environmental Agency CORINE Land Cover maps and analysis for land use changes based on these maps conducted by the expert team. The sources of data for different categories are presented in Table 29. The areas that were used in GHG inventory in the category Grassland are in A II.1.3, Table 69.

***Table 29. Data sources for Grassland***

| | Documents | Data provider |
|---|---|---|
| **Grassland** | Field crops, orchards and vineyards (2007-2014) Statistical Yearbook of Republic of Macedonia (1990-2006) | SSO |
| **Grassland remaining grassland** | Own calculation based on: Field crops, orchards and vineyards (2007-2014) and Statistical Yearbook of Republic of Macedonia (1990-2006); grassland area minus areas that are in change from CORINE Land Use changes estimation | Expert team |
| **Conversions (LU changes)** | Own estimation based on temporal analyses of CORINE Land Cover maps for year 2000, 2006 and 2012 | European Environmental Agency/Expert team |

### 5.7.2.4 Wetlands

Data for the preparation of GHG inventory for the Land Use category of Wetland was collected from European Environmental Agency CORINE Land Cover maps and analysis for land use and land use changes based on this maps conducted by the expert team. The sources of data for different categories are presented in Table 30. The areas that were used in GHG inventory in the category Wetlands are in A II.1.3, Table 70.

***Table 30. Data sources for Wetlands***

| | Documents | Data provider |
|---|---|---|
| **Wetlands** | Own calculation based on CORINE Land cover maps | European Environmental Agency/Expert team |
| **Wetlands remaining wetlands** | Own calculation based on wetland area minus areas that are in change from CORINE Land Use changes estimation | Expert team |
| **Conversions (LU changes)** | Own estimation based on temporal analyses of CORINE Land Cover maps for year 2000, 2006 and 2012 | European Environmental Agency/Expert team |

### 5.7.2.5 Settlements

Data for the preparation of GHG inventory for the Land use category of Settlements was collected from European Environmental Agency CORINE Land Cover maps and analysis for land use and land use changes based on this maps conducted by the expert team. The sources of data for different categories are presented in Table 31. The areas that were used in GHG inventory in the category settlements are in A II.1.3, Table 71.

***Table 31. Data sources for Settlements***

| | Documents | Data provider |
|---|---|---|
| **Settlements** | Own calculation based on CORINE Land cover maps | European Environmental Agency/Expert team |
| **Settlements remaining settlements** | Own calculation based on settlements area minus areas that are in change from CORINE Land Use changes estimation | Expert team |
| **Conversions (LU changes)** | Own estimation based on temporal analyses of CORINE Land Cover maps for year 2000, 2006 and 2012 | European Environmental Agency/Expert team |

### 5.7.2.6 Other land

Data for the preparation of GHG inventory for the Land use classes Other land was collected derived from the expert team. Because all other land use classes were used we can say that data source for this land classes was all data sources provided in the previous land use classes and some specific sources presented in Table 32. The areas that were used in GHG inventory in the category other land are in A II.1.3,

Table 72.

***Table 32. Data sources for Other Land***

| | Documents | Data provider |
|---|---|---|
| **Other lands** | Own calculation based on subtraction of the land use classes Forest land, Cropland, Wetland and Settlements from whole territory of Republic of Macedonia | European Environmental Agency/Expert team |
| **Other land remaining other land** | Own calculation based on other land area minus areas that are in change from CORINE Land Use changes estimation | Expert team |
| **Conversions (LU changes)** | Own estimation based on temporal analyses of CORINE Land Cover maps for year 2000, 2006 and 2012 | European Environmental Agency/Expert team |

# 6 Waste

## 6.1 Overview

The estimations show that the Waste sector is a significant source of GHG emissions, as it accounts for 17.7%, 19% of the total emissions in Macedonia for 2013 and 2014, respectively. The categories used for reporting are Solid Waste Disposal, Biological Treatment of Solid Waste, Incineration and Open Burning of Waste and Waste Water Treatment and Discharge. The data categorization format is consistent with previous years in order to preserve the existing time series, except in sectors where data was introduced for the first time.

According to the National Waste Management Plan 2009 – 2015, the solid waste generated in Macedonia is mostly disposed on landfills. The landfill Drisla, serving the Skopje region, with approximately 590 000 habitants, is the only permitted landfill in Macedonia and it is relatively well managed. At the municipal landfills, or dumpsites, in rural areas the wastes are simply dumped by the Communal Enterprises with no operational costs, except some overheads and occasional waste consumption costs for the extinguishing of emerging landfill fires. There are around 54 authorized municipal landfills. The need for improvement of their waste management practices has been recognized. Furthermore, there are around 320 illegal disposal sites which need to be terminated. In accordance with the national legislative, the mayors of municipalities are obliged to provide yearly reports on the municipalities management of non-hazardous waste. The hazardous waste generated by Macedonian mining and processing industries faced severe problems during the transition period and many have stopped their activities, with no change of being restarted. Their on-site process waste dumps were abandoned as well, and little or no information is available on the history of these dumpsites.

At the Drisla disposal site, a two-chamber medical waste incinerator has been installed and started operating in the year 2000. Data on incinerated amounts of waste are available, but the emissions caused by this activity were not reported in the FBUR and are not included in this inventory, too. Nonetheless, these emissions should be provided in future reports, which should include a revision of other components of the Waste sector as well. In the past, a number of facilities for the biological treatment of organic wastes, including biogas and composting installations, have been installed in Macedonia which vary in capacity and operation time. Only the data on amounts of composted waste were available and used in this inventory report.

## 6.2 Emission trends

Waste greenhouse gas emissions follow an increasing trend throughout the years included in this report. Their value in 2014 is 8.2% higher when compared to 2012 and 49.8% higher when compared to 2003. Out of all the sectors, the Solid Waste Disposal emissions are most significant averagely accounting for 94.4% of the total waste emissions. Emissions from Biological Treatment of Solid Waste have been, for the first time, introduced for the period from 2012 to 2014 as a result of data availability. The $CH_4$ and $N_2O$ emissions from this category however, do not contribute largely to the overall emissions due to the small amount of reported composted waste. Since waste incineration hasn't been reported, the emissions reported under Incineration and Open Burning represent the greenhouse gases emitted only by open burning of waste. The decrease of these emissions in 2014 stops the previously established upward trend. Nevertheless, emissions from incineration and open burning of waste represent less than 2% of the total waste emissions. The gasses which are emitted from the Wastewater Treatment and Discharge category are methane and nitrous oxide. They are

the result of domestic and wastewater treatment and discharge. Because domestic wastewater treatment and discharge emissions depend on the population size, the methane emissions gradually increase. On the other hand, nitrous oxide emissions are constant from 2012 to 2014, but show no particular long term trend. Industrial wastewater treatment and discharge emission constantly increase from 2012 to 2014. However, when the time series 1990 – 2014 is taken into account, the variations disrupt any consistent pattern. Table 33 contains the emissions of each sub-sector in Gg $CO_2$-eq.

***Table 33. GHG emissions from Waste sector, by category (Gg $CO_2$-eq)***

| | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Waste / Отпад** | **1,550.7** | **1,765.5** | **2,146.8** | **2,226.1** | **2,323.5** |
| Solid Waste Disposal / Депонии за цврст отпад | 1,428.3 | 1,652.7 | 2,023.6 | 2,101.8 | 2,193.0 |
| Biological Treatment of Solid Waste / Биолошки третман на цврст отпад | 0.0 | 0.0 | 0.3 | 0.2 | 0.8 |
| Incineration and Open Burning of Waste / Согорување и отворено горење на отпадот | 12.5 | 22.4 | 36.2 | 37.1 | 31.6 |
| Wastewater Treatment and Discharge / Третман и испуштање на отпадни води | 109.9 | 90.4 | 86.7 | 87.0 | 98.1 |

Figure 37 below depicts the emissions of gases in the Waste sector as $CO_2$-eq. The upward emission's trend is thus evident, as is the predominance of solid waste disposal emissions.

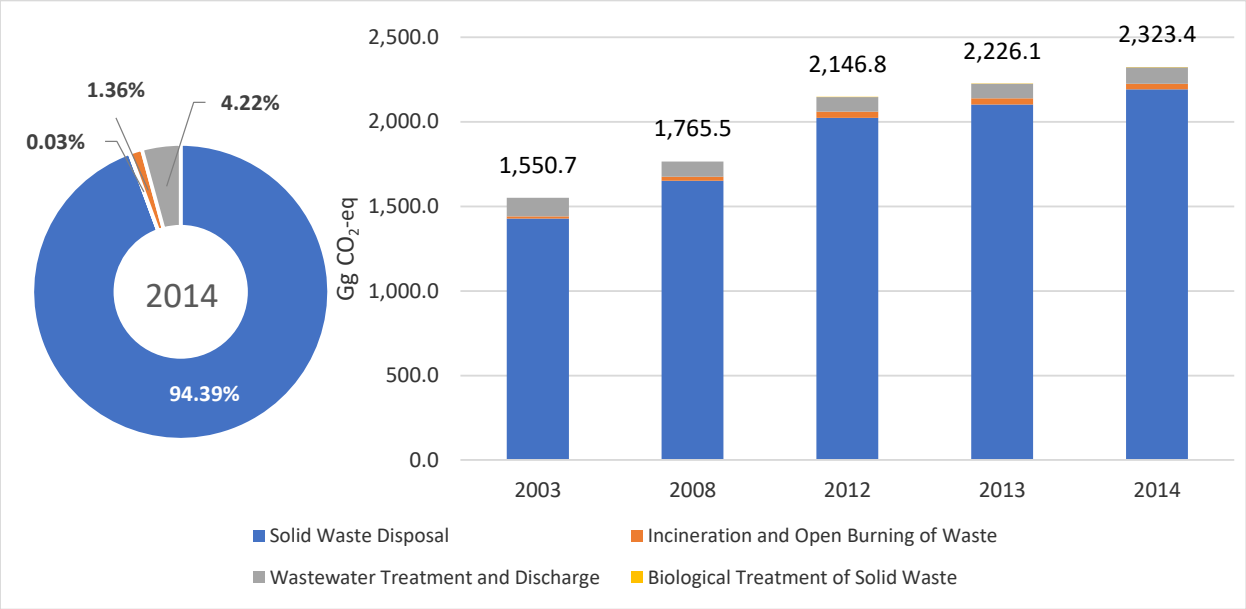



***Figure 37. GHG emissions from Waste sector, by category (in Gg CO2-eq)***

Methane emissions constitute 97.6% of the total emissions in the Waste sector in 2014 (Figure 38). Moreover, the Solid Waste Disposal category is the single biggest contributor to these emissions with share of 96.8%.

Emissions of $CO_2$ gases in Macedonia from Waste sector occur only as a result of open burning of waste and account for 0.4% of the sectoral emissions.

Nitrous oxide emissions display no variations with time and average around 47.7 Gg $CO_2$-eq for 2012 to 2014, or 2% of the total waste emissions. Table 34 contains detailed information of the $CO_2$-eq emissions of carbon dioxide, methane and nitrous oxide for each category.

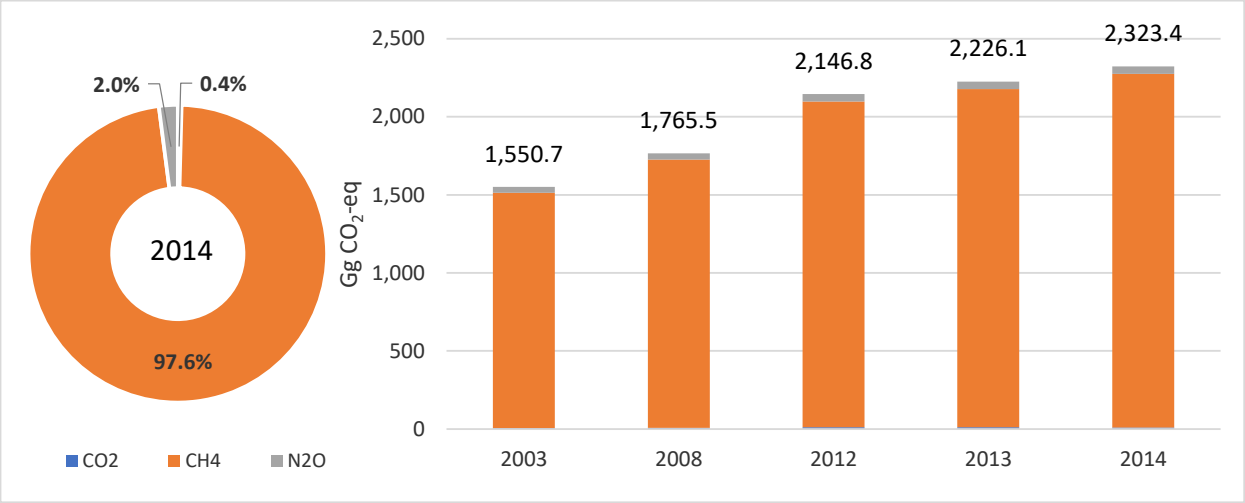



***Figure 38. GHG emissions form Waste sector, by gas (in Gg $CO_2$-eq)***

*Table 34. GHG emissions from Waste sector, by category and by gas (in Gg CO2-eq)*

| Categories / Категории | 2003 | | | 2008 | | | 2012 | | | 2013 | | | 2014 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2$ | $CH_4$ | $N_2O$ |
| **Waste / Отпад** | **4.6** | **1,509.0** | **37.1** | **8.2** | **1,717.3** | **40.0** | **10.9** | **2,088.0** | **47.9** | **11.2** | **2,166.9** | **48.0** | **9.5** | **2,266.6** | **47.3** |
| **Solid Waste Disposal / Депонии за цврст отпад** | **0.0** | **1,428.3** | **0.0** | **0.0** | **1,652.7** | **0.0** | **0.0** | **2,023.6** | **0.0** | **0.0** | **2,101.8** | **0.0** | **0.0** | **2,193.0** | **0.0** |
| Managed Waste Disposal Sites / Управувани депонии за цврст отпад | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| Unmanaged Waste Disposal Sites / Неуправувани депонии за цврст отпад | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| Uncategorized Waste Disposal Sites / Некатегоризирани депонии за цврст отпад | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| **Biological Treatment of Solid Waste / Биолошки третман на цврст отпад** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.2** | **0.1** | **0.0** | **0.1** | **0.1** | **0.0** | **0.4** | **0.4** |
| **Incineration and Open Burning of Waste / Согорување и отворено горење на отпад** | **4.6** | **7.9** | **0.0** | **8.2** | **14.2** | **0.0** | **10.9** | **19.0** | **6.3** | **11.2** | **19.5** | **6.4** | **9.5** | **16.6** | **5.5** |
| Waste Incineration / Согорување на отпад | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| Open Burning of Waste / Отворено горење на отпад | 4.6 | 7.9 | 0.0 | 8.2 | 14.2 | 0.0 | 10.9 | 19.0 | 6.3 | 11.2 | 19.5 | 6.4 | 9.5 | 16.6 | 5.5 |
| **Wastewater Treatment and Discharge / Третман и испуштање на отпадни води** | **0.0** | **72.8** | **37.1** | **0.0** | **50.4** | **40.0** | **0.0** | **45.2** | **41.5** | **0.0** | **45.5** | **41.5** | **0.0** | **56.6** | **41.5** |
| Domestic Wastewater Treatment and Discharge / Третман и испуштање на отпадни води од домаќинства | 0.0 | 16.8 | 37.1 | 0.0 | 17.0 | 40.0 | 0.0 | 17.1 | 41.5 | 0.0 | 17.1 | 41.5 | 0.0 | 17.1 | 41.5 |
| Industrial Wastewater Treatment and Discharge / Третман и испуштање на отпадни води од индустрија | 0.0 | 56.0 | 0.0 | 0.0 | 33.4 | 0.0 | 0.0 | 28.2 | 0.0 | 0.0 | 28.4 | 0.0 | 0.0 | 39.4 | 0.0 |
| **Other / Друго** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |

### 6.2.1 Solid waste disposal

Treatment and disposal of municipal, industrial and other solid waste produces significant amounts of methane ($CH_4$). A waste by composition approach was applied in the First Order Decay (FOD) calculation. Macedonia is categorized as an Eastern European country, hence, the DOC parameter and methane generation rate constant (k) were assumed to be equal to their corresponding default values provided in the IPCC 2006 Guidelines. A default value was also used for the composition of municipal solid waste. A slight uncertainty has been acknowledged in the data on fixed distribution of managed, unmanaged and uncategorized waste. It should be noted that future inventory reports should asses and resolve this issue, as it requires further research. Another change was made for the Delay time parameter, for which the default value of 6 months was used, because no official justification of the previously used value (in FBUR) was acknowledged.

In order to calculate the total municipal solid waste that was created in each year, the time series on population data has been revised for the period of 1990 to 2014. The data sources used for the revision are elaborated in detail in the Chapter 6.4. The average municipal solid waste per capita for the period 2012 to 2014 is 378.7 kg/cap/yr. Moreover, the ratio of collected and generated municipal solid waste was 70.6% in 2012, 70% in 2013 and 74.5% in 2014. It is worth mentioning that all of the collected municipal solid waste is deposited to solid waste disposal sites. Future inventory reports should include a revision of the percentage of waste deposited in disposal site for years previous to 2012, where sufficient data exists.

Emissions from industrial waste have been calculated using the information on national GDP in million USD. Finding national GDP data for the period before 1991 was challenging because, during that time, Macedonia was a part of Yugoslavia. Therefore, it was decided to calculate the GDP of Macedonia using the statistical data on GDP per capita of Yugoslavia (more details are given in the Chapter 6.3 Methodology and emission factors).

Figure 39 shows that the $CO_2$-eq emissions from solid waste disposal have been constantly rising. These methane-based emissions, on average, represent 94.6% of the total emissions in the Waste sector.

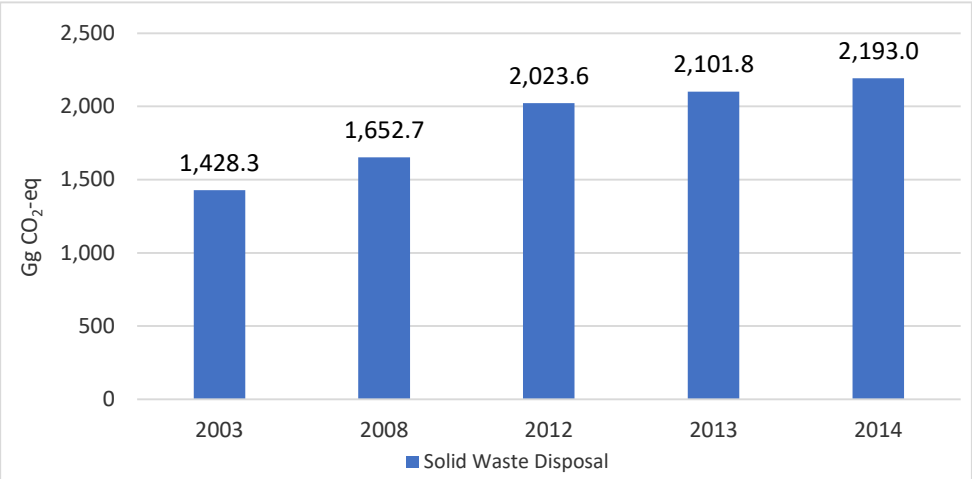



***Figure 39. Emissions of $CH_4$ from Solid Waste Disposal (in Gg $CO_2$-eq)***

### 6.2.2 Biological treatment of solid waste

Biological treatment of solid waste in Macedonia is represented by the composting of waste. The existence of composting facilities has been acknowledged in the past, but it is only recently that data on the amount of composted waste has been reported. Methane is formed in anaerobic section from the compost, but it is oxidized to a large extent in aerobic sections of the compost. Composting can also produce emissions of $N_2O$. As no country-specific emission factors exist, default values have been used.

The emissions from composting have been reported for the years 2012, 2013 and 2014. Observance shows that they are insignificant, i.e. less than 1 Gg $CO_2$-eq. Nevertheless, it may be concluded that the composting practice has become present to the extent that the amount of composted waste is worth reporting, which may be considered as progress. The same cannot be stated for years prior to 2011. The amount of waste composted in 2012 is equal to 738 t, while 441 t and 1945 t had been composted in 2013 and 2014, respectively. The methane and nitrous oxide $CO_2$-eq emissions from this category are presented in Figure 40.

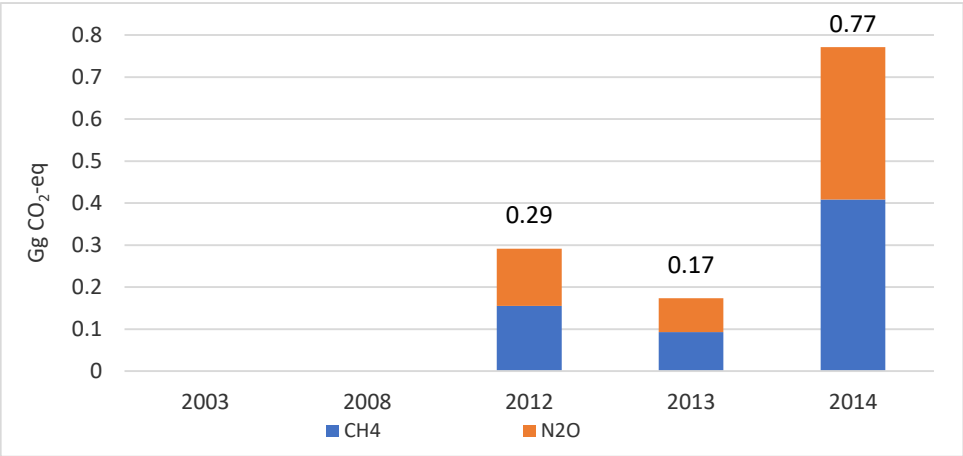



***Figure 40. GHG emissions from Biological Treatment of Solid Waste (in Gg $CO_2$-eq)***

It is evident that, although physically a smaller quantity of nitrous oxide is emitted, the $CO_2$-eq of the gases are fairly equal throughout the years.

### 6.2.3 Incineration and open burning of waste

#### 6.2.3.1 Waste Incineration

Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities. The Drisla landfill is the only big landfill that has waste incineration facilities. The greenhouse gas emissions from incineration should be taken into account in future national inventory reports.

#### 6.2.3.2 Open Burning of Waste

Open burning of waste can be defined as the combustion of unwanted combustible materials such as paper, wood, plastics, textiles, rubber, waste oils and other debris in nature (open-air) or in open dumps, where smoke and other emissions are released directly into the air without passing through a chimney or stack. Open burning can also include incineration devices that do not control the combustion air to maintain an adequate temperature and do not provide sufficient residence time for complete combustion.

Following the recommendations from the IPCC 2006 Guidelines, the fraction of the population burning waste is assumed to be equal to the fraction of waste not deposited in landfills. This approach was used for the values from 2012 to 2014. Future inventory reports should revise this fraction throughout the whole time series in a similar fashion, at least where data availability allows it. Additionally, the fraction of waste that is open-burned is assumed to be equal to its default value. The per capita daily waste generation corresponds to the national statistical data on annual per capita municipal waste.

The emissions of carbon dioxide, methane and nitrous oxide have been estimated for this category. Methane emissions are most significant and represent the majority of the total emissions of the gases emitted through open burning (Figure 41). As a consequence of the revised emission factor for nitrous oxide, a significant spike in emissions for the period from 2012 to 2014 is obvious.

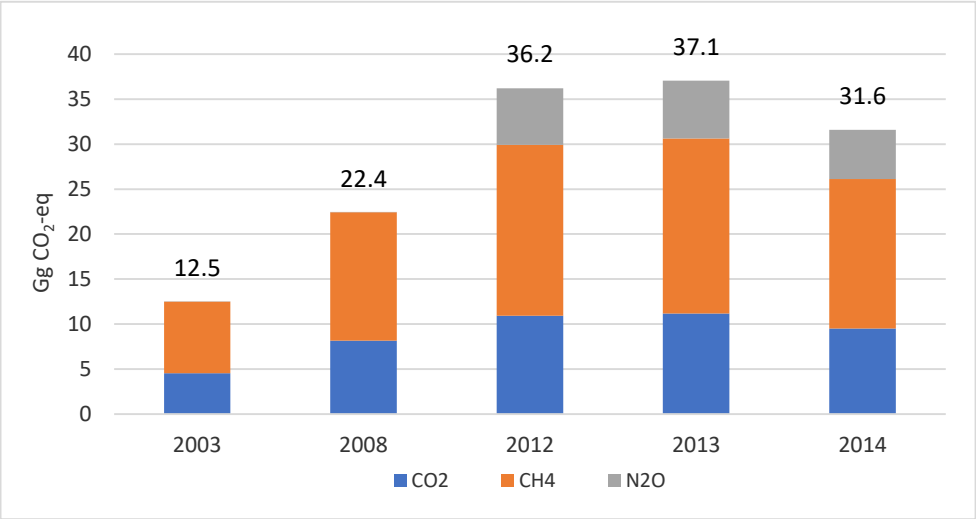



***Figure 41. GHG emissions from Incineration and Open Burning of Waste (in Gg $CO_2$-eq)***

## 6.2.4 Wastewater treatment and discharge

Wastewater can be a source of methane ($CH_4$) when treated or disposed anaerobically. It can also be a source of nitrous oxide ($N_2O$) emissions. Carbon dioxide ($CO_2$) emissions from wastewater are not considered in the IPCC Guidelines because these are of biogenic origin and should not be included in national total emissions.

Wastewater originates from a variety of domestic, commercial and industrial sources and may be treated on site (uncollected), sewered to a centralized plant (collected) or disposed untreated nearby or via an outfall. Domestic wastewater is defined as wastewater from household water use, while industrial wastewater is from industrial practices only.

The emissions from the Wastewater Treatment and Discharge category had the following shares in the reported years with regards to the Waste sector's emissions: 4.1% in 2012, 3.9% in 2013 and 4.2% in 2014. When accounting for the 7.1% in 2003 and 5.1% in 2008, it seems that the share of these emissions has increased. However, due to the small number of years included in this inventory report, no long-term conclusions should be reached.

### 6.2.4.1 Domestic Wastewater Treatment and Discharge

Because this category is not a key source of greenhouse gas emissions, the default parameters and emissions factors have been used. The revised time series from 1990 to 2014 on population data has been included in the estimations.

The emissions in the category do not change significantly over time because of their relation to the population size, as can be seen on Figure 42. It should be noted that they account for just above 50% of the all the emissions in the category Wastewater Treatment and Discharge.

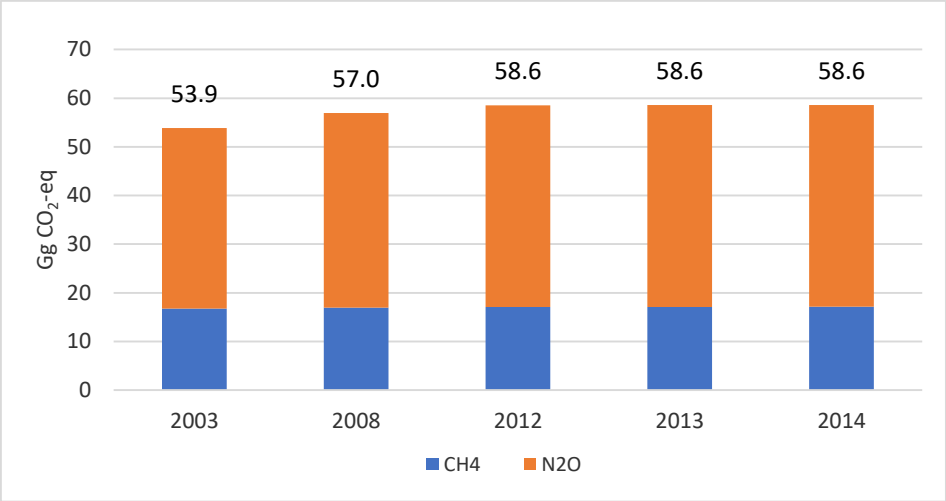



***Figure 42. GHG emissions from Domestic Wastewater Treatment and Discharge (Gg $CO_2$-eq)***

Nitrous oxide and methane are present as greenhouse gas emissions in this category. Methane occurs as a result of the existence of biodegradable organic compound in the waste. For the period from 2012 to 2014, the share of methane emissions is around 30%. Nitrous oxide emissions are associated with the degradation of nitrogenic components in the wastewater, such as urea, nitrate and protein. They account for around 70% from the total domestic wastewater treatment and discharge emissions.

#### 6.2.4.2 Industrial Wastewater Treatment and Discharge

The emissions of greenhouse gases from industrial wastewater treatment and discharge have been estimated using the industrial production data. In order to preserve the existing time series, the data have been classified in the following industrial sectors: Alcohol Refining, Beer & Malt, Petroleum Refineries, Pulp & Paper (combined), Vegetable Oils, Meat & Poultry. Furthermore, it is assumed that the generated wastewater and the chemical oxygen demand parameter correspond to the default values provided in the IPCC 2006 Guidelines.

Concerning the data on industry production, an inconsistency has been acknowledged in the reports of the current data source, especially in the Meat & Poultry category. This results in equivalently inconsistent emissions throughout the time series. It is believed that since other relevant data sources exist, a change of the data source in future inventory reports should yield more certain results. The emissions of industrial wastewater treatment and discharge in Gg $CO_2$-eq are shown on Figure 43.

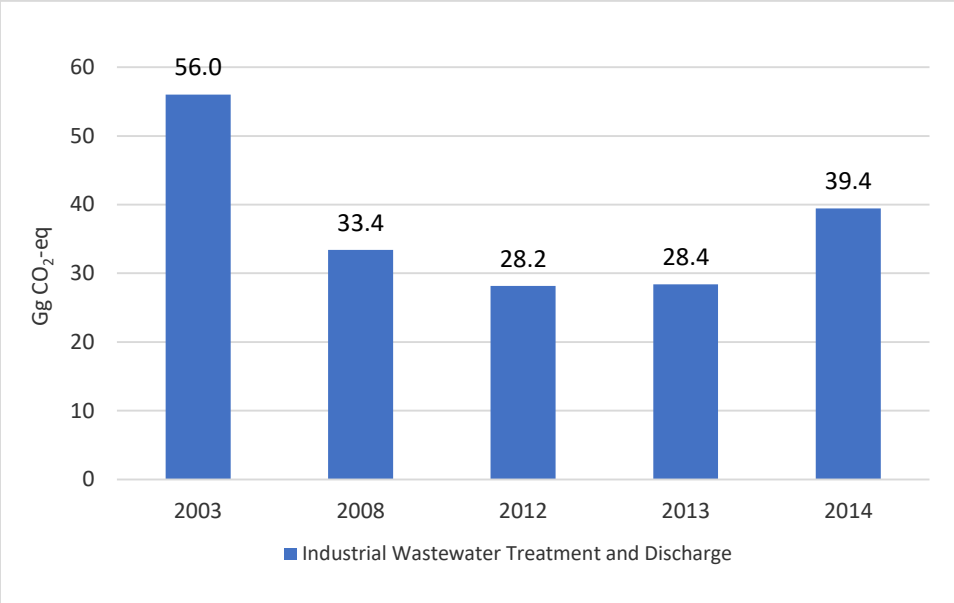



***Figure 43. Emissions of $CH_4$ from Industrial Wastewater Treatment and Discharge (in Gg $CO_2$-eq)***

Methane emissions account for all of the emissions which are the result of industrial wastewater treatment and discharge. The share of emissions from industrial wastewater treatment and discharge out of the total emissions in the category Wastewater Treatment and Discharge are 32% in 2012, 33% in 2013 and 40% in 2014.

## 6.3 Methodology and emission factors

In the inventory prepared in the SBUR framework, the Solid Waste Disposal emissions are estimated in accordance with the IPCC 2006 Guidelines using the IPCC Inventory Software, which impose the First Order Decay (FOD) methodology. It produces a time-dependent emission profile that reflects the true pattern of the degradation process over time. Having in mind that solid waste disposal sites contribute the most to the sector's emissions, as well as the fact that country specific historic data on the amount of disposed waste are available, Tier 2 methodology has been used. Recent documentation reporting the amount of composted waste has made the relevant data available for the year 2011, 2012, 2013 and 2014. Because biological treatment of solid waste is not a widespread practice in Macedonia so country specific emission factors have not been assessed so far. Consequently, Tier 1 was applied for the estimation for the gases emitted from biological treatment of solid waste. Following the IPCC 2006 Guidelines, the Incineration and Open Burning of Waste and the Wastewater Treatment and Discharge are not found to be key sectors, thus, Tier 1 methodologies have also been applied for these sectors.

The emission factors used for the estimation of the GHG emissions of the Waste sector are presented in Table 35. All of them have been assumed to be equal to the default values provided in the IPCC 2006 Guidelines. The default emission factors methane ($CH_4$) and nitrous oxide ($N_2O$), which have been used to estimate the emissions from composting activities, are introduced in the SBUR.

It is assumed that the nitrous oxide emission factor used in the FBUR is equal to the default value divided by 1000. This has been corrected in the SBUR and the default emission factor has been used.

***Table 35. Emission factors used for Waste sector***

| Emission factor | Used in FBUR | SBUR | Comment |
|---|---|---|---|
| **Municipal Solid Waste** | DF | DF | IPCC 2006 Guidelines<br>National Waste Management Plan 2009 - 2015 |
| **Biological Treatment of Solid Waste** | - | DF | IPCC 2006 Guidelines |
| **Incineration and Open Burning of Waste** | | | |
| Open Burning of Waste | DF | DF | IPCC 2006 Guidelines |
| **Wastewater Treatment and Discharge** | | | |
| Domestic Wastewater Treatment and Discharge | DF | DF | IPCC 2006 Guidelines |
| Industrial Wastewater Treatment and Discharge | DF | DF | IPCC 2006 Guidelines |

## 6.4 Data sources

In the Solid Waste Disposal sector, the population data from 1990 until 2014 has been revised. All of the data for the years when population size had been estimated with a census are included. However, as no census had been made since 2002, the population size has been estimated by using information from the reports of the State Statistical Office and the United Nations. The population size from 1995 to 2001 has been estimated to follow the trend from the UN reports, while taking into account the censuses in 1994 and 2002. The estimation of population in Macedonia at 30.06 by specific age group, by sex, by municipality, by years according to territorial division is used for 2003 and 2004, while the estimation made on population in Macedonia at 30.06 by specific age group, by sex, by municipality, by years from the MAKStat database was used for 2005. The report on population at 31.12 is used from the same database for all other years. The revised time series was also used for the categories Incineration and Open Burning of Waste and Domestic Wastewater Treatments and Discharge.

The calculation of the national GDP has been completed using data from UN and national reports. There is no national information on GDP per capita in Macedonia prior to 1991 because it was a part of Yugoslavia. Therefore, for the period of 1970 to 1990, the GDP per capita of Yugoslavia was used from UN reports in combination with the population size of Macedonia for the corresponding period. For the period from 1991 to 1995, data on GDP of Macedonia has also been obtained from UN reports. The State Statistical Office has provided GDP data since 1996. However, it is in the national MKD currency. In order to convert it to current USD, which is the currency used in all other years, the conversion factor was calculated using the UN GDP data which was provided in both MKD and USD.

The State Statistical Office has issued news releases on Municipal Waste for the years 2012, 2013 and 2014. It contains information on quantities on generated, collected and waste disposed in waste disposal sites. The Ministry of Environment and Physical Planning releases annual reports on Quality of the Environment which include the amounts of composted waste. The industry product used as input in the category Industrial Wastewater Treatment and Discharge was obtained from the State Statistical Office Yearbook. All other data was used from the IPCC 2006 Guidelines.

Table 36 contains all of the used data sources for the estimation of greenhouse gases in this inventory report.

***Table 36. Data sources for Waste sector***

| | Documents | Data provider |
|---|---|---|
| **Municipal Solid Waste** | Municipal Waste for 2012, 2013, 2014<br>Estimation of Population of R. Macedonia (<br>World Population Prospects: The 2015 Revision<br>Former Yugoslavia, GDP at current prices – USD<br>R. Macedonia, GDP at current prices – National currency<br>R. Macedonia, GDP at current prices – USD | SSO<br>MAKStat database<br>United Nations Population Division, National Accounts Main Aggregates Database |
| **Biological Treatment of Solid Waste** | Annual Report on Quality of Environment 2012, 2013, 2014 | MOEPP |
| **Incineration and Open Burning of Waste** | | |
| Open Burning of Waste | Municipal Waste for 2012, 2013, 2014 | SSO |
| **Wastewater Treatment and Discharge** | | |
| Domestic Wastewater Treatment and Discharge | Estimation of Population of R. Macedonia<br>World Population Prospects: The 2015 Revision | MAKStat database<br>United Nations Population Division |
| Industrial Wastewater Treatment and Discharge | Statistical Yearbook of the Republic of Macedonia 2016<br>Statistical Yearbook of the Republic of Macedonia 2015<br>Statistical Yearbook of the Republic of Macedonia 2014 | SSO |

# 7 Precursors and indirect emissions

In the Decision 17/CP.8, annex, paragraph 16, Non-Annex I Parties ***are encouraged***, as appropriate, to report on anthropogenic emissions by sources of indirect GHGs, such as CO, $NO_x$ and NMVOC, while in Decision 17/CP.8, annex, paragraph 17, other gases not controlled by the Montreal Protocol, such as $SO_x$, included in the Revised 1996 IPCC Guidelines ***may be included*** at the discretion of the Parties.

The most recent 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 7: Precursors and Indirect Emissions introduces ways to adopt methodologies to calculate the non-GHG emissions, provides a link to relevant methodology chapters in the EMEP/CORINAIR Emission Inventory Guidebook. Some of the methodologies and emission factors in the EMEP/CORINAIR Guidebook are technology-specific and are relevant to conditions and categories in both developed and developing countries. However, for some sectors, like solvents, small combustion sources (biomass in particular) and open burning, differences between the developed and developing countries may be larger, and the EMEP/CORINAIR Guidebook should be used with great care.

Taking into the consideration the recommendations provided in the review report of the FBUR submission of Macedonia, the emissions of $NO_x$, CO, NMVOC and $SO_2$ were estimated in the framework of the SBUR preparation. The emissions estimates have been done in line with the methodology in the EMEP/CORINAIR Emission Inventory Guidebook, in a consistent, complete and comparable manner for the entire inventory period 1990 – 2014. Unfortunately, the IPCC Inventory Software doesn't contain a module which supports calculation of the precursors and indirect emissions, and the estimation of the emissions of this gases was done in separate excel files.

## 7.1 Emission trends

The emission trend of the Indirect GHG emissions and the emissions of $SO_2$ in Macedonia for the period 1990-2014 are presented in Figure 44.

The detailed emissions of precursors and indirect emissions by category, are presented in A II.3.4 and also available at this link: http://www.unfccc.org.mk/Default.aspx?LCID=244.

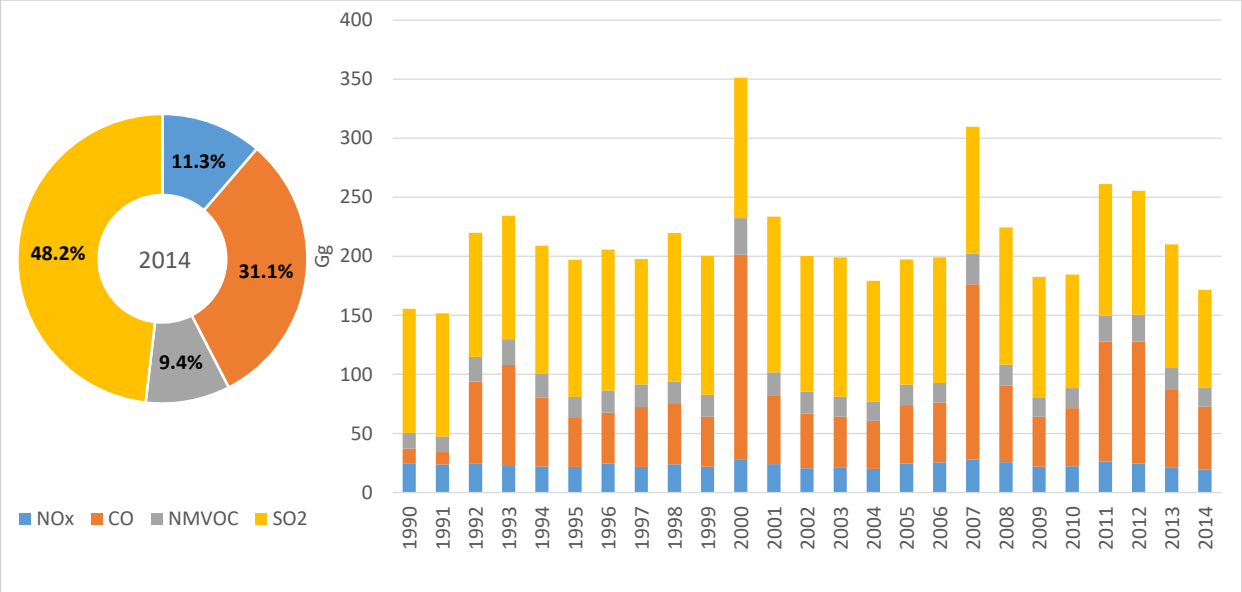


***Figure 44. Emissions of NOx, CO, NMVOC and $SO_2$ in the period 1990 – 2014 (in Gg)***

The assessment of the overall sectoral emissions of the precursors and indirect emissions of the period 1990-2014 shows that the Energy sector is the most significant contributor (including AFOLU).

Furthermore, in the year 2014, the Energy sector is a source of the most significant share of $NO_x$ emissions (89.2% from total $NO_x$ emissions), followed by the sector IPPU with 5.8%, AFOLU with 3.0% and Waste with 2%. In the same time, 67.1% of the national emissions of CO originate from the Energy sector, 15.6% from the sector IPPU, 12.7% from the Waste sector and 4.6% from the sector AFOLU. When it comes to the emissions of NMVOC, the sector Energy is again most dominant sector in the national NMVOC emissions with 67.2%, while the sector AFOLU contributes with a significant share of 27.9%, followed by the sector IPPU with 4.0% and Waste with 0.9%. At the end, the major part of $SO_2$ emissions or 89.4% again originates from the Energy sector, while the IPPU sector contributes with 10.6% (see Figure 45).

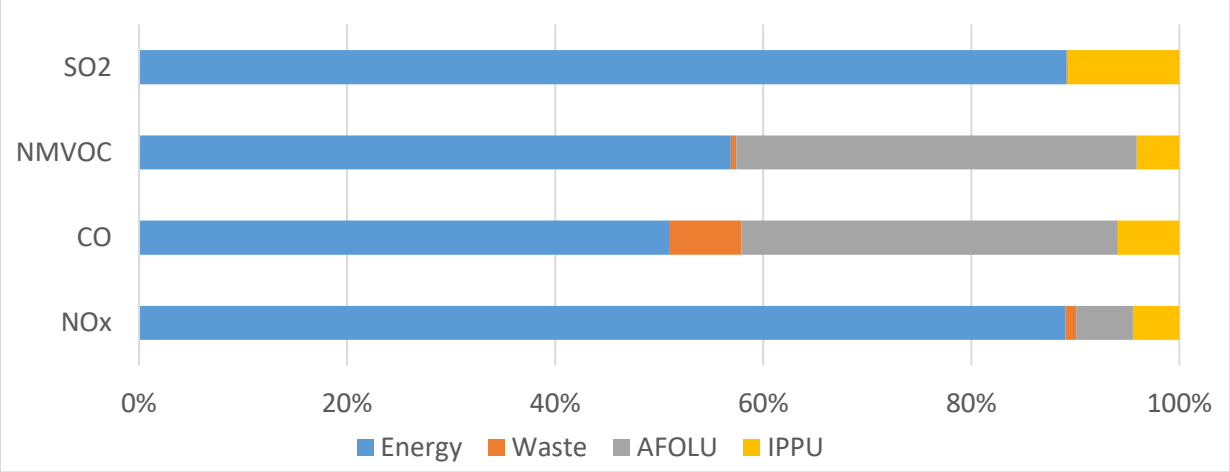



***Figure 45. Share of the precursors and indirect GHG emissions by sectors in the year 2014 (in %)***

## 7.2 Energy

### 7.2.1 Overview

In Sector Energy, most of the $NO_x$ emissions resulting from fuel combustion are typically 'fuel-NO' that is formed from the conversion of chemically bound nitrogen in the fuel. CO and NMVOCs are generated during under-stoichiometric combustion conditions and are dependent on a variety of factors, including fuel type and combustion conditions. Emissions of $SO_2$ are primarily related to the sulphur content of the fuel, although some sulphur can be retained in the ash. Abatement in stationary combustion can reduce the amount emitted.

### 7.2.2 Emission trends

The Energy sector emissions of Macedonia are originating from the category Fuel Combustion Activities (categories Energy Industries, Manufacturing Industries and Construction, Transport, Other Sectors and Non-specified) and the category Fugitive emissions from fuels (categories Solid fuels, Oil and Natural Gas). The emissions from the category Carbon dioxide Transport and Storage are not occurring in the country, so the notation keys NO are used.

The emissions of the precursors and indirect emissions from the Energy sector in the reporting years are presented in Figure 46. The emission trend of the emissions of precursors and indirect gases of the Energy sector is to a large extend proportional with the amount of coal burned for production of electricity, as well as the amount of fuel spent in different categories and subcategories. If we consider the general emission trend of the precursors and indirect emissions, a decreasing emission trend is observed in the year 2013 and 2014, due to reduced electricity production from the Energy Industries, replaced mainly with electricity import.

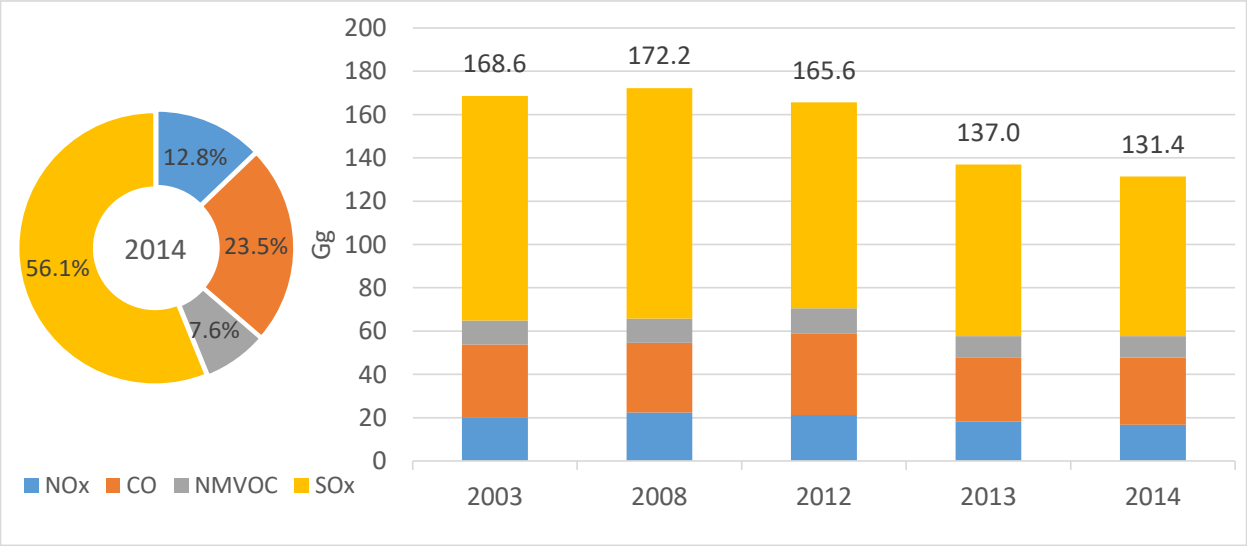



***Figure 46. Emissions of NOx, CO, NMVOC and $SO_2$ from the Energy sector (in Gg)***

The detailed emissions of the Energy sector, by category and by gas, are presented in Table 37.

***Table 37. Emissions of NOx, CO, NMVOC and $SO_2$ from the Energy sector (in Gg)***

| Categories / Категории | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO |
| **Energy / Енергетика** | **20.2** | **33.6** | **22.4** | **32.1** | **21.2** | **37.8** | **18.2** | **29.7** | **16.8** | **30.9** |
| **Fuel Combustion Activities / Активности при кои се согорува гриво** | **20.2** | **33.6** | **22.4** | **32.1** | **21.2** | **37.8** | **18.2** | **29.7** | **16.8** | **30.9** |
| Energy Industries / Енергетски индустрии | 15.0 | 0.7 | 15.6 | 0.7 | 13.6 | 0.6 | 11.4 | 0.6 | 10.6 | 0.5 |
| Manufacturing Industries and Construction / Производствени индустрии и градежништво | 2.6 | 5.1 | 4.9 | 3.9 | 5.6 | 6.3 | 5.3 | 5.4 | 4.7 | 4.5 |
| Transport / Транспорт | 0.1 | 0.3 | 0.2 | 0.4 | 0.2 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 |
| Other Sectors / Други сектори | 2.5 | 27.5 | 0.8 | 26.7 | 0.8 | 30.3 | 0.7 | 23.3 | 0.7 | 25.5 |
| Non-Specified / Неспецифицирани | 0.0 | 0.0 | 0.9 | 0.4 | 1.0 | 0.4 | 0.7 | 0.3 | 0.6 | 0.3 |
| **Fugitive emissions from fuels / Фугитивни емисии** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** | **0.0** |
| Solid Fuels / Цврсти горива | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Oil and Natural Gas / Нафта и природен гас | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| Categories / Категории | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ |
| **Energy / Енергетика** | **11.1** | **103.7** | **11.3** | **106.4** | **11.5** | **95.1** | **9.8** | **79.2** | **9.9** | **73.7** |
| **Fuel Combustion Activities / Активности при кои се согорува гриво** | **4.9** | **103.7** | **4.9** | **106.4** | **5.7** | **95.1** | **4.5** | **79.2** | **4.8** | **73.7** |
| Energy Industries / Енергетски индустрии | 0.1 | 98.3 | 0.1 | 102.5 | 0.1 | 88.9 | 0.1 | 74.0 | 0.1 | 69.5 |
| Manufacturing Industries and Construction / Производствени индустрии и градежништво | 0.6 | 4.8 | 0.6 | 3.5 | 0.9 | 5.8 | 0.8 | 4.9 | 0.7 | 4.0 |
| Transport / Транспорт | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Other Sectors / Други сектори | 4.2 | 0.6 | 4.0 | 0.3 | 4.5 | 0.2 | 3.5 | 0.2 | 3.8 | 0.2 |
| Non-Specified / Неспецифицирани | 0.0 | 0.0 | 0.2 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| **Fugitive emissions from fuels / Фугитивни емисии** | **6.2** | **0.0** | **6.4** | **0.0** | **5.8** | **0.0** | **5.3** | **0.0** | **5.2** | **0.0** |
| Solid Fuels / Цврсти горива | 6.2 | NO | 6.4 | NO | 5.8 | NO | 5.3 | NO | 5.2 | NO |
| Oil and Natural Gas / Нафта и природен гас | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

*NO – Not occurring;*

Analysing the emissions od precursors and indirect gases by categories in the energy sector (see Figure 47), it is clear that the majority of the $NO_x$ emissions from the Energy sector in Macedonia are originating from the category Energy Industries, responsible for 63.2% of the $NO_x$ emissions in 2014, followed by 28.0% originating from the Manufacturing Industries and Construction, 4.1% from the Other Sectors (containing the categories Commercial/Institutional sector, Residential sector and Agriculture/Forestry/Fishing) and 3.8% from Non-specified category and 0.8% from Transport.

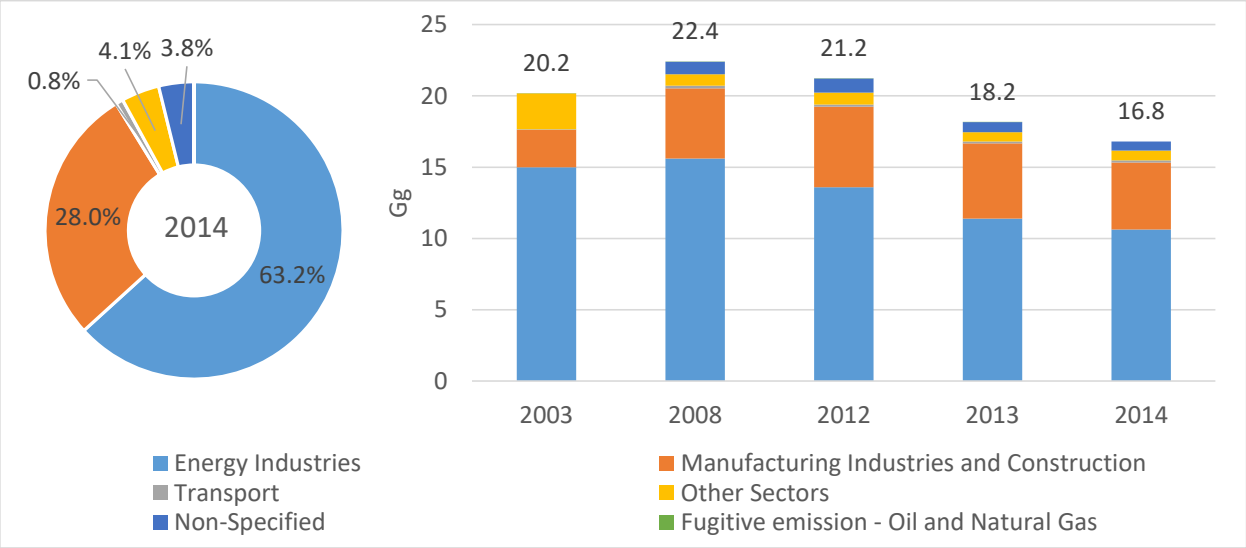



***Figure 47. NOx emissions from the Energy sector, by category (in Gg)***

Regarding the estimates of the CO emissions (see Figure 48), 82.5% of the Energy sector CO emissions in the year 2014 are originating from the category Other Sectors. The second most significant contributor is the category Manufacturing Industries and Construction with 14.7% of the Energy sector CO emissions in 2014, and the categories Energy Industries, Non-specified and Transport contribute with 1.6%, 0.8% and 0.3%, respectively..

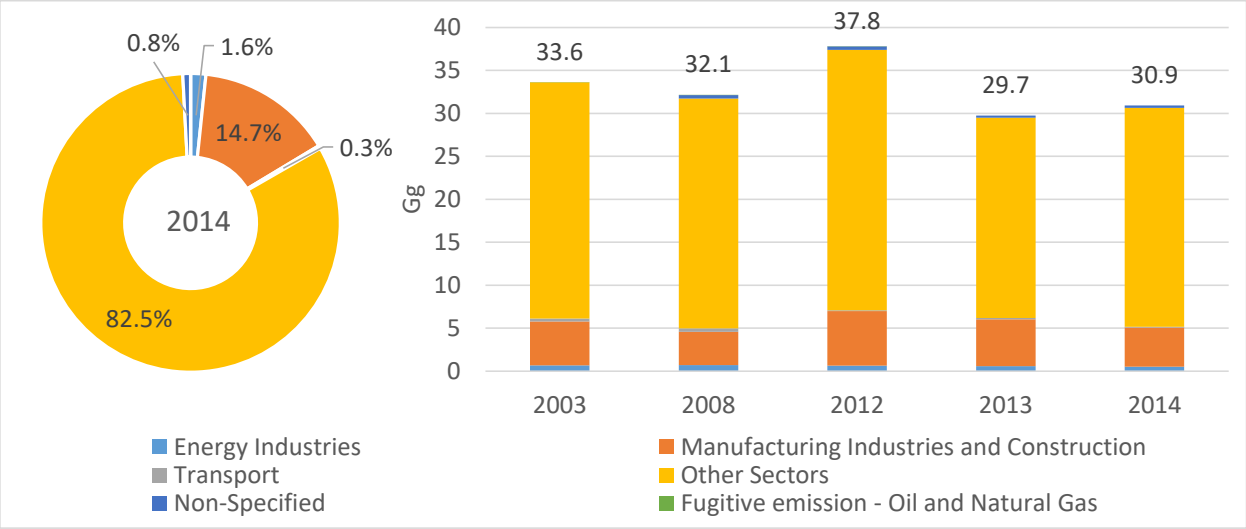



***Figure 48. CO emissions from the Energy sector, by category, (in Gg)***

The majority of the NMVOC emissions of the Energy sector in the year 2014, or 52.2%, are originating from the category Fugitive emissions from Solid fuels, followed by the category

Other sectors with 38.6% and the category Manufacturing Industries and Construction with 7.2% (see Figure 49). The other categories Non-specified, Energy Industries, Transport and Fugitive emissions from Oil and Natural Gas, contribute with approximately 2% to the NMVOC emissions.

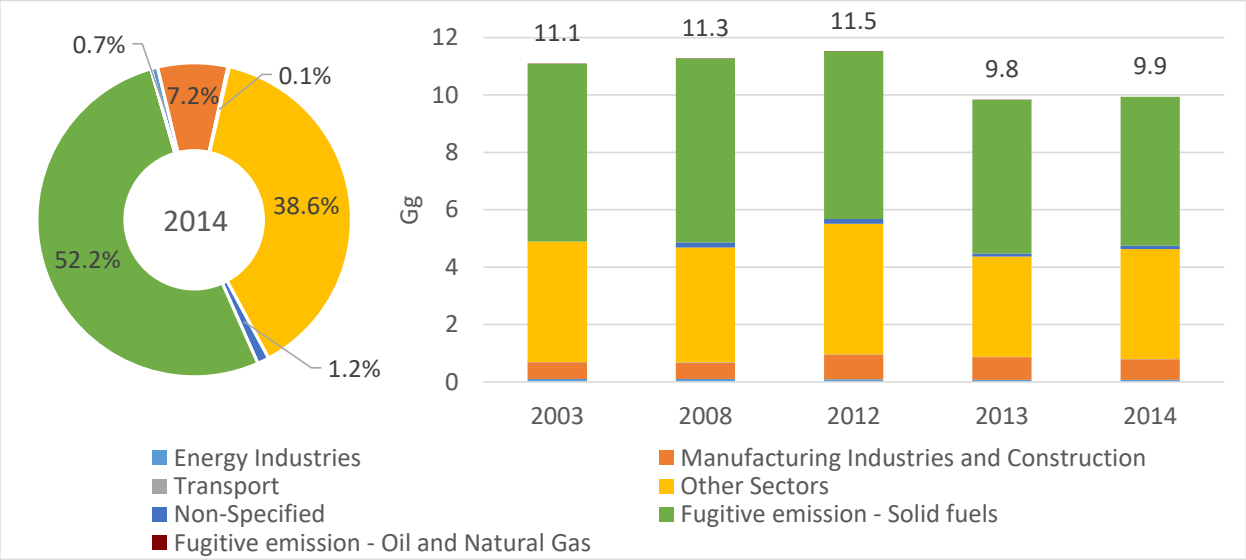



***Figure 49. NMVOC emissions from the Energy sector, by category (in Gg)***

As illustrated in Figure 50, the majority of the $SO_2$ emissions in the year 2014 are originating from the category Energy Industries with 94.3%, followed by the category Manufacturing Industries and Construction with 5.4%. The other categories Other Sectors, Non-specified, Transport and Fugitive emissions from Oil and Natural Gas, contribute with approximately 0.3% to the $SO_2$ emissions in the Energy sector.

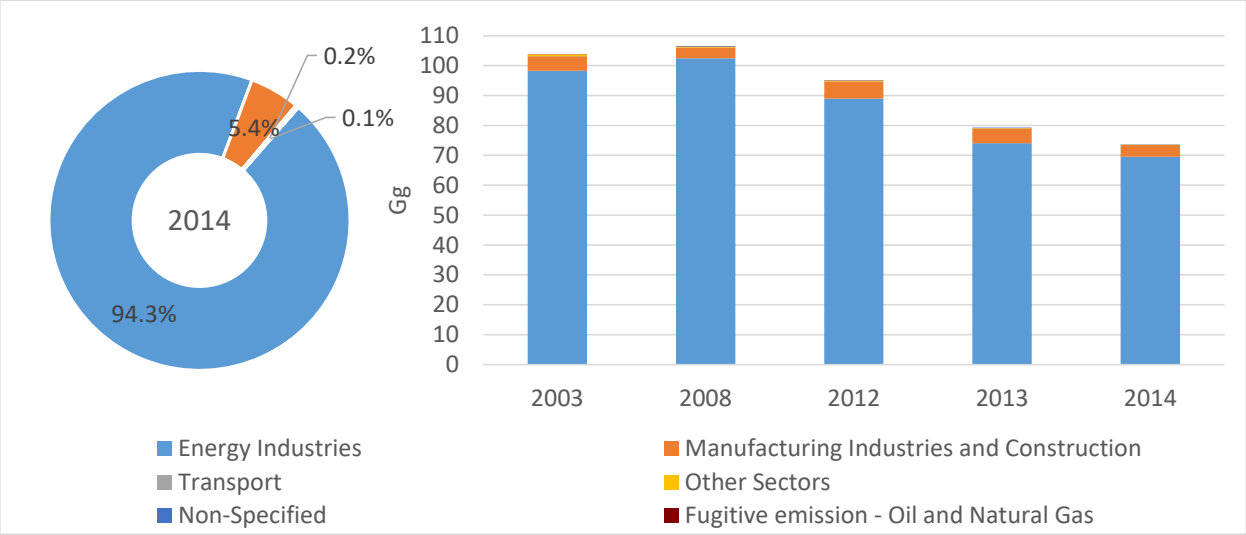



***Figure 50. $SO_2$ emissions from the Energy sector, by category (in Gg)***

The subcategory Road Transportation is also a significant source of the $NO_x$, CO, NMVOC and $SO_2$ emissions in most of the countries, and furthermore is identified as a key source of GHG emissions in Macedonia. Unfortunately, the emissions of precursors and indirect gases of the subcategory Road transportation of Macedonia have not been estimated due to lack of disaggregated data (which are required by the IPCC 2006 and CORINE methodology for estimation of the emissions of precursors and indirect gases of the road transportation). This

is the reason why the category Transport contains only the emissions of the Rail transportation and Aviation, and is not identified as a significant source of $NO_x$, CO, NMVOC and $SO_2$ emissions.

### 7.2.3 Fuel combustion activities

The emissions of this category, by categories and subcategories are presented in Table 38. The emission trend of all precursors and indirect emissions is decreasing in the last two years. In more details, the $NO_x$ emissions of this category for the year 2014 have decreased for 16.2% in comparison with the year 2003, and for 20.7% in comparison with the year 2012. The CO emissions of 2014 are decreasing for 8.6% in comparison with the year 2003 and 18.2% in comparison with 2012. The NMVOC emissions of 2014 have decreased for 6.1% in comparison with 2003 and 16.0% in comparison with 2012, while $SO_2$ emissions have decreased for 29.2% in comparison with 2003 and 22.8% in comparison with 2012.

It is very important to be mentioned that the emissions of the subcategory Petroleum Refining are included in the category Other Energy Industries, while the emissions from the Road Transport are not calculated, since the EMEP CORINAIR methodology is indicating that the emissions of the Road Transport should be calculated on a vehicle type level, while disaggregation of the fuel consumption by vehicle type is not available in the country.

### 7.2.4 Fugitive emissions from fuels

The emission trend of all precursors and indirect emissions of the category Fugitive emissions from fuels are decreasing in the last 3 years of the reporting period, which is owned to the decreased production of solid and liquid fuels in the country (Table 39).

***Table 38. Emissions of $NO_x$, CO, NMVOC and $SO_2$ from the Fuel Combustion Activities (in Gg)***

| Categories | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO |
| **Fuel Combustion Activities / Активности при кои се согорува гориво** | **20.2** | **33.6** | **22.4** | **32.1** | **21.2** | **37.8** | **18.2** | **29.7** | **16.8** | **30.9** |
| **Energy Industries / Енергетски индустрии** | **15.0** | **0.7** | **15.6** | **0.7** | **13.6** | **0.6** | **11.4** | **0.6** | **10.6** | **0.5** |
| Main Activity Electricity and Heat Production / Главна активност производство на електрична и топлинска енергија | 15.0 | 0.7 | 15.6 | 0.7 | 13.5 | 0.6 | 11.3 | 0.6 | 10.6 | 0.5 |
| Electricity Generation / Производство на електрична енергија | 13.9 | 0.5 | 14.9 | 0.5 | 13.0 | 0.5 | 10.9 | 0.4 | 10.3 | 0.4 |
| Combined Heat and Power Generation / Комбинирано производство на топлинска и електрична енергија | 0.2 | 0.0 | 0.1 | 0.0 | 0.3 | 0.1 | 0.3 | 0.1 | 0.2 | 0.1 |
| Heat Plants / Топлани | 0.9 | 0.2 | 0.6 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.1 | 0.1 |
| Petroleum Refining / Рафинирање на на нафта | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| Manufacture of Solid Fuels and Other Energy Industries / Производство на цврсти горива и други енергетски индустрии | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| Manufacture of Solid Fuels / Производство на цврсти горива | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other Energy Industries / Други енергетски индустрии | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 |
| **Manufacturing Industries and Construction / Производствени индустрии и градежништво** | **2.6** | **5.1** | **4.9** | **3.9** | **5.6** | **6.3** | **5.3** | **5.4** | **4.7** | **4.5** |
| **Transport / Транспорт** | **0.1** | **0.3** | **0.2** | **0.4** | **0.2** | **0.1** | **0.1** | **0.2** | **0.1** | **0.1** |
| Domestic Aviation / Домашна авијација | 0.0 | 0.3 | 0.0 | 0.4 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 |
| Road Transportation / Патен сообраќај | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| Railways / Железнички сообраќај | 0.1 | 0.0 | 0.2 | 0.0 | 0.2 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 |
| **Other Sectors / Други сектори** | **2.5** | **27.5** | **0.8** | **26.7** | **0.8** | **30.3** | **0.7** | **23.3** | **0.7** | **25.5** |
| Commercial/Institutional / Комерцијален/Институционален сектор | 1.7 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Residential / Домаќинства | 0.6 | 26.9 | 0.6 | 26.7 | 0.7 | 30.2 | 0.5 | 23.2 | 0.5 | 25.4 |
| Agriculture/Forestry/Fishing/Fish Farms, Stationary / Земјоделство/Шумарство/Рибарство/Рибници | 0.2 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 |
| **Non-Specified / Неспецифицирани** | **0.0** | **0.0** | **0.9** | **0.4** | **1.0** | **0.4** | **0.7** | **0.3** | **0.6** | **0.3** |

*NO – Not occurring; NE – Not estimated; IE – Included elsewhere*

| Categories / Категории | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ |
| **Fuel Combustion Activities / Активности при кои се согорува гориво** | **4.9** | **103.7** | **4.9** | **106.4** | **5.7** | **95.1** | **4.5** | **79.2** | **4.8** | **73.7** |
| **Energy Industries / Енергетски индустрии** | **0.1** | **98.3** | **0.1** | **102.5** | **0.1** | **88.9** | **0.1** | **74.0** | **0.1** | **69.5** |
| Main Activity Electricity and Heat Production / Главна активност производство на електрична и топлинска енергија | 0.1 | 98.3 | 0.1 | 102.5 | 0.1 | 88.5 | 0.1 | 73.9 | 0.1 | 69.4 |
| Electricity Generation / Производство на електрична енергија | 0.1 | 94.6 | 0.1 | 100.7 | 0.1 | 87.8 | 0.1 | 73.5 | 0.1 | 69.3 |
| Combined Heat and Power Generation / Комбинирано производство на топлинска и електрична енергија | 0.0 | 1.1 | 0.0 | 0.5 | 0.0 | 0.3 | 0.0 | 0.3 | 0.0 | 0.1 |
| Heat Plants / Топлани | 0.0 | 2.6 | 0.0 | 1.3 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| Petroleum Refining / Рафинирање на на нафта | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE |
| Manufacture of Solid Fuels and Other Energy Industries / Производство на цврсти горива и други енергетски индустрии | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.2 | 0.0 | 0.1 |
| Manufacture of Solid Fuels / Производство на цврсти горива | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Other Energy Industries / Други енергетски индустрии | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.2 | 0.0 | 0.1 |
| **Manufacturing Industries and Construction / Производствени индустрии и градежништво** | **0.6** | **4.8** | **0.6** | **3.5** | **0.9** | **5.8** | **0.8** | **4.9** | **0.7** | **4.0** |
| **Transport / Транспорт** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Domestic Aviation / Домашна авијација | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Road Transportation / Патен сообраќај | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| Railways / Железнички сообраќај | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Other Sectors / Други сектори** | **4.2** | **0.6** | **4.0** | **0.3** | **4.5** | **0.2** | **3.5** | **0.2** | **3.8** | **0.2** |
| Commercial/Institutional / Комерцијален/Институционален сектор | 0.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Residential / Домаќинства | 4.0 | 0.3 | 4.0 | 0.3 | 4.5 | 0.2 | 3.5 | 0.1 | 3.8 | 0.1 |
| Agriculture/Forestry/Fishing/Fish Farms, Stationary / Земјоделство/Шумарство/Рибарство/Рибници | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Non-Specified / Неспецифицирани** | **0.0** | **0.0** | **0.2** | **0.1** | **0.2** | **0.1** | **0.1** | **0.1** | **0.1** | **0.1** |

*NO – Not occurring; NE – Not estimated; IE – Included elsewhere*

***Table 39. Emissions of $NO_x$, CO, NMVOC and $SO_2$ from the Fugitive emissions of fuels (in Gg)***

| Categories / Категории | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO |
| **Fugitive emissions from fuels / Фугитивни емисии од горива** | **0.0002** | **0.0001** | **0.0002** | **0.0001** | **0.0001** | **0** | **0** | **0** | **0** | **0** |
| **Solid Fuels / Цврсти горива** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** | **NO** |
| Coal mining and handling / Ископување на јаглен и ракување | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Uncontrolled combustion / Неконтролирано горење | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Solid fuel transformation / Трансформации на цврсти горива | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Oil and Natural Gas / Нафта и природен гас** | **0.0002** | **0.0001** | **0.0002** | **0.0001** | **0.0001** | **0** | **0** | **0** | **0** | **0** |
| Oil / Нафта | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Refining / Рафинирање | 0.0002 | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 0 | 0 | 0 | 0 | 0 |
| Natural Gas / Природен гас | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Categories / Категории** | **2003** | | **2008** | | **2012** | | **2013** | | **2014** | |
| | **NMVOC** | **$SO_2$** | **NMVOC** | **$SO_2$** | **NMVOC** | **$SO_2$** | **NMVOC** | **$SO_2$** | **NMVOC** | **$SO_2$** |
| **Fugitive emissions from fuels / Фугитивни емисии од горива** | **6.2010** | **0.0004** | **6.4098** | **0.0006** | **5.8488** | **0.0002** | **5.3491** | **0** | **5.1855** | **0** |
| **Solid Fuels / Цврсти горива** | **6.2009** | **NO** | **6.4096** | **NO** | **5.8487** | **NO** | **5.3491** | **NO** | **5.1855** | **NO** |
| Coal mining and handling / Ископување на јаглен и ракување | 6.2009 | NO | 6.4096 | NO | 5.8487 | NO | 5.3491 | NO | 5.1855 | NO |
| Uncontrolled combustion / Неконтролирано горење | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Solid fuel transformation / Трансформации на цврсти горива | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **Oil and Natural Gas / Нафта и природен гас** | **0.0001** | **0.0004** | **0.0002** | **0.0006** | **0.0000** | **0.0002** | **0** | **0** | **0** | **0** |
| Oil / Нафта | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Refining / Рафинирање | 0.0001 | 0.0004 | 0.0002 | 0.0006 | 0.0000 | 0.0002 | 0 | 0 | 0 | 0 |
| Natural Gas / Природен гас | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

*NO = Not occurring*

### 7.2.5 Methodology and emission factors

The IPCC Guidelines contain links to information on methods, used under other agreements and conventions, for the estimation of emissions of tropospheric precursors which may be used to supplement the reporting of emissions and removal of greenhouse gases. Table 7.1 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 7: Precursors and Indirect Emissions provides a link between the IPCC categories and the corresponding methodology chapters in EMEP/CORINAIR Guidebook 2016 (http://www.eea.europa.eu/publications/EMEPCORINAIR4).

Detailed methodologies for estimating the emissions of precursors are provided in the EMEP/CORINAIR Emission Inventory Guidebook 2016. 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 and should therefore be considered as primary source of information for estimation of these emissions.

The emissions of precursors and indirect GHG of the Energy sector are estimated by using Tier 1 methodology, as prescribed in different Chapters of the 2006 Guidelines. The reason behind that is that the higher Tier methodologies require detailed characteristics of the fuels used in combination with onsite measurements or other detailed parameters, which were not available in the period of preparation of the SBUR. It is also worth mentioning that the application of higher Tiers for the estimation of the precursors and indirect emissions requires a longer period for data collection, data verification and preparation of the emissions estimates. As a starting point, the Report on National $CO_2$ and non-$CO_2$ emission factors for Key Sectors under IPCC and CORINAIR methodology (Tehnolab, 2013) can be used for developing higher Tier estimations in the future submissions.

***Table 40. Emission factors used for estimation of the emissions of Precursors and Indirect emissions of the Energy sector***

| Emission factor | FBUR | SBUR | Comment |
|---|---|---|---|
| **Energy sector** | NE | Tier 1 EF from Table 7.1 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 7: Precursors and Indirect Emissions | Tier 1 methodology applied. Not enough onsite measurement data and detailed parameters for application of higher Tier methodologies. |

### 7.2.6 Data sources

Since the estimates of the precursors and the indirect emissions of the Energy sector are done by using the Tier 1 approach and the default emission factors, all data in regards to the collection of the activity data are taken from the national energy balances published by the State Statistical Office and International Energy Agency database. The specific documents and databases used are presented in Table 41.

***Table 41. Data sources for estimation of the emissions of Precursors and Indirect emissions of the Energy sector***

| | Documents | Data provider |
|---|---|---|
| **Energy sector** | IEA Database, (annual databases from 1990 until 2003)<br>Energy balance, Final data, (annual reports for 1994, and from 2004 until 2013)<br>Energy balance, Preliminary data 2014 | International Energy Agency<br>SSO |

## 7.3 IPPU

### 7.3.1 Overview

Industrial processes can generate $NO_x$, CO, NMVOC and $SO_2$ emissions. Emissions of these gases depend on the type of process, abatement techniques, and other conditions. Industrial process and product use emissions include both channelled emissions (e.g., point sources emissions from a stack) and diffuse emission sources.

### 7.3.2 Emission trends

In the IPPU sector, the indirect gases are showing an increase in the period after year 2000 and they have doubled in the entire period 1990-2014. The emissions depend on the industrial production in the country (food and drink industries for NMVOC and $SO_2$ emissions), production of iron and steel in metal industry for CO emissions and production of cement in terms of $NO_x$ and partially $SO_2$ emissions (see Figure 51):

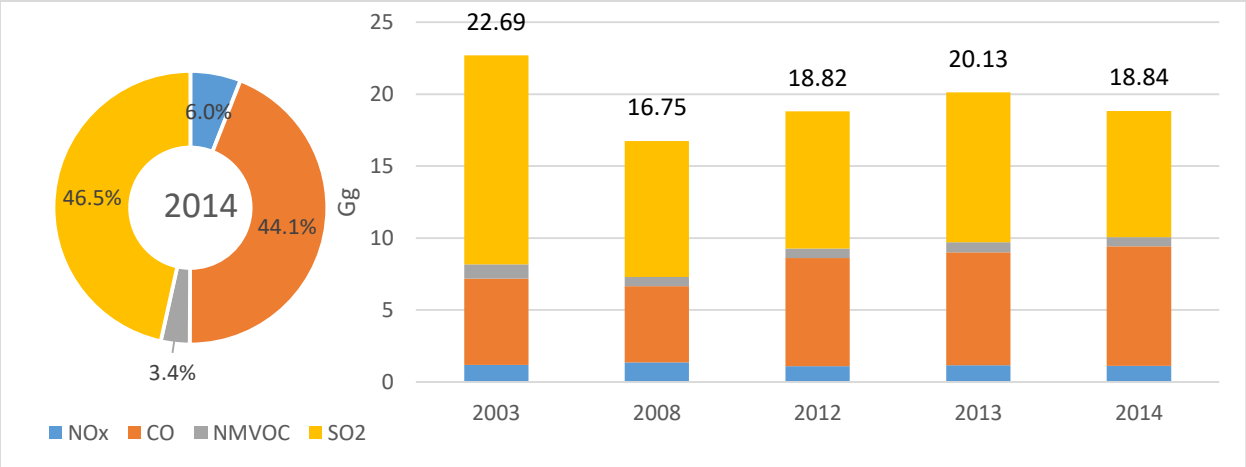



***Figure 51. Emissions of NOx, CO, NMVOC and $SO_2$ from the IPPU sector (in Gg)***

Emissions of $NO_x$, CO, NMVOC and $SO_2$ from the IPPU sector, by category, for the reporting years, are provided in Table 42.

***Table 42. Emissions of $NO_x$, CO, NMVOC and $SO_2$ from the IPPU sector, in Gg***

| Categories / Категории | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO |
| **Industrial Processes and Product Use / Индустриски процеси и користење на производи** | **1.18** | **6.02** | **1.37** | **5.30** | **1.09** | **7.54** | **1.15** | **7.85** | **1.12** | **8.31** |
| **Mineral Industry / Минерална индустрија** | **1.04** | **0.00** | **1.24** | **0.00** | **0.92** | **0.00** | **0.99** | **0.00** | **0.93** | **0.00** |
| Cement production / Производство на цемент | 1.04 | NE | 1.24 | NE | 0.92 | NE | 0.99 | NE | 0.93 | NE |
| Glass Production / Производство на стакло | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Chemical Industry / Хемиска индустрија** | **0.00** | **0.03** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| Soda Ash Production / Производство на сода бикарбонат | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Metal Industry / Метална индустрија** | **0.12** | **5.90** | **0.10** | **5.14** | **0.15** | **7.45** | **0.16** | **7.78** | **0.16** | **8.11** |
| Iron and Steel Production / Производство на железо и челик | 0.12 | 5.90 | 0.10 | 5.14 | 0.15 | 7.45 | 0.16 | 7.78 | 0.16 | 8.11 |
| **Other / Друго** | **0.02** | **0.12** | **0.03** | **0.15** | **0.02** | **0.09** | **0.01** | **0.07** | **0.04** | **0.19** |
| Pulp and Paper Industry / Индустрија за целулоза и хартија | 0.02 | 0.12 | 0.03 | 0.15 | 0.02 | 0.09 | 0.01 | 0.07 | 0.04 | 0.19 |
| Food and Beverages Industry / Индустрија за храна и пијалоци | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Categories / Категории | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ |
| **Industrial Processes and Product Use / Индустриски процеси и користење на производи** | **0.97** | **14.53** | **0.62** | **9.47** | **0.65** | **9.55** | **0.70** | **10.43** | **0.64** | **8.76** |
| **Mineral Industry / Минерална индустрија** | **0.18** | **3.92** | **0.21** | **4.67** | **0.16** | **3.48** | **0.17** | **3.72** | **0.16** | **3.50** |
| Cement production / Производство на цемент | 0.18 | 3.92 | 0.21 | 4.67 | 0.16 | 3.48 | 0.17 | 3.72 | 0.16 | 3.50 |
| Glass Production / Производство на стакло | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Chemical Industry / Хемиска индустрија** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| Soda Ash Production / Производство на сода бикарбонат | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Metal Industry / Метална индустрија** | **0.05** | **0.08** | **0.05** | **0.07** | **0.07** | **0.10** | **0.07** | **0.10** | **0.07** | **0.11** |
| Iron and Steel Production / Производство на железо и челик | 0.05 | 0.08 | 0.05 | 0.07 | 0.07 | 0.10 | 0.07 | 0.10 | 0.07 | 0.11 |
| **Other / Друго** | **0.74** | **10.53** | **0.37** | **4.73** | **0.43** | **5.97** | **0.46** | **6.61** | **0.41** | **5.16** |
| Pulp and Paper Industry / Индустрија за целулоза и хартија | 0.04 | 0.04 | 0.06 | 0.06 | 0.03 | 0.03 | 0.02 | 0.02 | 0.07 | 0.07 |
| Food and Beverages Industry / Индустрија за храна и пијалоци | 0.70 | 10.49 | 0.31 | 4.68 | 0.40 | 5.93 | 0.44 | 6.58 | 0.34 | 5.09 |

*NE=Not Estimated*

Most of the $NO_x$ emissions in the year 2014 originate from the category Mineral industry, category Cement production, or 82.4%, followed by 14.4% from the category Metal industry, category Iron and steel production and 3.2% from category Other (Figure 52).

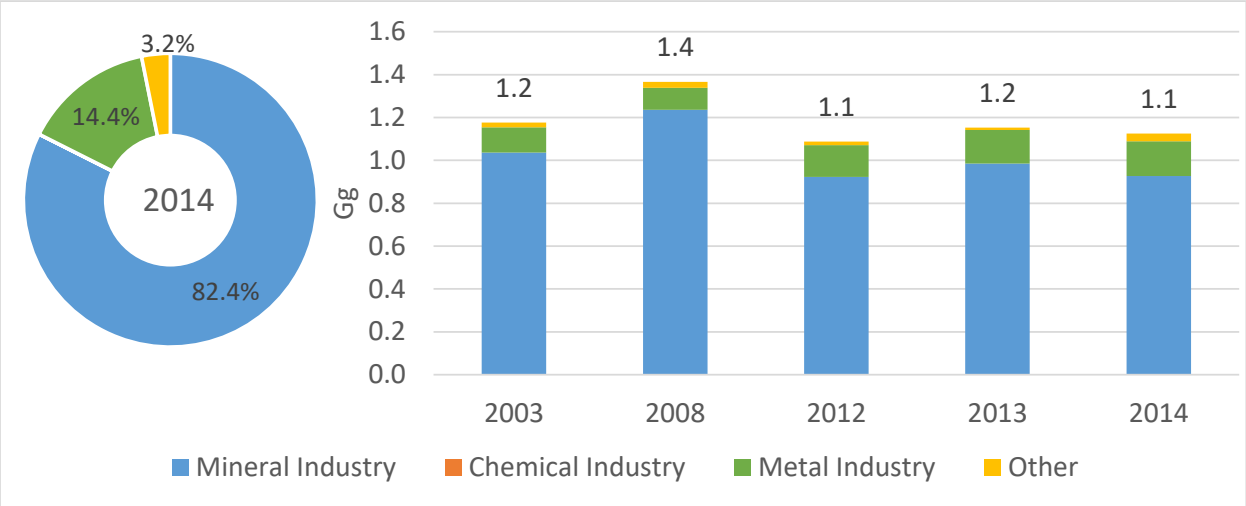



***Figure 52. NOx emissions from the IPPU sector, by category (in Gg)***

Analysing the CO emissions in IPPU sector, in 2014 97.65% originate from the category Metal industry, category Iron and Steel, while 2.35% originate from category Other industries, category Pulp and Paper (Figure 53).

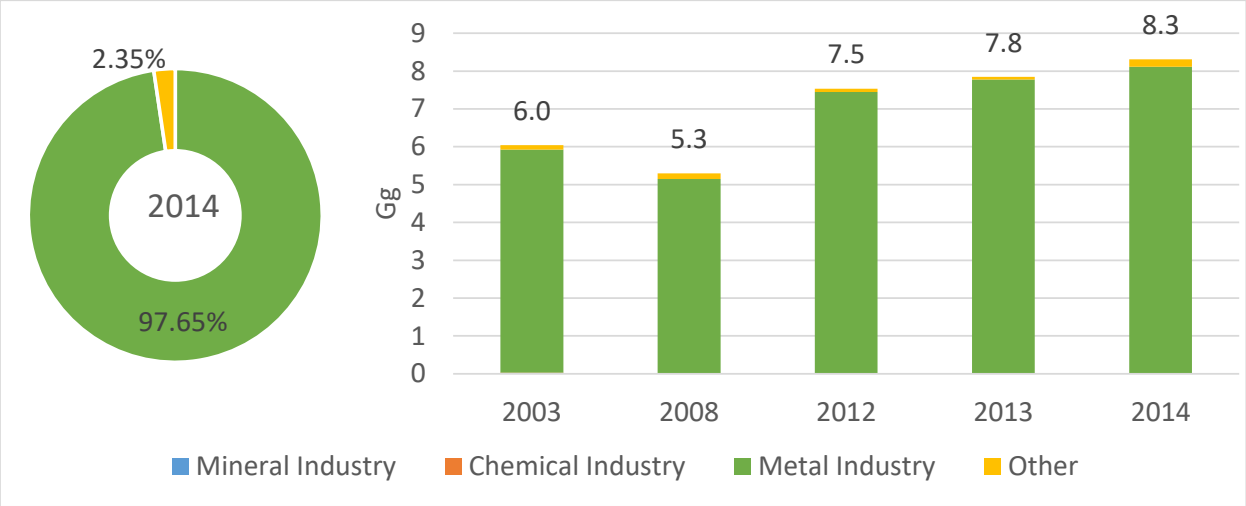



***Figure 53. CO emissions from the IPPU sector, by category (in Gg)***

The NMVOC emissions originating from the category Other industries in 2014 account for 64.0% (52.9% from the category Food and Beverages and 11.1% from the category Pulp and Paper), 24.6% from the category Mineral industry (category Cement production), and 11.4% are coming from the category Metal industry (category Iron and Steel Production) – see Figure 54.

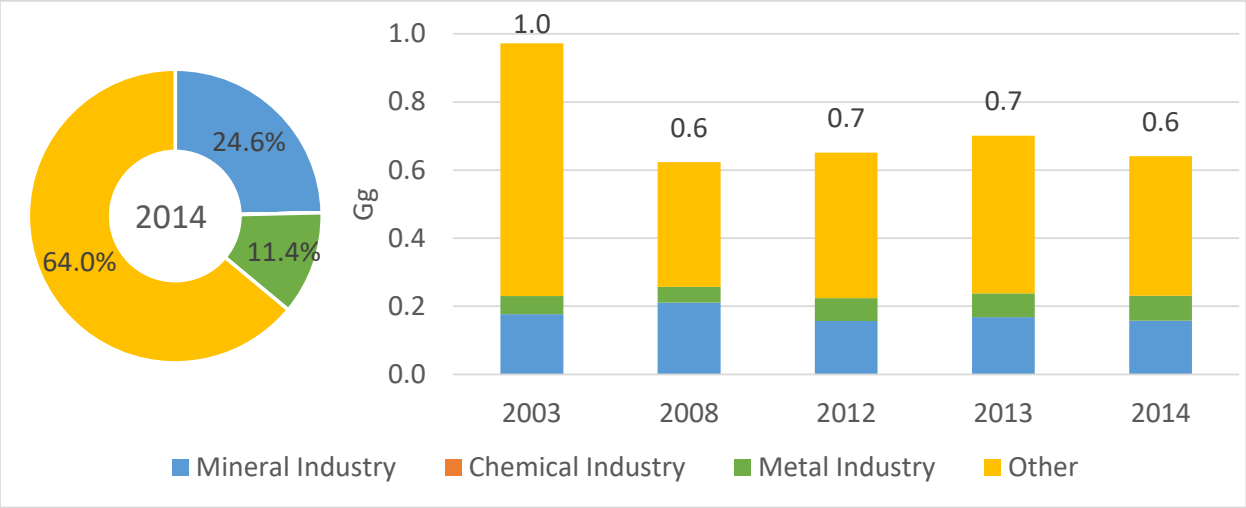



***Figure 54. NMVOC emissions from the IPPU sector, by category (in Gg)***

Regarding the $SO_2$ emissions of the sector IPPU in 2014, 58.8% of $SO_2$ emissions are originating from category Other (58.0% from the category Food and Beverages and 0.8% from the category Pulp and Paper), the Mineral industry in responsible for 40.0% (category Cement production), while the category Metal industry is responsible for 1.2% of the emission (category Iron and Steel) – see Figure 55.

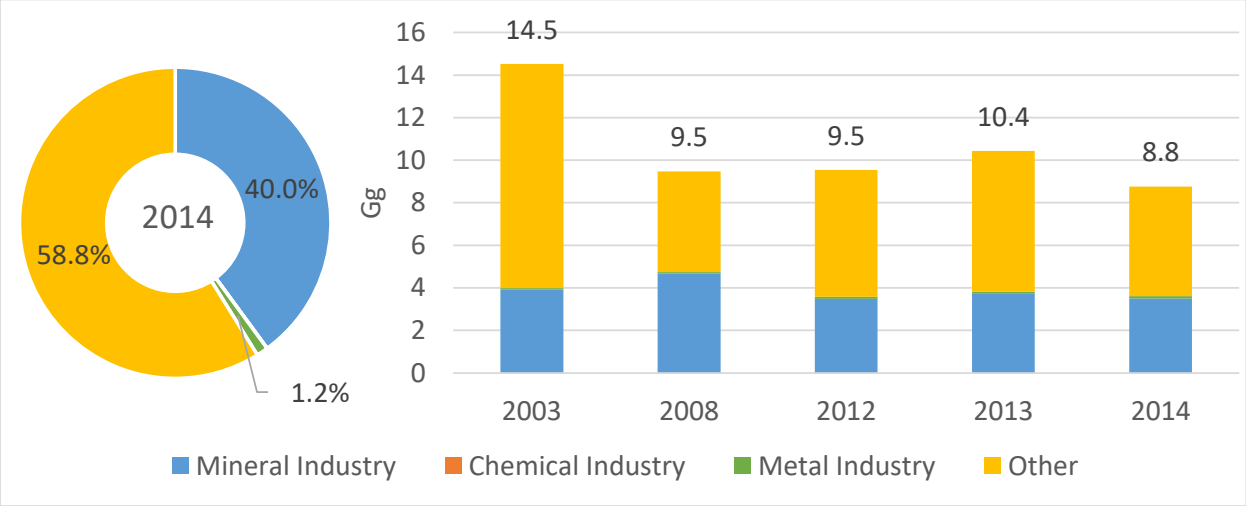



***Figure 55. $SO_2$ emissions from the IPPU sector, by category, (in Gg)***

### 7.3.3 Mineral industry

Emissions of $NO_x$, NMVOC, CO can occur in the primary steps of the Cement production - kiln process (preheater, precalciner), when impurities (such as organic matter) that are present in the raw materials are volatised as the raw mix is heated (Table 42).

There are minor $SO_2$ emissions from category Glass production. Emissions are generally constant in the whole time-series.

### 7.3.4 Chemical industry

In this category, there are emissions of CO only from Soda ash production and consumption (including sodium carbonate, Na2CO3). There is general trend of reduction (by 86%) of CO emissions during period 1990-2014 or from 0.0284 in 1990 to 0.00004 Gg in 2014.

### 7.3.5 Metal industry

Nationally, Iron and Steel are produced in only in one factory. To be more precise, the activity of this factory covers steel and hot rolled plate production.

The activity data on steel production and materials consumed have been obtained from the Application for A – Integrated Environmental Permit submitted by Makstil AD Skopje, Annex 1, Table IV.1.1, page 65.

### 7.3.6 Other industry (Pulp and paper industry and Food and beverages)

Emissions from Paper and Pulp production include NMVOC, $SO_x$, particulates, $NO_x$ and CO. Food and Beverages manufacturing processes are significant sources of NMVOC emissions. In general, there is trend of increase of $NO_x$ and CO emissions, while NMVOCs are constant and $SO_2$ emissions are decreasing in the time series 1990 - 2014.

### 7.3.7 Methodology and emission factors

The Tier 1 approach was used to calculate the emissions of precursors and indirect gases from IPPU sector. Emission factors are taken from Table 3.1 of EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, for each relevant Chapter, as prescribed in Table 7.1 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 7: Precursors and Indirect Emissions.

***Table 43.Emission factors used for estimation of the emissions of Precursors and Indirect emissions of the IPPU sector***

| Emission factor | FBUR | SBUR | Comment |
|---|---|---|---|
| **IPPU-all categories** | NE | Tier 1 EF from Table 7.1 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 7: Precursors and Indirect Emissions | Recommended from TTE |

### 7.3.8 Data sources

Activity data used for each industry is production per year (tons/year) as given in five-year data reports on the industry production in Macedonia from the State Statistical Office.

***Table 44. Data sources for estimation of the emissions of Precursors and Indirect emissions of the IPPU sector***

| | Documents | Data provider |
|---|---|---|
| **IPPU-all categories** | Industry (1990-1995, 1996-2001, 2002-2006, 2006-2010, 2011-2016) | SSO |
| **IPPU-Metal industry** | Application for A – Integrated Environmental Permit submitted by Makstil AD Skopje, Annex 1, Table IV.1.1, page 65. | MOEPP |

## 7.4 AFOLU

### 7.4.1 Overview

In the sector Agriculture, Forestry and Other Land use, the burning of crop residues emits $NO_x$ as does the addition of nitrogen to the soils from nitrogen fertilizers and other nutrients. CO and $SO_2$ are emitted when biomass is burned. The primary sources of the NMVOC emissions are burning of crop residues and other plant wastes, and the anaerobic degradation of livestock feed and animal excreta. There are five main sources of emissions related to livestock husbandry and manure management: manure storage ($NH_3$, NO, NMVOCs), field-applied manure ($NH_3$, NO, NMVOCs) and the excreta deposited during grazing ($NH_3$, NO, NMVOCs).

Plants, mainly trees and cereals, also contribute to NMVOC concentrations in the atmosphere.

Emissions of $NH_3$, NO and NMVOCs arise from the excreta of agricultural livestock that are deposited in and around buildings and collected as liquid slurry, solid manure or litter-based farmyard manure. These emissions occur from buildings housing livestock and outdoor yard areas, from manure stores, after land spreading of manures and during grazing.

### 7.4.2 Emission trends

In the sector AFOLU, the NOx and NMVOC emissions are occurring from the category Agriculture, category Manure management, while in category Forestry and Other Land Use, all emissions are originating from the category Aggregate sources and non-$CO_2$ emissions sources on land: subcategory Biomass burning in Croplands and Forest land (forest fires) and subcategory Crop production and agricultural soils.

During the analysed period emissions of NOx are typically in range 0.5-1.5 Gg, with exception of years 2000, 2007, 2008 and 2012, were the emissions are 3-5 Gg, due to extensive forest fires and area burned in the country. In respect to CO, the emissions are in range 3-10 Gg, but in years 2000 and 2007 they were 138 and 105 Gg, because of the fires. NMVOCs are in average 5 Gg/year, while in the year 2000 they are estimated on 19 Gg. The $SO_2$ emissions are in average 0.02 Gg, but again there are peaks in the year 2000 due to the forest fires. The emissions of precursors and indirect gas of the sector AFOLU is shown in Figure 56.

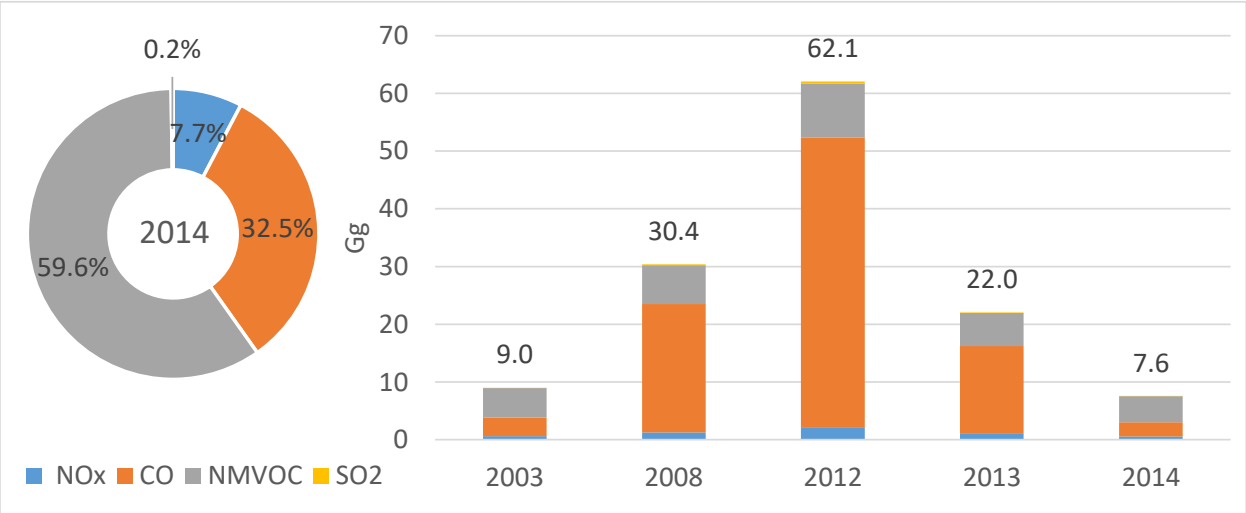



***Figure 56. Emissions of NOx, CO, NMVOC and $SO_2$ from AFOLU sector (in Gg)***

The detailed emissions of the sector AFOLU, by category, for the reported years are provided in Table 45.

***Table 45. Emissions of NOx, CO, NMVOC and $SO_2$ from the AFOLU sector in Gg***

| Categories / Категории | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO |
| **Agriculture, Forestry, and Other Land Use / Земјоделство, шумарство и друго користење на земјиштето** | **0.6** | **3.2** | **1.3** | **22.2** | **2.2** | **50.2** | **1.0** | **15.2** | **0.6** | **2.5** |
| **Livestock / Сточарство** | **0.1** | **0.0** | **0.1** | **0.0** | **0.1** | **0.0** | **0.1** | **0.0** | **0.1** | **0.0** |
| Manure Management / Управување со добиточно ѓубре | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 |
| **Aggregate sources and non-$CO_2$ emissions sources on land / Збирни извори и извори на емисии на други гасови од земјиштето кои не се $CO_2$** | **0.5** | **3.2** | **1.2** | **22.2** | **2.1** | **50.2** | **0.9** | **15.2** | **0.5** | **2.5** |
| Emissions from biomass burning / Емисии од горење на биомаса | 0.1 | 3.2 | 0.7 | 22.2 | 1.7 | 50.2 | 0.5 | 15.2 | 0.1 | 2.5 |
| Direct $N_2O$ emissions from managed soils / Директни $N_2O$ емисии од обработени почви | 0.4 | 0.0 | 0.4 | 0.0 | 0.4 | 0.0 | 0.4 | 0.0 | 0.4 | 0.0 |
| **Categories / Категории** | **2003** | | **2008** | | **2012** | | **2013** | | **2014** | |
| | **NMVOC** | **$SO_2$** | **NMVOC** | **$SO_2$** | **NMVOC** | **$SO_2$** | **NMVOC** | **$SO_2$** | **NMVOC** | **$SO_2$** |
| **Agriculture, Forestry, and Other Land Use / Земјоделство, шумарство и друго користење на земјиштето** | **5.1** | **0.0** | **6.7** | **0.1** | **9.4** | **0.3** | **5.7** | **0.1** | **4.5** | **0.0** |
| **Livestock / Сточарство** | **4.8** | **0.0** | **4.5** | **0.0** | **4.4** | **0.0** | **4.2** | **0.0** | **4.3** | **0.0** |
| Manure Management / Управување со добиточно ѓубре | 4.8 | 0.0 | 4.5 | 0.0 | 4.4 | 0.0 | 4.2 | 0.0 | 4.3 | 0.0 |
| **Aggregate sources and non-$CO_2$ emissions sources on land / Збирни извори и извори на емисии на други гасови од земјиштето кои не се $CO_2$** | **0.3** | **0.0** | **2.2** | **0.1** | **5.0** | **0.3** | **1.5** | **0.1** | **0.3** | **0.0** |
| Emissions from biomass burning / Емисии од горење на биомаса | 0.3 | 0.0 | 2.2 | 0.1 | 5.0 | 0.3 | 1.5 | 0.1 | 0.2 | 0.0 |
| Direct $N_2O$ emissions from managed soils / Директни $N_2O$ емисии од обработени почви | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

In the year 2014, the majority or 72.9% of the emissions of $NO_x$ are originating by the category Direct $N_2O$ emissions from the managed soils. The category Emissions from biomass burning are responsible for 14.1%, while the category Manure management is responsible for 13.0%. In the years in which severe forest fires are registered, the $NO_x$ emissions of the category Emissions of biomass burning are much more significant and can be a dominant source of the $NO_x$ emissions from the AFOLU sector (Figure 57).

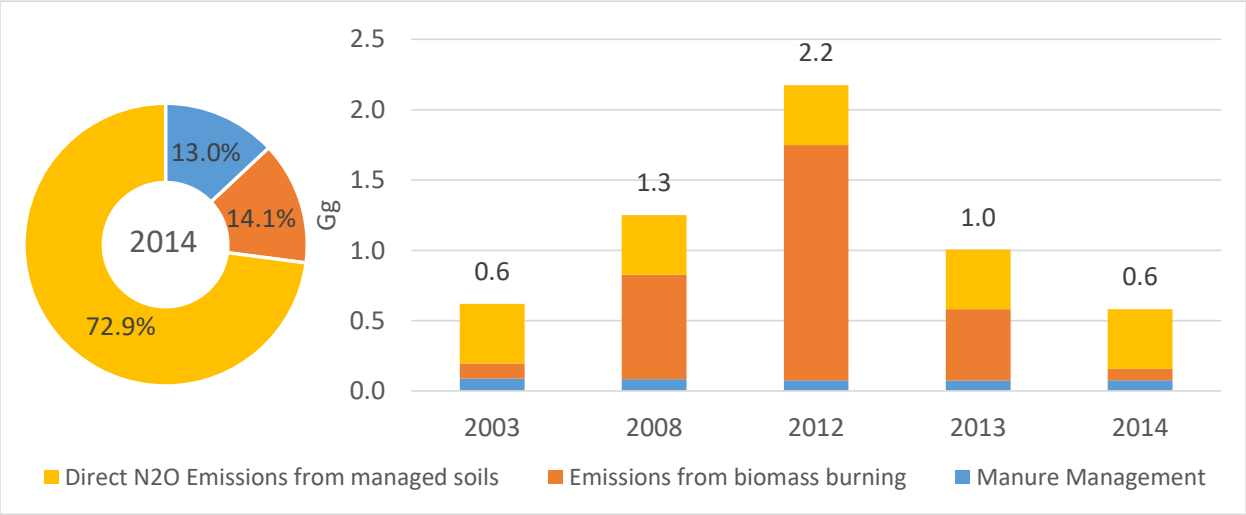
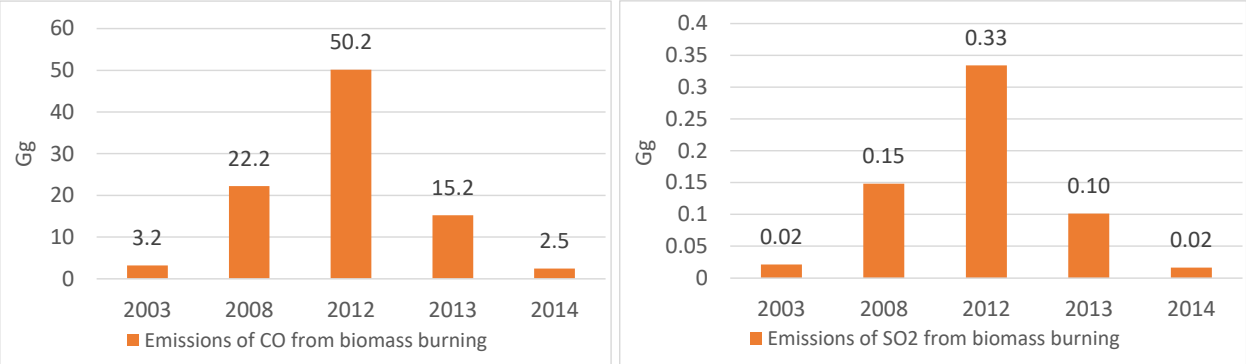



***Figure 57. NOx emissions from AFOLU sector, by category, (in Gg)***

When it comes to the emissions of CO and $SO_2$, in the sector AFOLU the category Biomass burning is the only source category. The emissions are proportional with naturally or man-induced burning of non-managed and managed forests and other vegetation (Figure 58).




a) b)

***Figure 58. Emissions of a) CO and b) $SO_2$ from AFOLU sector (in Gg)***

The emissions of NMVOC in the AFOLU sector are mainly originating from the category Manure management, which in 2014 is responsible for 94.4%, followed by the category Emissions from biomass burning with share of 5.4% and the category Direct $N_2O$ emissions from managed soils with 0.2% (Figure 59).

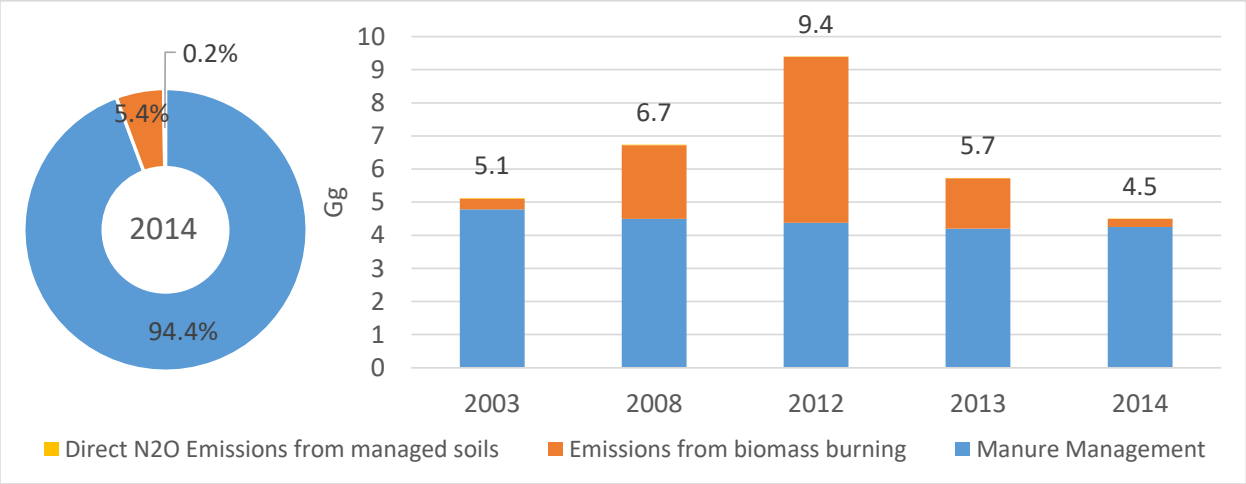



***Figure 59. NMVOC emissions from AFOLU sector, by category (in Gg)***

### 7.4.3 Manure Management

Emissions of NMVOCs occur from silage, manure in livestock buildings, outside manure storages, field application of manure and from grazing animals. There are lack of emissions estimates related to feeding with silage, outdoor manure stores, manure application and grazing animals, due to lack of appropriate activity data.

Emissions of $NH_3$, NO and NMVOCs arise from the excreta of agricultural livestock that are deposited in and around buildings and collected as liquid slurry, solid manure or litter-based farmyard manure. These emissions occur from buildings housing livestock and outdoor yard areas, from manure storages, after manure land spreading and during grazing.

Generally, there is overall trend of decrease in emissions that can be linked to the observed reductions of the livestock population in the period 2002-2014.

### 7.4.4 Aggregate sources and non-$CO_2$ emissions sources on land - Biomass burning

Burning of crop residues leads to the emissions of a number of atmospheric pollutants: ammonia ($NH_3$), $NO_x$, NMVOCs, $SO_2$, CO.

The subcategory Biomass burning in forests includes emissions from (naturally or man-induced) burning of non-managed and managed forests and other vegetation, excluding agricultural burning of stubble, etc. This includes domestic fires (fuel wood-, crop residue-, dung and charcoal burning) as well as open vegetation fires (forest, shrub-, grass- and cropland burning).

As previously mentioned, the emissions are constant during all time-series, with exception of the years with significant burned area due to forest fires, as the years 2000, 2007, 2008 and 2012.

### 7.4.5 Aggregate sources and non-$CO_2$ emissions sources on land - Crop production and agricultural soils

There are four main sources of emissions from crop production and agricultural soils:

- mineral nitrogen fertilizer, livestock manure and organic waste application ($NH_3$);
- soil microbial processes (NO);
- crop processes ($NH_3$ and NMVOCs);
- soil cultivation and crop harvesting (PM).

### 7.4.6 Methodology and emission factors

A basic Tier 1 methodology was used for all sub sectors in the AFOLU. The emission factors are taken from various Chapters as prescribed in the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016.

***Table 46. Emission factors used for estimation of the emissions of Precursors and Indirect emissions of the AFOLU sector***

| Emission factor | FBUR | SBUR | Comment |
|---|---|---|---|
| **Manure Management** | NE | EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 3.B Manure management (p.17-19) | Used for the first time due to recommendations from TTE |
| **Biomass burning in forests** | NE | Table 3–1 EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 11.B Forest fires, p.9 | Used for the first time due to recommendations from TTE |
| **Biomass burning in croplands** | NE | Table 3.1 of EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 3.F Field burning of agricultural wastes, p.5 | Used for the first time due to recommendations from TTE |
| **Crop production and agricultural soils** | NE | Table 3.1 of EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 3.D Crop production and agricultural soils, p.12 | Used for the first time due to recommendations from TTE |

### 7.4.7 Data sources

The activity data used for manure management are livestock populations. For biomass burning the activity data are the areas burned (forests, croplands), while for crop production the nitrogen applied as fertilizer, manure or excreta, or the nitrogen deposited in soils due to the microbial processes. Data for area grown by crops: wheat, maize, rice, oats and barley, as well as the livestock populations were obtained from SSO (MAKSTAT database). Data on forest fires were obtained from MAFWE, State Inspectorate for Forestry and Hunting and the Crisis Management Centre (Table 47).

***Table 47. Data sources for estimation of the emissions of Precursors and Indirect emissions of the AFOLU sector***

| Sector | Documents | Data provider |
|---|---|---|
| **Livestock-Manure Management** | Total number of livestock & poultry in Macedonia | SSO –MAKSTAT database |
| **Biomass burning in forests** | Technical assistance for development of integrated system for prevention and early warning of forest fires, 2014 (p.6) | Public Enterprise for Forests Management – “Macedonian Forests”, Crisis Management Centre, MAFWE-State Inspectorate for Forestry and Hunting |
| **Biomass burning in croplands** | Crop production | MEIC (MOEPP), SSO |
| **Crop production and agricultural soils** | CORINE land cover 2000-2006-2012, urea and fertilizers use | MAFWE, SSO, Agricultural Institute of RM |

## 7.5 Waste

### 7.5.1 Overview

In the Waste sector, the emissions of $NO_x$, CO, and $SO_2$ are produced by open burning of waste, by the solid waste incineration processes (mainly medical waste), as well as by the incineration of sludge from wastewater treatment. NMVOC emissions can originate from wastewater treatment plants and open burning of waste.

In Macedonia, the majority of the emissions of precursors and indirect gases in the Waste sector are originating from the category Open burning of waste, followed by the category Incineration of medical waste and the category Wastewater treatment and discharge.

### 7.5.2 Emission trends

The trend of the precursors and indirect gases of the Waste sector for the reporting years is presented in the Figure 60. The emissions of precursors and indirect gases are increasing, mostly due to the increased CO and NOx emissions from the open burning of waste at the dump sites (which is result from increased waste generation), and as a result of the Incineration of medical waste at the landfill Drisla (starting from the year 2000)

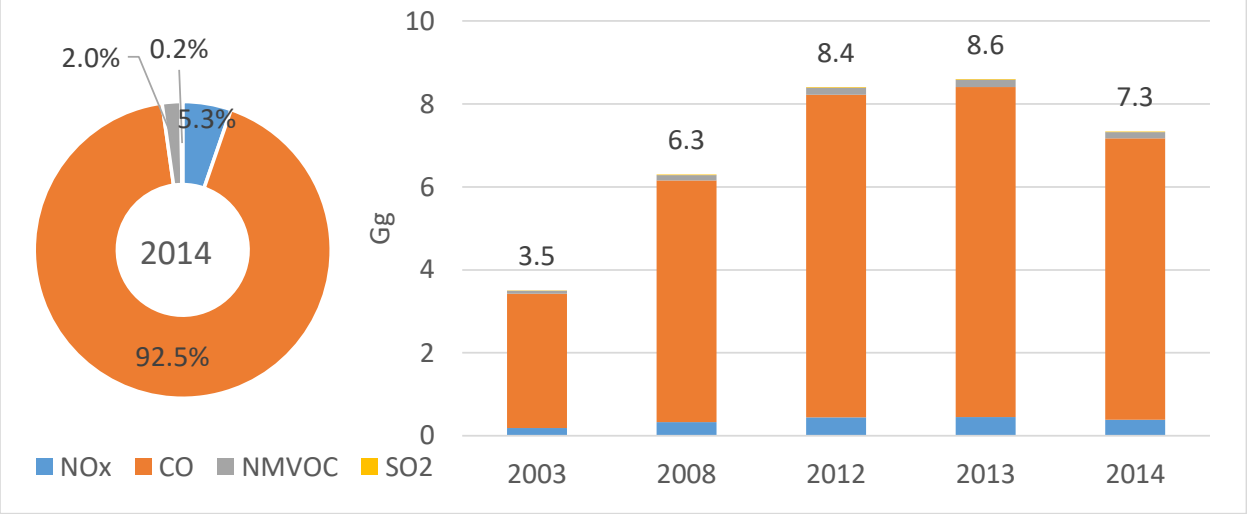



***Figure 60. Emissions of $NO_x$, CO, NMVOC and $SO_2$ from the Waste sector (in Gg)***

Analysing the year 2014, 99.7% of NOx emissions are coming from the category Open burning of waste, while 0.3% from the category Incineration of medical waste.

In the same time, 99.8% of CO emissions originate from the category Open burning of waste, while 0.2% from the Incineration of medical waste.

Following the same rationale, 99.7% of the NMVOC emissions are originating from the category Open burning of waste, followed by 0.2% from the category Incineration of waste and negligible shares (of 0.1%) from the categories domestic and industrial wastewater treatment and discharge.

And once again, the category Open burning of waste has dominant share of 97.7% in $SO_2$ emissions, while 2.3% are from the subcategory Incineration of medical waste in the country. Emissions can be seen in Table 48.

***Table 48. Emissions of NOx, CO, NMVOC and $SO_2$ from the Waste sector (in Gg)***

| Categories / Категории | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO | $NO_x$ | CO |
| **Waste / Отпад** | **0.19** | **3.24** | **0.33** | **5.82** | **0.44** | **7.78** | **0.45** | **7.96** | **0.39** | **6.78** |
| Solid Waste Disposal / Депонии за цврст отпад | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Biological Treatment of Solid Waste / Биолошки третман на цврст отпад | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Incineration and Open Burning of Waste / Согорување и отворено горење на отпадот | 0.19 | 3.24 | 0.33 | 5.82 | 0.44 | 7.78 | 0.45 | 7.96 | 0.39 | 6.78 |
| Wastewater Treatment and Discharge / Третман и испуштање на отпадни води | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Categories / Категории | 2003 | | 2008 | | 2012 | | 2013 | | 2014 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ | NMVOC | $SO_2$ |
| **Waste / Отпад** | **0.07** | **0.01** | **0.13** | **0.01** | **0.17** | **0.02** | **0.18** | **0.02** | **0.15** | **0.01** |
| Solid Waste Disposal / Депонии за цврст отпад | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Biological Treatment of Solid Waste / Биолошки третман на цврст отпад | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Incineration and Open Burning of Waste / Согорување и отворено горење на отпадот | 0.07 | 0.01 | 0.13 | 0.01 | 0.17 | 0.02 | 0.18 | 0.02 | 0.15 | 0.01 |
| Wastewater Treatment and Discharge / Третман и испуштање на отпадни води | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

### 7.5.3 Waste Incineration and Open Burning of Waste

This category is containing the pollutants $SO_x$, $NO_x$, NMVOCs, CO, $CO_2$ and $N_2O$.

Since the Drisla landfill incinerator of medical (clinical) waste is the only facility of this type in the country, the majority of the country (40%) is practicing incineration at open dump sites.

The resulting $NO_x$ emissions are slowly increasing, CO emissions and NMVOCs have rapidly increased, while $SO_2$ were constant during the period.

### 7.5.4 Wastewater Handling

In urban areas, non-methane volatile organic compounds (NMVOC) emissions from waste water treatment plants will be of local importance. Activities considered within this sector are biological treatment plants and latrines (storage tanks of human excreta, located under naturally ventilated wooden shelters). Emissions are calculated from both domestic waste water treatment and industry wastewater treatment. For the domestic wastewater, 59% of total population in the country was used as a data source, while for the industries, the Industry statistics regarding the annual amount of wastewater treated (m3/per ton of product produced) was used as a data source.

Emissions of NMVOC from the category Wastewater Handling is slightly decreasing during the period 1990-2014.

### 7.5.5 Methodology and emission factors

For the waste incineration, open burning of wastes and wastewater handling estimations, the default Tier 1 was used.

Default emission factors for Tier 1 are given in the section. Table 3-1 from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 5.C.1.b.iii Clinical waste incineration.

For the open burning of waste, the simpler methodology involves the use of a single emission factor for each pollutant representing the emission per mass of waste burned, combined with activity statistics, prescribed in general equation. Table 3-1 from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 5.C.2 Open burning of wastes, provides default emission factors.

In respect to Wastewater handling, activities considered within this sector are biological treatment plants and latrines (storage tanks of human excreta, located under naturally ventilated wooden shelters). The Tier 1 approach for emissions from waste water handling uses the general equation. The Tier 1 emission factors assume an averaged or typical technology and abatement implementation in the country and integrate all different sub-processes in the handling of waste water. Table 3.1 from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 5.D. Wastewater handling, can be used to obtain EF for NMVOCs. The relevant statistical data for the Tier 1 approach is the total amount of waste water handled by all waste water treatment plants in the country.

***Table 49. Emission factors used for estimation of the emissions of Precursors and Indirect emissions of the Waste sector***

| Emission factor | FBUR | SBUR | Comment |
|---|---|---|---|
| **Waste incineration of clinical waste** | NO | Table 3-1 from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 5.C.1.b.iii Clinical waste incineration, on p. 8 | Used for the first time due to recommendations from TTE |
| **Open burning of waste** | NO | Table 3-1 from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 5.C.2 Open burning of wastes, on p. 6 | Used for the first time due to recommendations from TTE |
| **Wastewater handling** | NO | Table 3.1 from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016, Chapter 5.D. Wastewater handling, p.7 | Used for the first time due to recommendations from TTE |

### 7.5.6 Data sources

Data used in the estimation of the emissions of precursors and indirect gases were taken from the MOEPP reports or the reports from the landfill Drisla.

***Table 50. Data sources for estimation of the emissions of Precursors and Indirect emissions of the Waste sector***

| | Documents | Data provider |
|---|---|---|
| **Waste incineration of clinical waste** | Drisla landfill data on incineration of medical waste | Drisla web site, MOEPP reports on environment 2000-2015 |
| **Open burning of waste** | Report on non-compliant landfilling in the R Macedonia, 2011 | MOEPP |
| **Wastewater handling** | Population connected to WWTP | SSO (industries), MOEPP (domestic) |

# 8 Key category analysis

The analysis of key categories that contribute the most to the absolute level of national emissions and removals (level assessment) and to the trend of emissions and removals (trend assessment), is conducted using the Approach 1. According to this approach, key categories are identified using a pre-determined cumulative emissions threshold. Key categories are those that, when summed together in descending order of magnitude, add up to 95% of the total level/trend.

The level assessment is performed for 1990 as a base year and for 2014, as the latest year,. The results in Gg $CO_2$-eq and percentages (up to 95%) for 2014 are depicted in Figure 61. Consequently, the top five categories with the highest values of Gg $CO_2$-eq (both emissions and removals) include: Forest Land Remaining Forest Land (35.1%), Energy Industries – Solid Fuels (22.8%), Solid Waste Disposal (11.4%), Road Transportation (8.2%), and Manufacturing Industries and Construction – Liquid Fuels (3.4%). The level assessment of key categories in 1990 and 2014 in details is given in Appendix IV, Table 96 and Table 97, respectively.

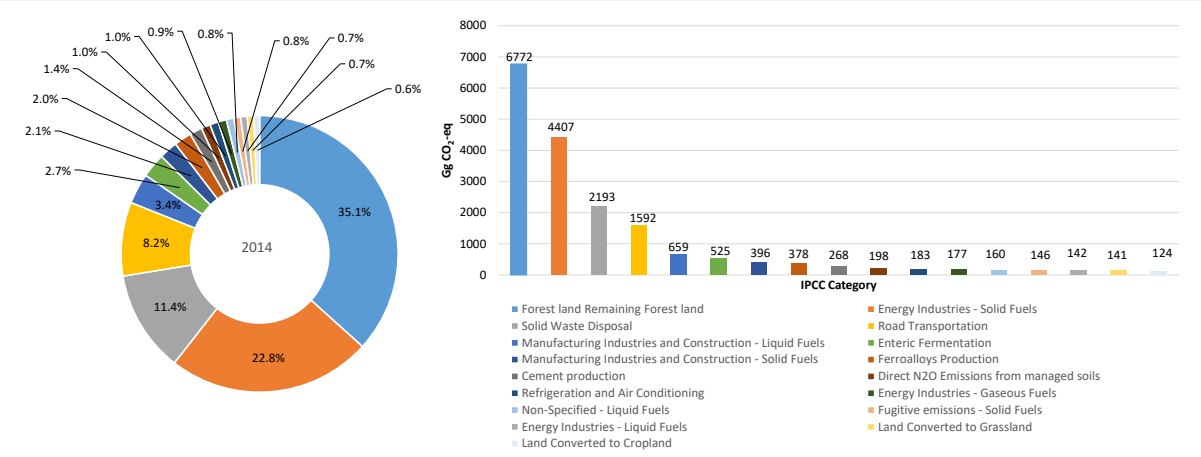



***Figure 61. Level assessment of key categories and their contribution in 2014***

The trend assessment of source categories is also executed, taking 1990 as base year and 2014 as latest inventory year. The purpose of this trend assessment is to emphasize the categories whose trend is significantly different from the trend of the overall inventory, regardless whether the category trend is increasing or decreasing, or is a sink or source. The results in percentages (up to 95%) are illustrated in Figure 62.

Unlike the key categories level assessment for 2014, the trend assessment for 1990 and 2014 detects different order of top 5 key categories, as follows: Solid Waste disposal (23.5%), Road Transportation (19.7%), Energy Industries (7.5%), Other Sectors – Liquid Fuels (5.7%), and Energy Industries – Liquid Fuels (3.6%). An overview of the trend assessment relating to 1990 and 2014 is given in Appendix IV, Table 98.

The identified key categories, with both level and trend assessment, for 2014 are summarized in Table 51.

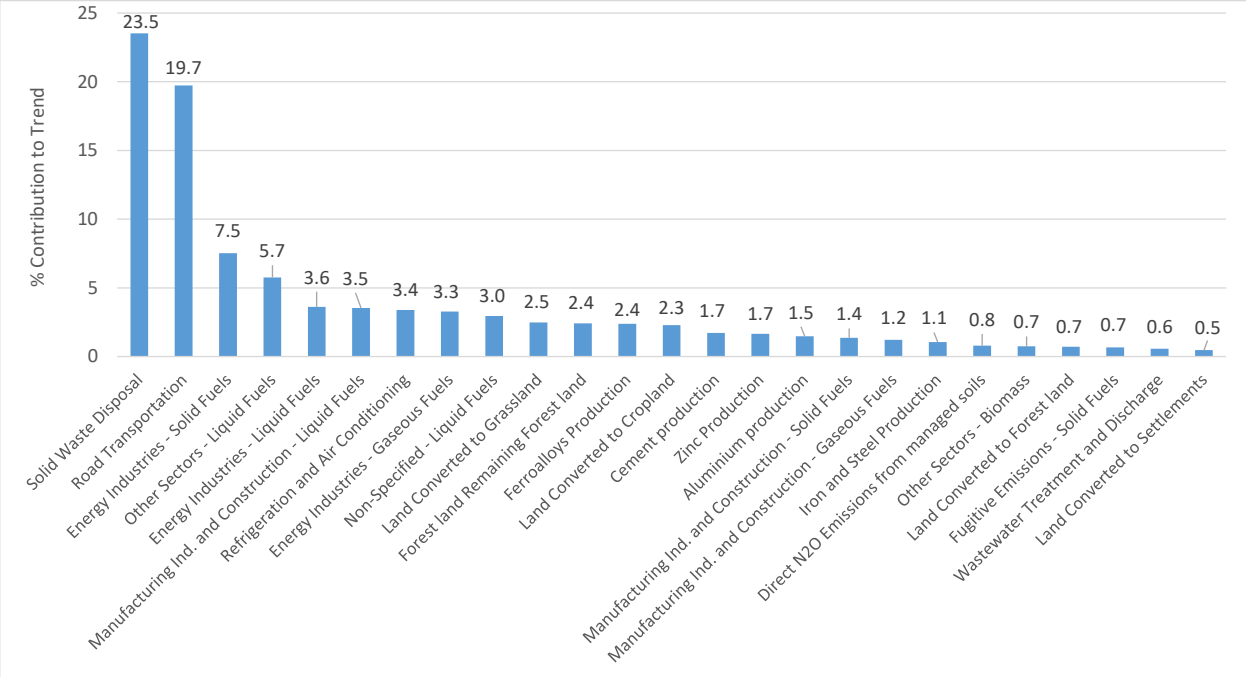



***Figure 62. Contribution of key categories to the Trend (1990, 2014) in percentages***

***Table 51. Summary of key category analysis in 2014***

| | IPCC Category code | IPCC Category | Greenhouse gas | Identification Criteria | Comment |
|---|---|---|---|---|---|
| 1 | 3.B.1.a | Forest land Remaining Forest land | $CO_2$ | L1, T1 | |
| 2 | 1.A.1 | Energy Industries - Solid Fuels | $CO_2$ | L1, T1 | |
| 3 | 4.A | Solid Waste Disposal | $CH_4$ | L1, T1 | |
| 4 | 1.A.3.b | Road Transportation | $CO_2$ | L1, T1 | |
| 5 | 1.A.2 | Manufacturing Industries and Construction - Liquid Fuels | $CO_2$ | L1, T1 | |
| 6 | 3.A.1 | Enteric Fermentation | $CH_4$ | L1 | |
| 7 | 1.A.2 | Manufacturing Industries and Construction - Solid Fuels | $CO_2$ | L1, T1 | |
| 8 | 2.C.2 | Ferroalloys Production | $CO_2$ | L1, T1 | |
| 9 | 2.A.1 | Cement production | $CO_2$ | L1, T1 | |
| 10 | 3.C.4 | Direct N2O Emissions from managed soils | $N_2O$ | L1, T1 | |
| 11 | 2.F.1 | Refrigeration and Air Conditioning | HFCs, PFCs | L1, T1 | |
| 12 | 1.A.1 | Energy Industries - Gaseous Fuels | $CO_2$ | L1, T1 | |
| 13 | 1.A.5 | Non-Specified - Liquid Fuels** | $CO_2$ | L1, T1 | |
| 14 | 1.B.1 | Fugitive emissions - Solid Fuels | $CH_4$ | L1, T1 | |
| 15 | 1.A.1 | Energy Industries - Liquid Fuels | $CO_2$ | L1, T1 | |
| 16 | 3.B.3.b | Land Converted to Grassland | $CO_2$ | L1, T1 | |
| 17 | 3.B.2.b | Land Converted to Cropland | $CO_2$ | L1, T1 | |
| 18 | 1.A.4 | Other Sectors - Liquid Fuels** | $CO_2$ | T1 | |
| 19 | 2.C.6 | Zinc Production | $CO_2$ | T1 | |
| 20 | 2.C.3 | Aluminium production | PFCs (PFCs) | T1 | |
| 21 | 1.A.2 | Manufacturing Industries and Construction - Gaseous Fuels | $CO_2$ | T1 | |
| 22 | 2.C.1 | Iron and Steel Production | $CO_2$ | T1 | |
| 23 | 1.A.4 | Other Sectors - Biomass | $CH_4$ | T1 | |
| 24 | 3.B.1.b | Land Converted to Forest land | $CO_2$ | T1 | |
| 25 | 4.D | Wastewater Treatment and Discharge | $CH_4$ | T1 | |
| 26 | 3.B.5.b | Land Converted to Settlements | $CO_2$ | T1 | |

*L1 – Level assessment, Approach 1; L2 – Trend assessment, Approach 1*
**Non-specified - as a subcategory under the Manufacturing Industries and Construction in Fuel combustion activities in Energy sector*
***Other sectors – as a category under the Fuel combustion activities in Energy sector, consisted of the subcategories Commercial/Institutional, Residential and Agriculture/Forestry/Fishing/Fish farms*

# 9 Uncertainty analysis

In each analysis, the accuracy of input data is very important because they dictate the precision of the results. The reduction of the uncertainty in the input data may greatly increases the reliability of the result. This is a major reason for making uncertainty analyses, as they are seen as a means to help prioritize national efforts to reduce the uncertainty of inventories in the future. Therefore, the uncertainty analyses are an essential part of the GHG inventory.

There are two basic approaches for determining uncertainty of the inventories: Approach 1 (Error Propagation method) and Approach 2 (which is actually an implementation of the Monte Carlo method). As a well-established practice in the previous inventory reports, both of these methods are implemented for the purpose of this inventory, and also a comparison between them is made.

The Approach 1 is based upon Error Propagation method and it is very easy to use because it is already implemented in the IPCC Inventory Software. This uncertainty tool of the software calculates the uncertainty of the whole inventory for a given year, as well as uncertainty in trend between a year of interest and a base year. Although, the software does not determine disaggregated results at sector level, they can be calculated in spreadsheet software implementing the well-known equations for Approach 1 - Error Propagation method. For the purposes of this inventory, this method was implemented in Excel, so that uncertainty results by sector are calculated.

The second approach according to which the uncertainty can be calculated is the Monte Carlo method. According to this method, random values of the input variables are selected from within their probability density function and the corresponding output is calculated. This procedure is repeated many times or until the mean and the distribution of the output variables do not change. The input variables may include activity data, emission factors, conversion factors etc. and the output variable is the quantity of emissions.

After a review made on a number of recent inventories (including inventories of Annex I countries), it can be concluded that in very few of them Approach 2 is implemented, because it is more complex than Approach 1, and on the other hand requires greater skills to connect the Monte Carlo simulation with the IPCC Inventory Software.

As this approach is not implemented in the IPCC 2006 software, for the purpose of this inventory a separate model was developed in MATLAB. This model directly uses the database of the Inventory (created through the IPCC Inventory Software), calculates random values for each input variable (according to their probability density function) and as a result computes the emissions.

Concerning the uncertainty calculations in the previous national reports, in the Second National Communication uncertainty is done using both methods for the Energy sector for 2000. In the Third National Communication Approach 2 is used for determining the uncertainty in the IPPU sector for the years 2003 to 2009, while in the First Biennial Update Report Approach 1 is used for the inventory for 2012 and for calculating uncertainty in trend for the years 1990 and 2012. In this report for the first time both, Approach 1 and Approach 2, are applied for each sector of the inventory for 2012, 2013 and 2014.

## 9.1 Input data

In order to calculate the uncertainty of the emissions for each sector separately, as well as the uncertainty of the total annual emissions, it is first needed to define uncertainty values for the input data. The IPCC Inventory Software allows input of uncertainty for activity data and emission factors. Based on these data the software automatically calculates uncertainty using

the Error Propagation method (Approach 1). The disadvantage of this approach is that in certain sectors where activity data and emission factor is composed of multiple inputs that have different uncertainty, those have to be summarized in just two values for activity data and emission factors. Therefore, this introduces further uncertainty in the calculations. As stated previously, for the Monte Carlo method (Approach 2) a special tool has been created, which allows input of uncertainty for each input data separately.

The input data in the Energy sector, according to the Guidelines, as well as according to the confidentiality of the available resources in Macedonia is the most reliable. Accordingly, the values of the uncertainty for activity data and emission factors are set to 5% in both methods (Table 52). Additionally, in the IPPU sector the same input data for uncertainty are used in both methods (Table 52). In these two sectors, the calculations of the emissions mainly depend only on the two inserted values for activity data and emission factors, therefore it was decided to use uncertainty only for these two variables.

***Table 52. Input data for uncertainty in the IPCC Inventory Software and Monte Carlo method for Energy and Industrial Processes and Product Use sectors (in %)***

| | Activity data uncertainty | Emission factors uncertainty |
|---|---|---|
| **Energy** | 5 | 5 |
| **Industrial Processes and Product Use** | | |
| **Mineral Industry** | | |
| Cement production | 10 | 3 |
| Glass Production | 5 | 30 |
| Other Process Uses of Carbonates | | |
| Ceramics | 3 | 5 |
| Other Uses of Soda Ash | 3 | 5 |
| Other | 3 | 5 |
| **Chemical Industry** | | |
| Soda Ash Production | 5 | 5 |
| **Metal Industry** | | |
| Iron and Steel Production | 10 | 5 ($CO_2$) |
| Ferroalloys Production | 5 | 5 ($CO_2$ and $CH_4$) |
| Aluminium production | 2 | 10 ($CO_2$) and 50 (PFC) |
| **Product Uses as Substitutes for Ozone Depleting Substances** | | |
| Refrigeration and Air Conditioning | | |
| Refrigeration and Stationary Air Conditioning | 5 | 5 (HFC) |

For the other two sectors - AFOLU and Waste, as activity data and emission factors are mainly calculated on the basis of multiple input data, as well as according to the directions given in the Guidelines, in the Monte Carlo method the uncertainty for each input data is entered separately (as presented in Table 53 and Table 54). When entering uncertainty in IPCC Inventory Software for these two sectors, an approximation is made to represent all these values for uncertainty by only two values by subcategory, given in Table 55.

In order to determine the input values for uncertainty in each sector, the corresponding Guidelines were followed.

***Table 53. Input data for uncertainty in the Monte Carlo method for AFOLU sector (in %)***

| | Uncertainty |
|---|---|
| **AFOLU** | |
| **Livestock** | |
| Number of animals | 5 |
| Emission Factor | 30 |
| **Land** | |
| **Forest Land** | |
| Wood/firewood removal | 20 |
| Area | 20 |
| Fraction of biomass lost in disturbance | 15 |
| Biomass conversion and expansion factor | 5 |
| Ratio of below-ground biomass to above-ground biomass | 5 |
| Carbon fraction of dry matter | 5 |
| **Cropland, Grassland, Settlement and Other Land** | |
| Area | 10 |
| Annual biomass carbon growth | 75 |
| Annual loss of biomass carbon | 75 |
| Dead wood/litter stock, under the old land-use category | 10 |
| Stock change factor for land-use system | 10 |
| Stock change factor for management regime | 5 |
| Stock change factor for C input | 10 |

***Table 54. Input data for uncertainty in the Monte Carlo method for Waste sector (in %)***

| | Uncertainty |
|---|---|
| **Waste** | |
| **Solid Waste Disposal** | |
| Total Municipal Solid Waste | 30 |
| Fraction of $MSW_T$ sent to SWDS | 30 |
| Degradable Organic Carbon | 20 |
| Fraction of Degradable Organic Carbon Decomposed | 20 |
| Methane Correction Factor | |
| = 1.0 | 10 |
| = 0.8 | 20 |
| = 0.5 | 20 |
| = 0.4 | 30 |
| = 0.6 | 50 |
| Fraction of $CH_4$ in generated Landfill Gas (F) = 0.5 | 5 |
| GDP | 5 |
| Waste Generation Rate | 10 |

***Table 55. Input data for uncertainty in the IPCC Inventory Software for AFOLU and Waste sectors (in %)***

| | Activity data uncertainty | Emission factors uncertainty |
|---|---|---|
| **AFOLU** | | |
| **Livestock** | 5 | 30 |
| **Land** | | |
| **Forest land** | | |
| Forest land remaining Forest land | 20 | 10 |
| Land Converted to Forest land | 10 | 10 |
| **Cropland, Grassland, Settlement and Other Land** | | |
| Land remaining Land | 10 | 50 |
| Land Converted to other Land | 10 | 50 |
| **Waste** | 30 | 30 |

For the Monte Carlo method it is assumed that each input variable has normal distribution.

## 9.2 Results

### 9.2.1 Error propagation method (Approach 1)

When using the Error Propagation method for calculating the uncertainty for each sector separately, the obtained results indicate that the AFOLU sector has the highest uncertainty (Figure 63). Immediately after this sector is the sector Waste. A characteristic of these two sectors is that uncertainty in certain subcategories reaches over 40%. On the other hand, the sector with the lowest uncertainty is the Energy sector of about 4%. This sector is followed by the IPPU sector, where the Metal Industry has the utmost uncertainty of about 9.8%. It is important to note that there is no drastic difference in the subcategory uncertainty among the three analyzed years, as the same input data for uncertainty are used in each year.

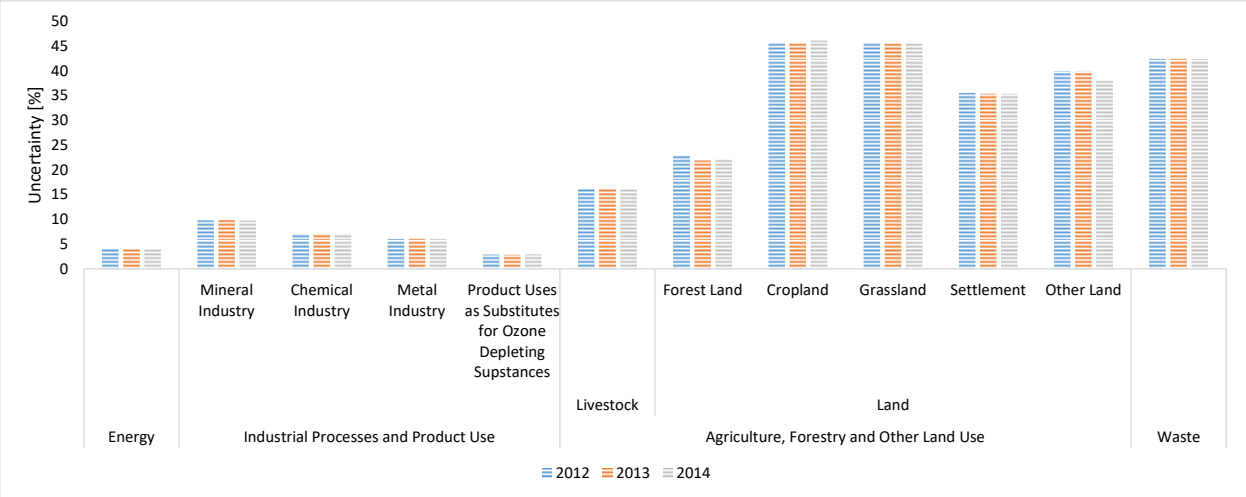



***Figure 63. Uncertainty for 2012, 2013 and 2014 using Error Propagation method by subcategory***

As a result of the different share of the individual subcategories in each analyzed year, the total annual uncertainty is different (Figure 64). The increase in the share of the AFOLU sector and especially of the Waste sector (which have the highest uncertainty) in 2013 and 2014 compared to 2012, contributes to corresponding increase of the total annual uncertainty in these two years.

The results show that the average deviation from the total annual emissions for 2012 is around ±977 Gg $CO_2$-eq, while for 2013 and 2014 it is around ±1,004 Gg $CO_2$-eq and ±1,153 Gg $CO_2$-eq, respectively (Figure 64).

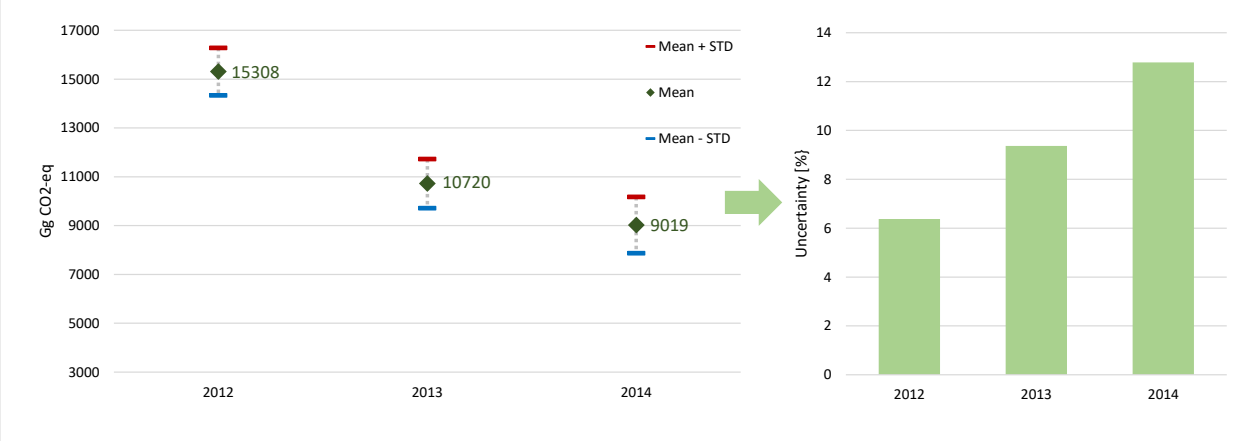



***Figure 64. Total yearly emissions (and standard deviation) and total uncertainty for 2012, 2013 and 2014 using Error Propagation method***

By using the Error Propagation method trend uncertainty is also made, and the results show that the trend uncertainty in 2013 in relation to 2012 is 7.3% and in 2014 in relation to 2012 it is increased to 9.16%.

### 9.2.2 Monte Carlo method (Approach 2)

The opportunity in the Monte Carlo method to insert uncertainty for each input variable separately, especially in the AFOLU and Waste sectors, changes the obtained results compared to the Error Propagation method. According to this Approach, by far the largest uncertainty is in the Waste sector, which exceeds 27% in all the three analyzed years (Figure 65). This sector is followed by the AFOLU sector, where the greatest uncertainty is in the Livestock subcategories of about 16%. On the other hand, Energy again has the lowest uncertainty, followed by the IPPU sector.

Because uncertainty is calculated as a quotient when dividing the standard deviation to the mean value in each of the subcategories, and because the range of values in the Forestry subcategory contains both positive and negative numbers, this metric does not represent a value for the Forestry subcategory that can be compared with other subcategories, so it is left out of Figure 65. However, this subcategory is included in the total emissions, where the results are positive for each iteration and each year.

***Figure 65. Uncertainty for 2012, 2013 and 2014 using Monte Carlo method by subcategory***

In order to obtain results from the Monte Carlo method 20,000 iterations were made. It is very important to note that the resulting annual average value is approximately the same as the calculated total emissions for each year and varies by less than 0.2% of the estimated annual emissions. This shows that the number of iterations is quite sufficient and that the method converged to the final solution.

By using this approach, an information may be obtained for the theoretical minimum and maximum emissions for each year, representing the highest possible error introduced in the input data (Figure 66). However, more important is the information for the average deviation of the annual emissions, which for 2012 is approximately ± 1,139 Gg $CO_2$-eq, while for 2013 and 2014 it is approximately ± 1,000 Gg $CO_2$-eq and ± 994 Gg $CO_2$-eq, respectively.

As with the Error Propagation method, the increase in the share of the sectors with greater uncertainty, also increases the total annual uncertainty in 2013 (9.3%) and 2014 (11%) compared to 2012 (7.4%).

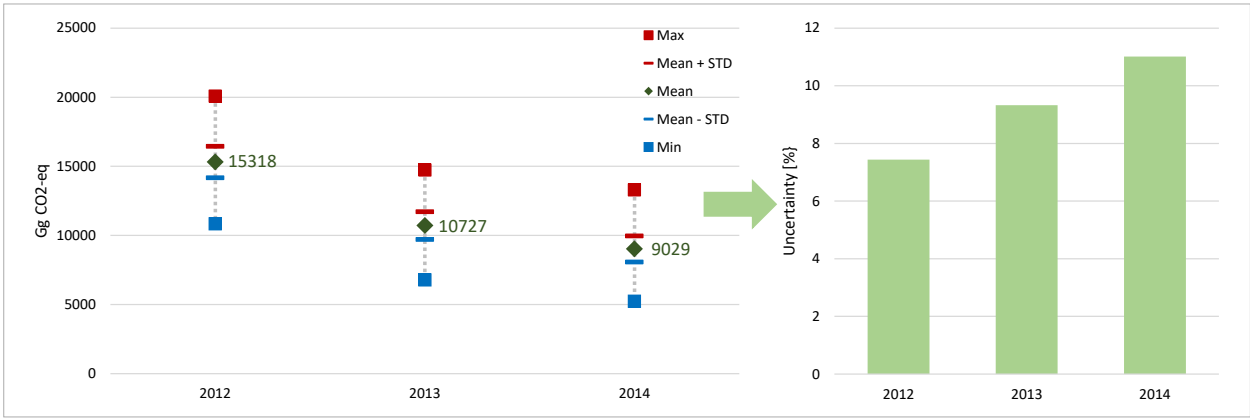



***Figure 66. Total yearly emissions and total uncertainty for 2012, 2013 and 2014 using Monte Carlo method***

### 9.2.3 Comparison between Error Propagation method (Approach 1) and Monte Carlo method (Approach 2)

If we compare the Monte Carlo and the Error Propagation method, by subcategory (Figure 67), it may be noted that there are no significant differences in the obtained results for the Energy and IPPU sectors. However, there are major differences in the other two sectors, due to the inability to accurately set uncertainty to all variables in the IPCC Inventory Software, i.e. the fact that all the uncertainty should be reduced to only two values (for activity data and emission factors), as previously mentioned.

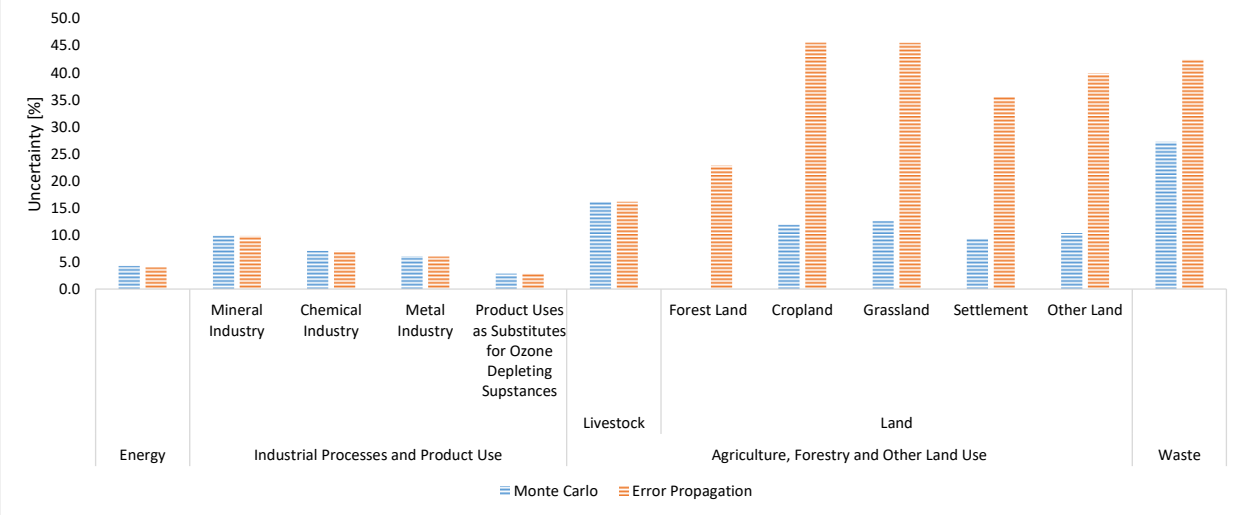



***Figure 67. Comparison of Monte Carlo and IPCC Inventory Software method by subcategory for 2012***

Obviously, these differences in the emissions by subcategory when using the two approaches leads to different uncertainty in the total annual emissions (Figure 68). However, it can be concluded that the trend of uncertainty by year in the both methods is the same, i.e. increases with the increase of the share of sectors with higher uncertainty.

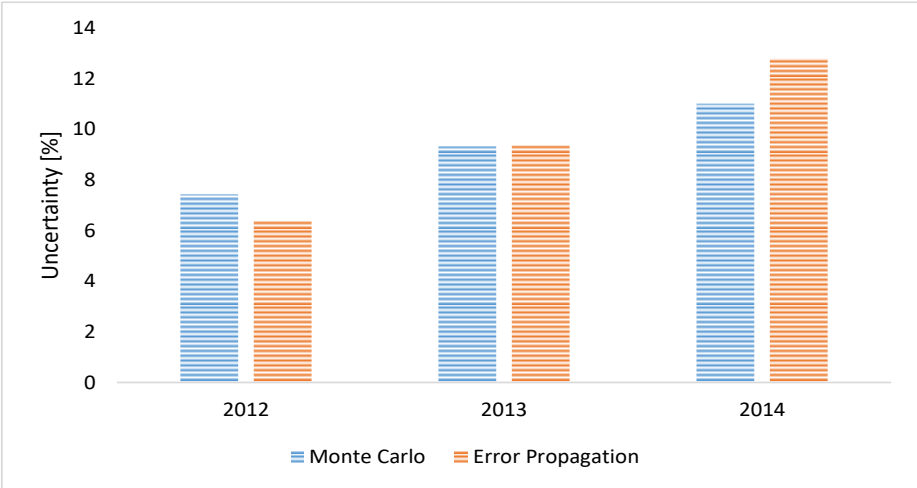



***Figure 68. Comparison of the total yearly uncertainty between the Monte Carlo method and IPCC Inventory Software method***

From the finding that the mean emissions from all iterations in the Monte Carlo method is nearly equal to the actual estimates of the emissions and that in this method individual uncertainty for each variable may be used (which is according to the Guidelines), it can be concluded that the results obtained from Approach 2 are much more relevant.

As it is presented, the highest uncertainty is in the Waste sector. This is primarily due to the large number of variables that have uncertainty, such as the total amount of municipal waste, the fraction of that amount sent to SWDS percentage wear landfill, methane correction factor, GPD and waste generation rate. Currently, regional waste management plans are in the process of preparation that can significantly contribute to uncertainty reduction in this sector. The data from these regional plans will be included in the preparation of the next GHG inventory.

Furthermore, there is great uncertainty in the Livestock subcategory. In this subcategory default emission factors are used, which according to the Guidelines have great uncertainty associated with them. If, in the future, national emission factors can be calculated, with lower uncertainty, it would significantly reduce the uncertainty in the sector. Following are the remaining subcategories from the AFOLU sector, where the main source of uncertainty are the areas of each type of land, as well as the areas that have been converted to other area type. As stated in the Section 6, due to the inconsistencies in the data related to this subcategories, it is recommended to establish system for continuous monitoring and inventory for each type of land that will also contribute to uncertainty reduction. However, according to the Guidelines there is also high uncertainty in the values for annual biomass carbon growth and annual loss of biomass carbon.

# 10 QA/QC and Verification Activities

The implementation of Quality Assurance and Quality Control (QA/QC) procedures is an important part of the development of national GHG inventories. As described in the IPCC Good Practice Guidance and the latest IPCC Guidelines (2006), an adequate QA/QC program ensures

- Continuous improvement
- Transparency,
- Consistency,
- Comparability,
- Completeness,
- Accuracy and
- Timeliness

of the national GHG inventories.

Quality Assurance and Quality Control measures are two distinct types of activities. The IPCC defines each as follows:

- Quality Assurance (QA) – a planned system of review procedures conducted by personnel NOT involved in the inventory development process.
- Quality Control (QC) – a system of routine technical activities implemented by the inventory development team to measure and control the quality of the inventory as it is prepared.

An effective QA/QC plan contains the following elements:

- GHG Inventory team,
- General QC activities and procedures,
- Source-specific QC activities and procedures (optional, as resources allow),
- QA review procedures.

The Macedonian approach towards QA/QC introduction in the national GHG inventory process is based on the in-depth analyses of the current practices of the inventory compilation in the country and the relevant international best practices. The resulting QA/QC plan was presented within the FBUR. It is applied in the same manner over the Inventory process of the SBUR, with slight extension of QA activities within the energy sector. This QA/QC plan has proved effective in achieving the above mentioned objectives, and as such is planned to be implemented for the inventory processes under forthcoming National Communications on Climate Change and Biennial Update Reports.

## 10.1 Personnel involved in QA/QC activities

### 10.1.1 Chief Technical Advisor (CTA)

The CTA is a national expert who has substantial experience in GHG inventory development and leadership quality. CTA is in charge for the following:

- Supervises the overall inventory process
- Provides advice and approval on the following GHG Inventory elements:
  - Input data collecting mechanisms,
  - Time series,
  - Emission factors,
  - Methodologies for emission calculation,

  - Reporting format,
  - Best practices (key sources analyses, uncertainty management).
- Checks, proposes corrective actions (if any) and approves the National Inventory Report (NIR).

### 10.1.2 Inventory Development Team (IDT)

At least one IDT member should be responsible for each GHG Inventory sector. At least one IDT member should be assigned a responsibility for compilation of the overall GHG inventory and at least one IDT member for conducting Key Sources analyses and Uncertainty management. IDT members conduct the following:

- Collect input data (activity data and emission factors),
- Calculate sectoral emissions,
- Conduct QC activities and procedures,
- Re-calculate sectoral emissions implementing the corrective actions proposed by Quality Assurance Team (QAT),
- Conduct Key Sources analyses and Uncertainty management,
- Implement corrective actions proposed by QAT regarding Key Sources analyses and Uncertainty management,
- Compile the overall inventory,
- Implement corrective actions proposed by QAT regarding the overall inventory
- Develop NIR,
- Implement corrective actions proposed by CTA regarding the NIR.

### 10.1.3 QA team (QAT)

Ideally, QAT members have previous experience in GHG inventory development (were involved in the preparation of the previous GHG inventories). At least one QAT member should be responsible for each GHG Inventory sector. At least one QAT member should be assigned a responsibility to check and verify the overall GHG inventory and at least one QAT member to check and verify Key Sources analyses and Uncertainty management. QAT members conduct the following:

- Check, propose corrective actions (if any) and verify the sectoral emissions,
- Check, propose corrective actions (if any) and verify the overall GHG inventory,
- Check, propose corrective actions (if any) and verify the Key Sources analyses and Uncertainty management.

***Table 56. SBUR GHG inventory team***

| Expert (contact info) | Role | Responsibility |
|---|---|---|
| Acad. Gligor Kanevce (kanevce@manu.edu.mk) | **IDT & QAT Leader** | Leading the overall inventory development |
| Natasa Markovska (natasa@manu.edu.mk) | **CTA** | Supervision and Monitoring<br>Approval of NIR and other reports<br>QA/QC activities |
| Verica Taseska-Gjorgievska (verica@manu.edu.mk) | **IDT Member**<br><br>**QAT Member**<br><br>**Compilation of overall inventory and NIR** | Sectors: Energy, Waste (QC, development of the sectoral chapters)<br>Key category analysis<br><br>Sectors: IPPU, AFOLU |
| Aleksandar Dedinec (dedinec@manu.edu.mk) | **IDT Member**<br><br>**QAT Member** | Sectors: Energy, Waste (QC, development of the sectoral chapters)<br>Key category and Uncertainty analysis<br><br>Sectors: IPPU, AFOLU |
| Aleksandra Dedinec (aleksandra.kanevche@finki.ukim.mk) | **IDT Member**<br><br>**QAT Member** | Sectors: Energy, Waste (QC, development of the sectoral chapters)<br>Uncertainty analysis<br><br>Sectors: IPPU, AFOLU |
| Vasil Bozhikaliev (bozhikaliev@gmail.com) | **IDT Member** | Sectors: Energy, Waste (collecting and entering data, development of the sectoral chapters)<br>Key category analysis |
| Vladimir Gjorgievski (vladimir.gjorgievski@gmail.com) | **IDT Member** | Sectors: Energy, Waste (collecting and entering data, development of the sectoral chapters)<br>Key category analysis |
| Emilija Poposka (emilija.poposka@gmail.com) | **IDT Member** | Sector: IPPU (collecting and entering data, development of the sectoral chapter)<br>Development of the web based platform |
| Sreten Andonov (sreten_andonov@yahoo.com) | **IDT Member** | Sector: AFOLU (collecting and entering data for Livestock, development of the sectoral chapter) |
| Ljupco Nestorovski (nestorovskil@hotmail.com) | **IDT Member** | Sector: AFOLU (collecting and entering data for Forestry, development of the sectoral chapter) |

| | | |
|---|---|---|
| Nikola Nikolov (nnikolov@sf.ukim.edu.mk) | **IDT Member** | Sector: AFOLU (collecting and entering data for Forestry, development of the sectoral chapter) |
| Dusko Mukaetov (d.mukaetov@zeminst.edu.mk) | **IDT Member** | Sector: AFOLU (collecting and entering data for Land Use, development of the sectoral chapter) |
| Ordan Cukaliev (cukaliev@gmail.com) | **IDT Member** | Sector: AFOLU (collecting and entering data for Land Use, development of the sectoral chapter) |
| Igor Ristovski (igor.ristovski@gmail.com) | **IDT Member** | Sector: Precursors and indirect emissions (collecting and entering data, development of the sectoral chapter) |
| Elena Gavrilova (egavrilova.mk@gmail.com) | **QAT Member** | Sectors: Energy, Waste, Precursors and indirect emissions<br>QA activities<br>UNFCCC certified reviewer |

## 10.2 Quality Control

Tier 1 approach which requires a minimum set of QC activities and procedures have been implemented by the IDT members for all sectors to ensure that basic standards of quality are met. These standards generally focus on:

- Data gathering, input, and handling,
- Data documentation,
- Emissions calculation.

***Table 57. SBUR Tier 1 QC activities and procedures for all sectors***

| **Data gathering, input, and handling checks** | |
|---|---|
| **QC Activities** | **Procedures** |
| Check that assumptions and criteria for the selection of activity data and emission factors are documented. | • Cross-check descriptions of activity data and emission factors with information on categories and ensure that these are properly recorded and archived. |
| Check for transcription errors in data input and reference. | • Confirm that bibliographical data references are properly cited in the internal documentation<br>• Cross-check a sample of input data from each category (either measurements or parameters used in calculations) for transcription errors.<br>• Utilize electronic data where possible to minimize transcription errors.<br>• Use IPCC Inventory Software to minimize user/entry error. |
| Check that emissions/removals are calculated correctly. | • Reproduce a representative sample of emissions/removals calculations.<br>• If models are used, selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy. |
| Check that parameter and emission/removal units are correctly recorded and that appropriate conversion factors are used. | • Check that units are properly labeled in calculation sheets.<br>• Check that units are correctly carried through from beginning to end of calculations.<br>• Check that conversion factors are correct.<br>• Check that temporal and spatial adjustment factors are used correctly. |

| | |
|---|---|
| Check the integrity of database files. | • To extent possible, confirm that the appropriate data processing steps are correctly represented in the database.<br>• To extent possible, confirm that data relationships are correctly represented in the database.<br>• Ensure that data fields are properly labeled and have the correct design specifications.<br>• Ensure that adequate documentation of database and model structure and operation are archived. |
| Check for consistency in data between categories. | • Identify parameters (e.g., activity data, constants) that are common to multiple categories and confirm that there is consistency in the values used for these parameters in the emissions/removals calculations. |
| Check that the movement of inventory data among processing steps is correct. | • Check that emissions/removals data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries.<br>• Check that emissions/removals data are correctly transcribed between different intermediate products. |
| **Data documentation** | |
| **QC Activities** | **Procedures** |
| Review of internal documentation and archiving. | • Check that there is detailed internal documentation to support the estimates and enable duplication of calculations.<br>• Check that every primary data element has a reference for the source of the data (via cell comments or another system of notation).<br>• Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review.<br>• Check that the archive is closed and retained in secure place following completion of the inventory<br>• Check integrity of any data archiving arrangements of outside organizations involved in inventory preparation. |
| **Calculation checks** | |
| **QC Activities** | **Procedures** |
| Check methodological and data changes resulting in recalculations. | • Check methodological and data changes resulting in recalculations.<br>• Check for consistency in the algorithm/method used for calculations throughout the time series.<br>• Reproduce a representative sample of emission calculations to ensure mathematical correctness. |
| Check time series consistency | • Check for temporal consistency in time series input data for each category.<br>• Check for consistency in the algorithm/method used for calculations throughout the time series.<br>• Check that the effects of mitigation activities have been appropriately reflected in time series calculations. |
| Check completeness | • Confirm that estimates are reported for all categories and for all years from the appropriate base year over the period of the current inventory.<br>• For subcategories, confirm that the entire category is being covered.<br>• Proved clear definition of 'Other' type categories.<br>• Check that known data gaps that result in incomplete category emissions/removals estimates are documented, including qualitative evaluation of the importance of the estimate in relation to total net emissions (e.g. subcategories classified as 'not estimated'). |
| Trend checks | • For each category, compare current inventory estimates to previous estimates, if available. If there are significant changes or departures from expected trends, re-check estimates and explain any difference. Significant changes in emissions or removals from previous years may indicate possible input or calculation errors.<br>• Check value of implied emission factors (aggregate emissions/removals divided by activity data) across time series. Are changes in emissions or removals being captured?<br>• Check if there any unusual or unexplained trends noticed for activity data or other parameters across the time series. |

## 10.3 Quality Assurance and Verification

The GHG inventory quality is assured introducing external expert review conducted by QAT members. They check, and if needed, propose corrective actions and verify the following:

- Adequacy of the selected activity data and emission factors,
- Adequacy of the applied methodologies,
- Accuracy and consistency of the calculated emissions,
- Adequacy of the data documentation,
- Correctness of the conducted Key Sources analysis and Uncertainty Management.

As a final step, CTA checks the National Inventory Report, if needed proposes corrective actions and verifies the National Inventory Report once the proposed corrective actions are implemented by the IDT members.

According to the IPCC Good Practice Guidance and Uncertainty Management in the National GHG Inventories , the priority in the QA process should be given to the key source categories, as well as source categories where significant changes in methods or data.

Since the Energy and the Waste sectors are the most significant contributors to the Macedonian GHG inventory, an expert peer review was conducted for QA of the national GHG estimates of those sectors.

The table provided bellow this paragraph contains the information of the sector specific data (Energy and Waste) reviewed when the QA procedures were carried out.

***Table 58. SBUR QA procedures implemented in the Energy and in the Waste sector***

| Data Type | QA Activity | Remarks / Comments / Examples |
|---|---|---|
| Activity Data Check | Check for transcription, typographical error and error transposition. | Compare the national data source with the inventory data contained in the IPCC Inventory Software |
| | Compare with official published data | Compare the national energy related data (the data of the Energy balances published by the SSO and the data published by ELEM) and the national waste related data (the Waste related data published by the SSO and the Waste Generation Reports published by MOEPP) with the AD contained in the IPCC Inventory Software |
| | Identify and fix outliers in data inputs (including checking the inclines and spikes in the trend) | Data which don't fall under the realistic range and are suspected as inaccurate are assessed and if necessary are removed and replaced with data from international sources or derived from expert judgment |
| | Compare with other international data | Compare the Energy related data with the data published by the IEA |
| | Check the documentation of all sources, data format and assumptions for easy reference | Keeping records on the data source and assumptions used in each data sheet of the IPCC Inventory Software. |
| | Assure if the Party able to provide an overview of the overall waste generation and treatment in the country | Assure that an overview of waste generation and treatment is provided and AD on all types of solid waste been collected (MSW, sludge, industrial and other waste) |

| | | |
|---|---|---|
| | Ensure that the AD are provided in the appropriate units | Check the background table for each category and ensure the consistency and the accuracy of the AD units |
| Emission factors | Check the implied emission factors (time series) | Ensure consistency check of the use of the EF |
| | Double check in regards to the country specific EF published in the EFDB and compare with the EF of the other countries | Ensure that the country specific EF in use are in the ranges provided by the IPCC guidelines |
| Calculation by the IPCC Inventory Software | Cross check all steps involved in the calculation | Ensure that all steps used for determining, estimating and deriving data are accurate, transparent and internally consistent |
| | Check the documentation of sources and correct use of units | Check if the documentation template records are appropriately fulfilled |
| | Check completeness of the data coverage | Ensuring that all relevant gases for all the activities were covered |
| Results (emissions) | Check the differences between the recalculated estimates and verify if proper justifications for the recalculated estimates are provided | Identification of changes, revisions and reallocations in order to improve accuracy and the transparency of the emission estimates |
| | Identify and fix outliers in the results | Checking for inconsistency of the emission trends and levels |
| | Check the difference between the sectorial and the reference approach in the Energy Sector | Ensure consistency between the emission estimates and the allocation of carbon in the sectoral and in the reference approach |
| | Check the completeness, use of notation keys and confidential information | Check if complete estimates are provided and if notation keys are used where no estimates are provided |
| | Creativeness of the use of the notation keys | Check if the appropriate notation keys are in use |
| | Verify the assumptions, corrections, data and sources | Ensure consistency, transparency, facilitate repeatability and easy retrieval |
| Documentation | Check the improvement list, recommendations and encouragements provided (internal and external) | Check if the recommendations and the encouragements of the technical assessments / reviews have been taken into consideration and implemented |

Four steps quality verification process of the GHG inventory has been introduced:

- Two steps on national level (inventory team and national UNFCCC certified reviewer – procedures described above)
- Two steps on international level (by the Global Support Programme (for the SBUR NIR) and technical analysis as part of the UNFCCC international consultation and analysis process for non-Annex I countries (for the SBUR)).

Recommendations from the last two steps have been introduced in this report to the extent possible. However, some of the recommendations for improvement shall be included in subsequent national BURs.

## 10.4 QA/QC implementation in the current GHG Inventory process

### 10.4.1 The process in a nutshell

***Step 1: Allocation of roles (CTA, IDT members, QAT members)***

***Step 2: Defining the GHG Inventory components***

For each sector, the corresponding IDT member, in consultation with CTA, Project manager and MOEPP decides upon:

- Input data collecting mechanisms
- Time series
- Emission factors (National/IPCC defaults)
- Methodologies for emission calculation

The following is taken into account: Current practices of the inventory compilation in the country, country specifics and relevant international best practices

***Step 3: Activity data collection***

For each sector, the corresponding IDT member collects data from the official publications and reports and/or contacts the identified institutions (data sources) for obtaining data. The IDT members should reference the inventory data sources and describe procedures and arrangements undertaken to collect and archive data for the preparation of national GHG inventories.

***Step 4: Data input, documenting and calculating of emissions (Tier 1 QC procedures undertaken in parallel)***

The IDT members use IPCC Inventory Software for National Greenhouse Gas Inventories to enter activity data and emission factors, document data and calculate emissions. This IPCC tool enables all-inclusive documentation of data, as well as includes functionalities for detailed Quality Check. In parallel, the IDT members implement all Tier 1 QC activities and procedures, as described previously.

***Step 5: QA at sectoral level***

QAT members check, and if needed, propose corrective actions and verify the adequacy of the selected activity data and emission factors, adequacy of the applied methodologies, accuracy and consistency of the calculated emissions and adequacy of the data documentation.

***Step 6: Compilation of overall inventory***

This activity is undertaken by one of the IDT members.

***Step 7: QA of overall inventory summary***

One QAT member checks, propose corrective actions and verifies accuracy and consistency of the overall inventory.

***Step 8: Conduct key category analyses***

This activity is undertaken by IDT member(s). Key sources analysis is conducted applying methodology from IPCC 2006 Guidelines. Dedicated chapter is also included in the NIR.

***Step 9: Uncertainty management (as decided)***

CTA and IDT member(s) decide the target sector(s) for uncertainty management taking into account the results of the key sources analysis and other country specifics. The corresponding IDT member(s) conducts the uncertainty management analysis applying methodology from IPCC 2006 Guidelines. Dedicated chapter is also included in the NIR.

***Step 10: QA of key sources analysis and uncertainty management***

One QAT member checks, proposes corrective actions and verifies the accuracy and consistency of the key sources analysis and uncertainty management.

***Step 11: Drafting the sectoral chapters of NIR***

For each sector, this activity is undertaken by the corresponding IDT member.

***Step 12: Draft summary inventory chapter***

This activity is undertaken by the IDT members (the same as in Step 6).

***Step 13: QA of NIR***

CTA checks, proposes corrective actions and approves the NIR.

***Step 14: Reporting***

MOEPP is in charge for GHG emissions reporting. In accordance to its international (including also European) and national obligations, the MOEPP should prescribe the reporting format to be followed by the IDT members. All the reports should be approved by CTA.

### 10.4.2 Reporting, documentation and archiving procedures

All GHG inventory documents are stored electronically on the server of the Ministry of Environment and Physical Planning and in the database of the Macedonian Academy of Sciences and Arts. This includes quality system documents, reports, original data from data providers, the IPCC Inventory Software files, CRF Reporter database files, the data submitted to the UNFCCC and spreadsheets of the emissions inventory. Furthermore, the decisions reached by the coordinating team, the results of key category and uncertainty analysis, the internal and external review documents, as well as inventory development processes and guidelines materials are documented and archived in the database. The geographical database used for preparing the AFOLU inventory and the digitized maps of land use classification are also stored on the server to assure proper documenting materials for the estimates and the procedures applied in the sector.

After each submission of the national inventory to UNFCCC a complete copy of the full database is archived by the Ministry of Environment and Physical Planning, which is the single location where archives of GHG submissions and all supporting reference material is stored and maintained. Backups of each submission and supportive material are also kept as separate CDs.

### 10.4.3 Ensuring sustainability

Summing up, the Macedonian inventory process, organized in a way as presented in the previous section, meets the necessary technical conditions for ensuring sustainability, since:

- A strong focus is put on documenting essential information in a concise format;
- Activities and tasks are standardized and clear procedures stipulated;
- Roles and responsibilities of all players are clearly defined.

On top, worth mentioning in this regard are the training materials on GHG inventory preparation developed by the GHG inventory team. These materials are rather country-specific, and being based on personal experience gathered and lessons learned during the GHG inventory preparation in Macedonian conditions, would provide clear guidance for new comers in the process. Additionally, capacity building activities have been introduced and two new people within the MASA team were trained on development of GHG inventories.

# 11 Good practices, improvements and recommendations

## 11.1 Energy

Good practices/improvements:

- The category *Diesel and Heating Oil* used in energy balances until 2011 has been separated into *Road Diesel* and *Heating & Other fueloil* in the energy balances from 2012 onwards. Similarly, the *Biomass* category has been separated into *Biomass* and *Wood Wastes, Wood Briquettes and Pellets*. Different NCVs are used in the IPCC Inventory Software for all of these categories.
- National emission factors are used for lignite, residual fuel oil and natural gas in Energy sector, Fuel combustion activities.

Recommendations for future inventories:

- Secure and constant channels for acquiring data on composition and carbon content of fuels should be established with relevant institutions in order to facilitate the estimation of country specific emission factors. This can be achieved by signing some kind of agreement, for instance, a Memorandum of Understanding.
- Update of the activity data in compliance with the revised Energy Balances for period 2005 – 2014 from the SSO (published in October 2016).
- Disaggregation of the activity data before 2005 for Manufacturing industries and Construction category in the IPCC Inventory Software database in accordance with the SSO Energy balances.

## 11.2 IPPU

Good practices/improvements:

- Revision of the 1990-2012 estimates in order to assure consistency throughout the time series.
- Estimation of the F-gas emissions from refrigeration and air-conditioning in order to improve the completeness of the entire time-series.

Recommendations for future inventories:

- More detailed data regarding the carbon content of the feedstock in the following sectors: cement production, lime production and steel production. These data can be gathered directly from the industrial plants.
- Segregated data for the F-gas emissions from refrigeration and air-conditioning for the specific part of the equipment life-cycle. These data should be collected by the Ministry of Environment and Physical Planning.
- F-gas emissions from fire protection, aerosols and solvents or reiteration that emissions from these categories are not occurring in the country.
- $N_2O$ emissions from medical appliances.
- $SF_6$ emissions from use and disposal of electrical equipment.

## 11.3 AFOLU

- **Livestock**

Good practices/improvements:

- Inventory of the GHG emissions in livestock for SBUR was done on a base of the previously inserted data into IPCC Inventory Software. It was checked and finds out that the data entry for dairy cows and other cattle was mismatched. In a file of dairy cow the data series form 1990 was entered data for other cattle and vice versa. It was corrected for the whole data series. Further on improvements were done in terms of segregation different categories in sheep, swine and poultry. Sheep data was split for adult sheep (live weight 40 kg) and sheep up to one year old with live weight of 28 kg. In swine it was determined category sow with 180 kg live weight and finishing pigs (live weight 50 kg). Additionally, in SBUR all poultry species were treated identically, and in FBUR, four different classes were determined, e.g. layers, broilers, turkey and other poultry. For each class separate emission factor was used.

Recommendations for future inventories:

- In order to apply Tier 2 methodology, it is necessary to do assessment, where a typical farm size, system and technology will be modeled. It is of particular importance to do assessment in Cattle, where majority of farms are small size and different production system and purpose is applied. For this report it was not possible to check ratios of different manure systems used in farms with dairy cows and other cattle. Also it is important to access small pig farms, since a half of the pig production is coming from them. On these farms there various manure management practices, and pig manure management is contributing with 20% in total livestock $N_2O$ emission.

- **Land use**

The inventory of GHG emissions in the Agriculture sector has been done on the base of the available statistical data related to areas udder certain type of land use which were taken as activity data (according the IPCC categories). Official data published by State Statistical Office are actual area under certain Land Use type, while data for the areas converted from one to another category of land use were calculated on the base of the available graphical data sets (CORINE Land cover). Land use change has been calculated on the base of 3 data sets: 2000-2006 and 2012 and extrapolated for the period 2012-2014. Moreover, to derived data on land remaining under certain land use type activity data taken from the State Statistical office for the period 1990-2014 (actual area under certain Land Use type) for the period 2000-2014 the actual area was reduced for the area under land use changes. However, it was not possible to be done for grape yards and orchards, because CORINE methodology do not take into account small areas under some land cover type and due to big discrepancies in data between CORINE and State Statistical Office.

Therefore, the improvement in the increasing accuracy of the activity data and introducing land use changes as one of the sources of GHG was not possible to be conducted for land use types below general category of Cropland.

The improvement of the assessment of GHG emissions from agricultural sector is important, particularly in establishing consistent data series. In this report, Land Use Changes for period 2000-2014, were introduced based on CORINE data sets. Unfortunately there is not CORINE data set available for period before 2000 and it is impossible to conduct even rough estimation of the land use changes in period before year 2000. This can be done through serious approach to assessment of Land Use in the country. It is necessary to develop remote sensing

(RS) and Earth Observation (EO) capacities in the country, in order to derive Land use changes because this data is not available from any institution.

The following RS and EO activities should be conducted:

- Analyze of the land use based on aerial photographs (available from State Cadastral Office) and development of the reference case.
- Comparing the reference case with satellite imagery (available from several providers free of charge) and establishing procedures for Land Use assessment.
- Assess the Land Use and Land use changes using historical satellite imagery.
- Regular (annual basis) assessment of the land use based on satellite imagery from the current year.
- Maintaining data derived from this activity in geo-data base and make it available for public
- Comparing data obtained from this activity with data provided by state statistical office
- Estimating land use changes on annual basis

In order to move to higher Tier`s an in addition to the proposed measures for development and improving of the existing data set, particular attention should be paid to development of national emission factor for assessing GHG emissions/removals taking in consideration:

a) Field measurement of GHG emissions under land use types in agricultural production and cropping systems applied,
b) Land productivity dynamics assessment (soil organic carbon) under different categories of land use, cropping systems and fertilizers management,
c) Annual bio-productivity of perennial crops measurements (orchards, vineyards, forage corps etc.)
d) Management practices with waste biomass in agriculture and forestry

This is complicated task and there is no other choice than building national capacities on assessing of this data that is not readily available in the country. This is serious gap that should be overcome trough investment in capacity building, particularly in institutions from agricultural and environmental sector.

- **Forestry**

Good practices/improvements:

- Introduced two new categories of Forest land
- Changed growing stock level factors for existing and for the new categories
- Implemented satellite images for land use change from and to Forest land (CORINE Land Cover) for 2000, 2006 and 2012, and interpolation of the data on annual bases to cover the years in between.
- Improved data for commercial and firewood removals
- Improved and updated data for burned forest area, using data from three different sources

Recommendations for future inventories:

- Forest inventory (PE “Makedonski sumi”, MAFWE, Faculty of Forestry)
- Installation of software for annual evidence of the Land use change
- Develop local tables for annual growth of different species
- Develop system for monitoring the natural disturbance and prompt evidential

## 11.4 Waste

Good practices/improvements:

- The population data 1990 until 2014 were revised.
- The Ministry of Environment and Physical Planning releases annual reports on Quality of the Environment which include the amounts of composted waste. Using those information, the emissions from waste composting activities have been introduced for the period from 2012– 2014.
- The parameter Delay Time of waste decomposition has been set to its' default value (6 months) because it was more appropriate than the previously used value.
- It is assumed that the nitrous oxide emission factor used in the FBUR is equal to the default value divided by 1000. This has been corrected in the SBUR and the default emission factor has been used.
- Instead of assuming a default value for the percentages of waste deposited in disposal sites, the actual percentages (shares) have been calculated for 2012, 2013 and 2014 using data from the State Statistical Office on municipal solid waste.
- In the estimations for the period from 2012 to 2014, the fraction of the population burning waste is assumed to be equal to the fraction of waste not deposited in landfills. This could be considered as an improvement when compared to the previously used fixed value.

Recommendations for future inventories:

- Currently, the regional waste management plans are in the process of preparation. The data from these regional plans regarding the waste fraction should be included in the preparation of the next GHG inventory.
- The percentages of waste deposited in disposal sites for the years prior to 2012 should be revised. This should be done in the same manner as for the years 2012, 2013 and 2014.
- The emissions from incineration should be estimated for the whole time series for which activity data are available.
- Regarding data on industry production, an inconsistency has been acknowledged in the reports of the current data source, especially in the Meat & Poultry category. This results in equivalently inconsistent emissions throughout the time series. A change of the data source and the categorization of the data should be considered in future inventory reports.
- The fraction of waste not disposed in disposal sites should be revised for all years prior to 2012 for which data are available.

# Appendix I Addressing recommendations from the TA of the FBUR

The *Summary report on the technical analysis (TA) of the Macedonia's First Biennial Update Report* presents the results of the technical analysis undertaken by a team of technical experts in accordance with the modalities and procedures contained in the annex to decision 20/CP.19.

Table 59, presents results of the identification of the extent to which the elements of information on GHGs are included in the first BUR of Macedonia in accordance with the relevant parts of the UNFCCC reporting guidelines on BURs (the same as Table 1 from the TA of SBUR), including additional column explaining how the identified missing or partly provided information are improved in the GHG Inventory under SBUR.

***Table 59. Response to the comments on the extent of the information on GHGs provided in the Macedonia's FBUR***

| *Decision* | *Reporting requirements* | *Yes/ Partly/No* | *Comments on the extent of the information provided* | ***Response to the comments*** |
|---|---|---|---|---|
| Decision 2/CP.17, paragraph 41(g) | The first BUR shall cover, at a minimum, the inventory for the calendar year no more than four years prior to the date of the submission, or more recent years if information is available | Yes | The inventory covers the period 1990–2012 | |
| Decision 2/CP.17, annex III, paragraph 5 | The updates of the sections on the national inventories of anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol should contain updated data on activity levels based on the best information available using the Revised 1996 IPCC Guidelines for National GHG Inventories, the IPCC good practice guidance and Uncertainty Management in National GHG Inventories, and the IPCC good practice guidance for LULUCF; any change to the emission factor may be made in the subsequent full national communication | Partly | The Party reports in the BUR that the activity data were updated and the 2006 IPCC Guidelines were used for the period 1990–2012.<br>However, neither the updated activity data nor the emission factors used are provided in the BUR | AFOLU sector: Activity data is provided in Annex I, and all emission factors are specified in the chapter 6.6 Methodology and emission factors, for AFOLU sector |
| Decision 2/CP.17, annex III, paragraph 9 | The inventory section of the BUR should consist of a national inventory report as a summary or as an update of the information contained in decision 17/CP.8, annex, chapter III (National greenhouse gas inventories), including: | Partly | The BUR provides an update of the inventory section in the third national communication submitted in 2014, in which 2003–2009 is the inventory time frame. However, some information in tables 1 and 2 is missing | Summary inventory tables are provided in Annex II, for years 1990, 1994, 2000, 2003, 2008, 2012, 2013 and 2014<br>. |
| | • Table 1 (National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gas precursors) | Partly | Provided for 1990 and 2012. Macedonia includes table 1 in annex 2 to the BUR, but the table does not provide the disaggregated information for LULUCF | The LULCF activity data are provided for general categories, further breakdown is not provided |
| | • Table 2 (National greenhouse gas inventory of anthropogenic emissions of HFCs, PFCs and $SF_6$) | Partly | A table containing F-gases is provided in annex 2 to the BUR, but only PFCs from the metal industry are estimated | PFC emissions from aluminium production are estimated and included in the national GHG inventory. HFC emissions from refrigeration and air-conditioning are estimated and included in the national GHG inventory. |
| Decision 2/CP.17, annex III, paragraph 6 | Non-Annex I Parties are encouraged to include, as appropriate and to the extent that capacities permit, in the inventory section of the BUR: | | | |
| | • Tables included in annex 3A.2 to chapter 3 of the IPCC good practice guidance for LULUCF | No | The tables are not reported in the BUR | Tables are not provided, but in due time can be generated |

| *Decision* | *Reporting requirements* | *Yes/ Partly/No* | *Comments on the extent of the information provided* | ***Response to the comments*** |
|---|---|---|---|---|
| | • The sectoral report tables annexed to the Revised 1996 IPCC Guidelines | No | The tables are not reported in the BUR | Tables are not provided, but in due time can be generated |
| Decision 2/CP.17, annex III, paragraph 7 | Each non-Annex I Party is encouraged to provide a consistent time series back to the years reported in the previous national communications | Yes | Provided in table 3-1 of the BUR | |
| Decision 2/CP.17, annex III, paragraph 8 | Non-Annex I Parties that have previously reported on their national GHG inventories contained in their national communications are encouraged to submit summary information tables of inventories for previous submission years (e.g. for 1994 and 2000) | Partly | Annex 2 to the BUR contains this information; however, it includes it only for the years 1990 and 2012. The previously submitted national communications cover the periods 1990–1998, 1999–2002 and 2003–2009 | Summary inventory tables are provided in Annex II, for years 1990, 2003, 2008, 2012, 2013 and 2014 |
| Decision 2/CP.17, annex III, paragraph 10 | Additional or supporting information, including sector-specific information, may be supplied in a technical annex | Yes | Sector-specific information is provided in sections 3.3–3.6 of the BUR | / |
| Decision 17/CP.8, annex, paragraph 13 | Non-Annex I Parties are encouraged to describe procedures and arrangements undertaken to collect and archive data for the preparation of national GHG inventories, as well as efforts to make this a continuous process, including information on the role of the institutions involved | Yes | The information is provided in section 3.1 of the BUR | / |
| Decision 17/CP.8, annex, paragraph 14 | Each non-Annex I Party shall, as appropriate and to the extent possible, provide in its national inventory, on a gas-by-gas basis and in units of mass, estimates of anthropogenic emissions of the following gases by sources and removals by sinks: | | | Summary inventory tables are provided in Annex II, for years 1990, 2003, 2008, 2012, 2013 and 2014 |
| | • $CO_2$ | Yes | Provided for 1990 and 2012 in table 1 of annex 2 to the BUR | / |
| | • $CH_4$ | Yes | Provided for 1990 and 2012 in table 1 of annex 2 to the BUR | / |
| | • $N_2O$ | Yes | Provided for 1990 and 2012 in table 1 of annex 2 to the BUR | / |
| Decision 17/CP.8, annex, paragraph 15 | Non-Annex I Parties are encouraged, as appropriate, to provide information on anthropogenic emissions by sources of HFCs, PFCs and $SF_6$ | Partly | A table containing F-gases is provided in annex 2 to the BUR, but only PFCs from the metal industry are estimated | PFC emissions from aluminium production are estimated and included in the national GHG inventory. HFC emissions from refrigeration and air-conditioning are estimated and included in the national GHG inventory. |

| *Decision* | *Reporting requirements* | *Yes/ Partly/No* | *Comments on the extent of the information provided* | ***Response to the comments*** |
|---|---|---|---|---|
| Decision 17/CP.8, annex, paragraph 19 | Non-Annex I Parties should, to the extent possible, and if disaggregated data are available, report emissions from international aviation and marine bunker fuels separately in their inventories: | | | |
| | • International aviation | Yes | Provided for 1990 and 2012 | / |
| | • Marine bunker fuels | Yes | Provided for 1990 and 2012 | NA for Macedonia |
| Decision 17/CP.8, annex, paragraph 16 | Non-Annex I Parties are encouraged, as appropriate, to report on anthropogenic emissions by sources of other GHGs such as: | | | |
| | • CO | No | Although the BUR indicates that CO is included in the inventory database | Included in summary inventory tables in Annex I |
| | • $NO_x$ | No | Although the BUR indicates that $NO_x$ is included in the inventory database | Included in summary inventory tables in Annex I |
| | • NMVOCs | No | Although the BUR indicates that NMVOCs are included in the inventory database | Included in summary inventory tables in Annex I |
| Decision 17/CP.8, annex, paragraph 17 | Other gases not controlled by the Montreal Protocol, such as $SO_x$, included in the Revised 1996 IPCC Guidelines, may be included at the discretion of the Parties | No | Although the BUR indicates that $SO_2$ is included in the inventory database | Emissions of $SO_2$ are included in the inventory |
| Decision 17/CP.8, annex, paragraph 21 | Non-Annex I Parties are encouraged to provide information on methodologies used in the estimation of anthropogenic emissions by sources and removals by sinks of GHGs not controlled by the Montreal Protocol, including a brief explanation of the sources of emission factors and activity data. If non-Annex I Parties estimate anthropogenic emissions and removals from country-specific sources and/or sinks that are not part of the Revised 1996 IPCC Guidelines, they should explicitly describe the source and/or sink categories, methodologies, emission factors and activity data used in their estimation of emissions, as appropriate. Parties are encouraged to identify areas where data may be further improved in future communications through capacity-building: | | | |
| | • Information on methodologies used in the estimation of anthropogenic emissions by sources and removals by sinks of GHGs not controlled by the Montreal Protocol | Partly | The methodological tier used (1 or 2) for most sources and sinks is indicated in the BUR. However, this information is missing for some sources (e.g. managed soils), and the calculation equations are not provided | The methodologies applied in the inventory are summarized in A II.2, Table 82.<br>All emissions are generated by IPCC Inventory Software. Explanation for the software background equations is needed. |

| *Decision* | *Reporting requirements* | *Yes/ Partly/No* | *Comments on the extent of the information provided* | ***Response to the comments*** |
|---|---|---|---|---|
| | • Explanation of the sources of emission factors | Yes | | |
| | • Explanation of the sources of activity data | Yes | | |
| | • If non-Annex I Parties estimate anthropogenic emissions and removals from country-specific sources and/or sinks that are not part of the Revised 1996 IPCC Guidelines, they should explicitly describe: | NA | The Party did not report on any country-specific sources or sinks | NA |
| | ○ Source and/or sink categories | | | |
| | ○ Methodologies | | | |
| | ○ Emission factors | | | |
| | ○ Activity data | | | |
| | • Parties are encouraged to identify areas where data may be further improved in future communications through capacity-building | Yes | An improvement plan is presented | |
| Decision 17/CP.8, annex, paragraph 24 | Non-Annex I Parties are encouraged to provide information on the level of uncertainty associated with inventory data and their underlying assumptions, and to describe the methodologies used, if any, for estimating these uncertainties: | | | |
| | • Level of uncertainty associated with inventory data | Yes | Although very general, a summary is provided on the level of uncertainty for the inventory and also the trend of uncertainties. Uncertainties at the sector or subsector levels are not provided | |
| | • Underlying assumptions | No | No information is provided on assumptions applied, such as the use of IPCC default values | Detailed tables with assumptions applied are provided in the chapter for Uncertainty analysis |
| | • Methodologies used, if any, for estimating these uncertainties | Yes | The use of the IPCC Inventory Software to apply a Monte Carlo algorithm is indicated, but additional details are not provided | |

*Abbreviations*: BUR = biennial update report, F-gas = fluorinated gas, GHG = greenhouse gas, IPCC = Intergovernmental Panel on Climate Change, IPCC good practice guidance = *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, IPCC good practice guidance for LULUCF = *Good Practice Guidance for Land Use, Land-Use Change and Forestry*, LULUCF = land use, land-use change and forestry, NA = not applicable, NMVOC = non-methane volatile organic compound, Revised 1996 IPCC Guidelines = *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, 2006 IPCC Guidelines = *2006 IPCC Guidelines for National Greenhouse Gas Inventories.*

# Appendix II Activity data, methodology and emission factors

## A II.1 Activity data

## A II.1.1 Energy

***Table 60. Activity data used in Energy sector, for 2003 (in TJ)***

| IPCC Categories | Solid fuels | | | | | Liquid fuels | | | | | Gaseous fuels | Biomass |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lignite | Coking coal | Sub-bituminous coal | Anthracite | Coke Oven Coke / Lignite Coke | Residual fuel oil | Motor gasoline | Gas/Diesel oil | LPG | Jet kerosene | Natural gas | Wood/ Wood waste |
| **1.A - Fuel Combustion Activities** | **58,646.4** | **1,833.0** | **1,001.7** | **267.0** | **817.8** | **9,040.0** | **5,537.5** | **14,319.0** | **1,750.1** | **11.6** | **2,782.0** | **7,160.0** |
| **1.A.1 - Energy Industries** | **57,036.8** | **-** | **-** | **-** | **-** | **4,960.0** | **-** | **516.0** | **94.6** | **-** | **1,511.0** | **235.0** |
| 1.A.1.a - Main Activity Electricity and Heat Production | 57,036.8 | - | - | - | - | 4,960.0 | - | 430.0 | 94.6 | - | 1,511.0 | 235.0 |
| 1.A.1.a.i - Electricity Generation | 56,239.9 | - | - | - | - | 200.0 | - | - | - | - | - | - |
| 1.A.1.a.ii - Combined Heat and Power Generation (CHP) | 497.1 | - | - | - | - | 560.0 | - | - | - | - | 113.0 | - |
| 1.A.1.a.iii - Heat Plants | 299.8 | - | - | - | - | 4,200.0 | - | 430.0 | 94.6 | - | 1,398.0 | 235.0 |
| 1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries | - | - | - | - | - | - | - | 86.0 | - | - | - | - |
| ` | - | - | - | - | - | - | - | 86.0 | - | - | - | - |
| **1.A.2 - Manufacturing Industries and Construction** | **1,286.1** | **1,833.0** | **1,001.7** | **267.0** | **817.8** | **2,160.0** | **-** | **989.0** | **141.9** | **-** | **1,271.0** | **45.0** |
| 1.A.2.m - Non-specified Industry | 1,286.1 | 1,833.0 | 1,001.7 | 267.0 | 817.8 | 2,160.0 | - | 989.0 | 141.9 | - | 1,271.0 | 45.0 |
| **1.A.3 - Transport** | **-** | **-** | **-** | **-** | **-** | **-** | **5,537.5** | **7,525.0** | **898.7** | **11.6** | **-** | **-** |
| 1.A.3.a - Civil Aviation | - | - | - | - | - | - | - | - | - | 11.6 | - | - |
| 1.A.3.a.ii - Domestic Aviation | - | - | - | - | - | - | - | - | - | 11.6 | - | - |
| 1.A.3.b - Road Transportation | - | - | - | - | - | - | 5,537.5 | 7,482.0 | 898.7 | - | - | - |
| 1.A.3.c - Railways | - | - | - | - | - | - | - | 43.0 | - | - | - | - |
| **1.A.4 - Other Sectors** | **323.5** | **-** | **-** | **-** | **-** | **1,920.0** | **-** | **5,289.0** | **614.9** | **-** | **-** | **6,880.0** |
| 1.A.4.a - Commercial/Institutional | 165.7 | - | - | - | - | 1,560.0 | - | 3,784.0 | 236.5 | - | - | 311.0 |
| 1.A.4.b - Residential | 149.9 | - | - | - | - | - | - | 1,247.0 | 378.4 | - | - | 6,527.0 |
| 1.A.4.c - Agriculture/Forestry/ Fishing/Fish Farms | 7.9 | - | - | - | - | 360.0 | - | 258.0 | - | - | - | 42.0 |
| 1.A.4.c.i - Stationary | 7.9 | - | - | - | - | 360.0 | - | 258.0 | - | - | - | 42.0 |
| **Memo Items** | | | | | | | | | | | | |
| **International Bunkers** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **539.8** | **-** | **-** |
| 1.A.3.a.i - International Aviation (International Bunkers) | - | - | - | - | - | - | - | - | - | 539.8 | - | - |

***Table 61. Activity data used in Energy sector, for 2008 (in TJ)***

| IPCC Categories | Solid fuels | | | Liquid fuels | | | | | | | Gaseous fuels | Biomass |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lignite | Sub-bituminous coal | Coke Oven Coke / Lignite Coke | Residual fuel oil | Motor gasoline | Gas/Diesel oil | LPG | Jet kerosene | Aviation gasoline | Other Petroleum products | Natural gas | Wood/ Wood waste |
| **1.A - Fuel Combustion Activities** | **61,950.2** | **277.0** | **1,331.4** | **7,807.0** | **5,232.1** | **14,993.5** | **3,159.7** | **7.3** | **5.8** | **3,716.9** | **4,017.6** | **7,193.6** |
| **1.A.1 - Energy Industries** | **59,896.4** | **-** | **-** | **3,721.3** | **-** | **412.4** | **70.4** | **-** | **-** | **-** | **2,710.8** | **96.9** |
| 1.A.1.a - Main Activity Electricity and Heat Production | 59,896.4 | - | - | 3,721.3 | - | 355.9 | 70.4 | - | - | - | 2,710.8 | 96.9 |
| 1.A.1.a.i - Electricity Generation | 59,401.3 | - | - | 1,830.3 | - | 0.5 | - | - | - | - | - | - |
| 1.A.1.a.ii - Combined Heat and Power Generation (CHP) | 292.8 | - | - | - | - | - | - | - | - | - | 48.0 | - |
| 1.A.1.a.iii - Heat Plants | 202.3 | - | - | 1,891.0 | - | 355.4 | 70.4 | - | - | - | 2,662.8 | 96.9 |
| 1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries | - | - | - | - | - | 56.5 | - | - | - | - | - | - |
| 1.A.1.c.ii - Other Energy Industries | - | - | - | - | - | 56.5 | - | - | - | - | - | - |
| **1.A.2 - Manufacturing Industries and Construction** | **1,894.8** | **277.0** | **1,331.4** | **3,539.8** | **-** | **934.7** | **211.7** | **-** | **-** | **3,716.9** | **1,270.6** | **50.1** |
| 1.A.2.a - Iron and Steel | 1,891.1 | 277.0 | 1,322.9 | 2,625.1 | - | 250.6 | 15.0 | - | - | - | 1,201.5 | 14.6 |
| 1.A.2.b - Non-Ferrous Metals | - | - | - | - | - | 6.7 | 25.8 | - | - | - | - | - |
| 1.A.2.c - Chemicals | - | - | - | - | - | 3.6 | - | - | - | - | 9.0 | - |
| 1.A.2.d - Pulp, Paper and Print | - | - | - | - | - | 0.2 | - | - | - | - | - | 0.9 |
| 1.A.2.e - Food Processing, Beverages and Tobacco | - | - | 8.3 | - | - | 109.9 | 13.9 | - | - | - | 60.2 | 5.6 |
| 1.A.2.f - Non-Metallic Minerals | - | - | - | 743.3 | - | 75.5 | 121.2 | - | - | 3,716.9 | - | 2.5 |
| 1.A.2.h - Machinery | 3.7 | - | 0.2 | 17.6 | - | 33.2 | 35.0 | - | - | - | - | 2.9 |
| 1.A.2.i - Mining (excluding fuels) and Quarrying | - | - | - | 106.0 | - | 260.2 | - | - | - | - | - | 0.9 |
| 1.A.2.l - Textile and Leather | - | - | - | - | - | 1.2 | 0.3 | - | - | - | - | 2.1 |
| 1.A.2.m - Non-specified Industry | - | - | - | 47.7 | - | 193.6 | 0.4 | - | - | - | - | 20.6 |
| **1.A.3 - Transport** | **-** | **-** | **-** | **-** | **5,217.8** | **9,597.0** | **2161.0** | **7.3** | **5.8** | **-** | **10.4** | **0.0** |
| 1.A.3.a - Civil Aviation | - | - | - | - | - | - | - | 7.3 | 5.8 | - | - | 0.0 |
| 1.A.3.a.ii - Domestic Aviation | - | - | - | - | - | - | - | 7.3 | 5.8 | - | - | - |
| 1.A.3.b - Road Transportation | - | - | - | - | 5,217.8 | 9,437.9 | 2161.0 | - | - | - | 10.4 | - |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3.c - Railways | - | - | - | - | - | 159.1 | - | - | - | - | - | - |
| **1.A.4 - Other Sectors** | **98.6** | **-** | **-** | **518.6** | **14.3** | **1,431.7** | **407.9** | **-** | **-** | **-** | **-** | **6,615.7** |
| 1.A.4.b - Residential | 96.2 | - | - | - | - | 1,425.7 | 406.8 | - | - | - | - | 6,534.1 |
| 1.A.4.c - Agriculture/Forestry/ Fishing/Fish Farms | 2.4 | - | - | 518.6 | 14.3 | 6.0 | 1.1 | - | - | - | - | 81.6 |
| 1.A.4.c.i - Stationary | 2.4 | - | - | 518.6 | 14.3 | 6.0 | 1.1 | - | - | - | - | 81.6 |
| **1.A.5 - Non-Specified** | **60.5** | **-** | **-** | **27.4** | **-** | **2,617.8** | **308.7** | **-** | **-** | **-** | **25.7** | **430.9** |
| 1.A.5.a - Stationary | 60.5 | - | - | 27.4 | - | 2,617.8 | 308.7 | - | - | - | 25.7 | 430.9 |
| **Memo Items** | | | | | | | | | | | | |
| **International Bunkers** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **263.7** | **-** | **-** | **-** | **-** |
| 1.A.3.a.i - International Aviation (International Bunkers) | - | - | - | - | - | - | - | 263.7 | - | - | - | - |

***Table 62. Activity data used in Energy sector, for 2012 (in TJ)***

| IPCC Categories | Solid fuels | | | | Liquid fuels | | | | | | | | Gaseous fuels | Biomass |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lignite | Coking coal | Other bitumen. coal | Sub-bitumin. coal | Residual fuel oil | Motor gasoline | Gas/Diesel oil (Road diesel) | Gas/Diesel oil (Heating and other gaseous oil) | LPG | Petroleum coke | Jet kerosene | Aviation gasoline | Natural gas | Wood/ Wood waste |
| **1.A - Fuel Combustion Activities** | **52,908.3** | **344.1** | **46.8** | **4,975.3** | **7,865.4** | **4,712.6** | **15,785.6** | **2,352.1** | **2,597.1** | **2,494.3** | **-** | **2.1** | **4,775.1** | **8,215.6** |
| **1.A.1 - Energy Industries** | **52,172.8** | **-** | **-** | **-** | **2,550.5** | **-** | **77.5** | **4.6** | **-** | **-** | **-** | **-** | **3,829.5** | **3.6** |
| **1.A.1.a - Main Activity Electricity and Heat Production** | 52,172.8 | - | - | - | 1616.9 | - | - | - | - | - | - | - | 3,829.5 | - |
| 1.A.1.a.i - Electricity Generation | 52,010.2 | - | - | - | 953.8 | - | - | - | - | - | - | - | - | - |
| 1.A.1.a.ii - Combined Heat and Power Generation (CHP) | 162.6 | - | - | - | - | - | - | - | - | - | - | - | 2,782.0 | - |
| 1.A.1.a.iii - Heat Plants | - | - | - | - | 663.1 | - | - | - | - | - | - | - | 1,047.5 | - |
| **1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries** | - | - | - | - | 933.6 | - | 77.5 | 4.6 | - | - | - | - | - | 3.6 |
| 1.A.1.c.ii - Other Energy Industries | - | - | - | - | 933.6 | - | 77.5 | 4.6 | - | - | - | - | - | 3.6 |
| **1.A.2 - Manufacturing Industries and Construction** | **614.3** | **344.1** | **46.8** | **4,975.3** | **4,383.9** | **-** | **1,227.5** | **654.5** | **350.8** | **2,494.3** | **0.0** | **0.0** | **849.9** | **286.5** |
| **1.A.2.a - Iron and Steel** | 485.6 | 339.1 | 46.8 | 4,975.3 | 3,240.6 | - | 289.7 | 1.9 | 10.9 | - | - | - | 437.2 | 110.7 |
| **1.A.2.b - Non-Ferrous Metals** | - | - | - | - | - | - | - | 1.0 | 41.3 | - | - | - | - | - |
| **1.A.2.c - Chemicals** | - | - | - | - | 59.2 | - | 1.5 | 16.3 | 0.0 | - | - | - | 39.1 | - |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.A.2.d - Pulp, Paper and Print** | 0.3 | - | - | - | 8.0 | - | 0.1 | 9.5 | - | - | - | - | 24.0 | 0.6 |
| **1.A.2.e - Food Processing, Beverages and Tobacco** | 1.2 | 4.9 | - | - | 395.2 | - | 8.4 | 329.0 | 97.8 | - | - | - | 216.5 | 49.9 |
| **1.A.2.f - Non-Metallic Minerals** | - | - | - | - | 510.8 | - | 25.7 | 106.5 | 171.8 | 2,494.3 | - | - | 53.5 | 1.0 |
| **1.A.2.h - Machinery** | 4.7 | 0.1 | - | - | 28.6 | - | 4.8 | 16.5 | 25.1 | - | - | - | 78.3 | 6.7 |
| **1.A.2.i - Mining (excluding fuels) and Quarrying** | - | - | - | - | - | - | 468.7 | 27.2 | 0.0 | - | - | - | - | 14.0 |
| **1.A.2.l - Textile and Leather** | 122.0 | - | - | - | 87.0 | - | - | 49.5 | 3.3 | - | - | - | 0.1 | 61.3 |
| **1.A.2.m - Non-specified Industry** | 0.5 | - | - | - | 54.4 | - | 428.6 | 97.1 | 0.3 | - | - | - | 1.3 | 42.5 |
| **1.A.3 - Transport** | **-** | **-** | **-** | **-** | **-** | **4,695.8** | **12,811.5** | **-** | **1,579.7** | **-** | **-** | **2.1** | **4.3** | **-** |
| **1.A.3.a - Civil Aviation** | - | - | - | - | - | - | - | - | - | - | - | 2.1 | - | - |
| 1.A.3.a.ii - Domestic Aviation | - | - | - | - | - | - | - | - | - | - | - | 2.1 | - | - |
| **1.A.3.b - Road Transportation** | - | - | - | - | - | 4,695.8 | 12,678.8 | - | 1,579.7 | - | - | - | 4.3 | - |
| **1.A.3.c - Railways** | - | - | - | - | - | - | 132.7 | - | - | - | - | - | - | - |
| **1.A.4 - Other Sectors** | **62.4** | **-** | **-** | **-** | **324.6** | **16.9** | **162.9** | **798.4** | **416.0** | **-** | **-** | **-** | **-** | **7,528.0** |
| **1.A.4.b - Residential** | 62.3 | - | - | - | - | - | - | 774.6 | 415.1 | - | - | - | - | 7,476.2 |
| **1.A.4.c - Agriculture/Forestry/ Fishing/Fish Farms** | 0.1 | - | - | - | 324.6 | 16.9 | 162.9 | 23.8 | 0.9 | - | - | - | - | 51.8 |
| 1.A.4.c.i - Stationary | 0.1 | - | - | - | 324.6 | 16.9 | 162.9 | 23.8 | 0.9 | - | - | - | - | 51.8 |
| **1.A.5 - Non-Specified** | **58.8** | **-** | **-** | **-** | **606.3** | **-** | **1,506.2** | **894.5** | **250.5** | **-** | **-** | **-** | **91.3** | **397.5** |
| **1.A.5.a - Stationary** | 58.8 | - | - | - | 606.3 | - | 1,506.2 | 894.5 | 250.5 | - | - | - | 91.3 | 397.5 |
| **Memo Items** | | | | | | | | | | | | | | |
| **International Bunkers** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **356.2** | **-** | **-** | **-** |
| 1.A.3.a.i - International Aviation (International Bunkers) | - | - | - | - | - | - | - | - | - | - | 356.2 | - | - | - |

***Table 63. Activity data used in Energy sector, for 2013 (in TJ)***

| IPCC Categories | Solid fuels | | | | Liquid fuels | | | | | | | | | Gaseous fuels | Biomass | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lignite | Coking coal | Other bitumin. coal | Sub-bitumin. coal | Residual fuel oil | Motor gasoline | Gas/ Diesel oil (Road diesel) | Gas/Diesel oil (Heating and other gaseous oil) | LPG | Petro-leum coke | Jet kero-sene | Aviation gasoline | Refinery gas | Natural gas | Wood/ Wood waste (Fuelwood) | Wood/ Wood waste (Wood wastes, briquettes and pellets) |
| **1.A - Fuel Combustion Activities** | **44,973.7** | **76.3** | **147.2** | **3,545.7** | **5,991.2** | **4,901.7** | **16,953.8** | **2,132.4** | **2635.1** | **2,686.3** | **-** | **5.1** | **0.6** | **5,394.7** | **6,115.7** | **225.2** |
| **1.A.1 - Energy Industries** | **43,569.7** | **-** | **-** | **-** | **1,703.0** | **-** | **73.7** | **4.8** | **-** | **-** | **-** | **-** | **0.6** | **4,265.6** | **4.1** | **-** |
| **1.A.1.a - Main Activity Electricity and Heat Production** | 43,569.7 | - | - | - | 1,337.6 | - | - | - | - | - | - | - | - | 4,265.6 | - | - |
| 1.A.1.a.i - Electricity Generation | 43,407.5 | - | - | - | 1,240.0 | - | - | - | - | - | - | - | - | - | - | - |
| 1.A.1.a.ii - Combined Heat and Power Generation (CHP) | 162.1 | - | - | - | - | - | - | - | - | - | - | - | - | 3,096.0 | - | - |
| 1.A.1.a.iii - Heat Plants | - | - | - | - | 97.6 | - | - | - | - | - | - | - | - | 1,169.6 | - | - |
| **1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries** | - | - | - | - | 365.3 | - | 73.7 | 4.8 | - | - | - | - | 0.6 | - | 4.1 | - |
| 1.A.1.c.ii - Other Energy Industries | - | - | - | - | 365.3 | - | 73.7 | 4.8 | - | - | - | - | 0.6 | - | 4.1 | - |
| **1.A.2 - Manufacturing Industries and Construction** | **1,245.4** | **76.3** | **147.2** | **3,545.7** | **3,891.6** | **-** | **1,144.3** | **611.2** | **362.8** | **2,686.3** | **-** | **-** | **-** | **1,012.6** | **228.0** | **96.4** |
| **1.A.2.a - Iron and Steel** | 1,100.4 | 70.9 | 147.2 | 3,545.7 | 2,966.0 | - | 103.6 | 1.5 | 20.4 | 145.5 | - | - | - | 612.6 | 6.5 | - |
| **1.A.2.b - Non-Ferrous Metals** | - | - | - | - | - | - | 0.3 | 1.1 | 41.1 | - | - | - | - | - | - | - |
| **1.A.2.c - Chemicals** | - | - | - | - | 55.4 | - | 1.3 | 16.1 | 0.0 | - | - | - | - | 37.4 | 0.4 | 0.3 |
| **1.A.2.d - Pulp, Paper and Print** | 0.3 | - | - | - | 8.3 | - | 0.3 | 7.7 | 0.1 | - | - | - | - | 15.2 | 0.5 | - |
| **1.A.2.e - Food Processing, Beverages and Tobacco** | 0.7 | 5.4 | - | - | 293.0 | - | 9.8 | 305.8 | 85.2 | - | - | - | - | 218.9 | 133.4 | 52.4 |
| **1.A.2.f - Non-Metallic Minerals** | - | - | - | - | 430.8 | - | 32.1 | 79.8 | 192.5 | 2,540.9 | - | - | - | 40.1 | 0.5 | - |
| **1.A.2.h - Machinery** | 0.1 | 0.1 | - | - | 20.1 | - | 8.2 | 16.5 | 19.5 | - | - | - | - | 84.0 | 4.9 | 2.8 |
| **1.A.2.i - Mining (excluding fuels) and Quarrying** | - | - | - | - | - | - | 434.4 | 22.3 | 0.0 | - | - | - | - | - | 8.8 | - |
| **1.A.2.l - Textile and Leather** | 143.5 | - | - | - | 77.9 | - | - | 74.7 | 3.3 | - | - | - | - | 1.2 | 39.4 | 10.4 |
| **1.A.2.m - Non-specified Industry** | 0.5 | - | - | - | 40.1 | - | 554.3 | 85.7 | 0.5 | - | - | - | - | 3.3 | 33.6 | 30.5 |
| **1.A.3 - Transport** | **-** | **-** | **-** | **-** | **-** | **4,885.4** | **14,821.8** | **-** | **1695.3** | **-** | **-** | **5.1** | **-** | **5.5** | **-** | **-** |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.A.3.a - Civil Aviation** | - | - | - | - | - | - | - | - | - | - | - | 5.1 | - | - | - | - |
| 1.A.3.a.ii - Domestic Aviation | - | - | - | - | - | - | - | - | - | - | - | 5.1 | - | - | - | - |
| **1.A.3.b - Road Transportation** | - | - | - | - | - | 4,885.4 | 14,713.6 | - | 1695.3 | - | - | - | - | 5.5 | - | - |
| **1.A.3.c - Railways** | - | - | - | - | - | - | 108.2 | - | - | - | - | - | - | - | - | - |
| **1.A.4 - Other Sectors** | **95.1** | **-** | **-** | **-** | **204.8** | **16.3** | **244.2** | **243.8** | **313.9** | **-** | **-** | **-** | **-** | **0.4** | **5,687.3** | **128.7** |
| **1.A.4.b - Residential** | 54.9 | - | - | - | - | - | - | 222.6 | 313.0 | - | - | - | - | 0.4 | 5,600.1 | 128.7 |
| **1.A.4.c - Agriculture/Forestry/ Fishing/Fish Farms** | 40.2 | - | - | - | 204.8 | 16.3 | 244.2 | 21.2 | 0.9 | - | - | - | - | - | 87.1 | - |
| 1.A.4.c.i - Stationary | 40.2 | - | - | - | 204.8 | 16.3 | 244.2 | 21.2 | 0.9 | - | - | - | - | - | 87.1 | - |
| **1.A.5 - Non-Specified** | **63.6** | **-** | **-** | **-** | **191.8** | **-** | **669.9** | **1,272.5** | **263.1** | **-** | **-** | **-** | **-** | **110.5** | **196.3** | **-** |
| **1.A.5.a - Stationary** | 63.6 | - | - | - | 191.8 | - | 669.9 | 1,272.5 | 263.1 | - | - | - | - | 110.5 | 196.3 | - |
| **Memo Items** | | | | | | | | | | | | | | | | |
| **International Bunkers** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **440.2** | **-** | **-** | **-** | **-** | **-** |
| 1.A.3.a.i - International Aviation (International Bunkers) | - | - | - | - | - | - | - | - | - | - | 440.2 | - | - | - | - | - |

***Table 64. Activity data used in Energy sector, for 2014 (in TJ)***

| IPCC Categories | Solid fuels | | | | Liquid fuels | | | | | | | | Gaseous fuels | Biomass | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lignite | Coking coal | Other bitumen. coal | Sub-bitumin. coal | Residual fuel oil | Motor gaso-line | Gas/ Diesel oil (Road diesel) | Gas/Diesel oil (Heating and other gaseous oil) | LPG | Petro-leum coke | Jet kero-sene | Aviation gasoline | Natural gas | Wood/ Wood waste (Fuel-wood) | Wood/ Wood waste (Wood wastes, briquettes and pellets) |
| **1.A - Fuel Combustion Activities** | **41,688.3** | **39.7** | **167.5** | **3,064.2** | **4,900.5** | **4,431.3** | **18040.7** | **1,928.4** | **2,841.0** | **2,950.9** | **-** | **2.6** | **4,622.1** | **6,712.2** | **399.9** |
| **1.A.1 - Energy Industries** | **40,849.7** | **-** | **-** | **-** | **1,748.6** | **-** | **76.0** | **3.1** | **-** | **-** | **-** | **-** | **3,218.3** | **5.3** | **0.0** |
| **1.A.1.a - Main Activity Electricity and Heat Production** | 40,849.7 | - | - | - | 1,646.6 | - | - | - | - | - | - | - | 3,218.3 | 0.0 | 0.0 |
| 1.A.1.a.i - Electricity Generation | 40,767.7 | - | - | - | 1,646.6 | - | - | - | - | - | - | - | - | - | - |
| 1.A.1.a.ii - Combined Heat and Power Generation (CHP) | 82.0 | - | - | - | - | - | - | - | - | - | - | - | 1,537.0 | - | - |
| 1.A.1.a.iii - Heat Plants | - | - | - | - | - | - | - | - | - | - | - | - | 1,681.4 | - | - |
| **1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries** | - | - | - | - | 102.0 | - | 76.0 | 3.1 | - | - | - | - | - | 5.3 | - |
| 1.A.1.c.ii - Other Energy Industries | - | - | - | - | 102.0 | - | 76.0 | 3.1 | - | - | - | - | - | 5.3 | - |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.A.2 - Manufacturing Industries and Construction** | **759.2** | **39.7** | **167.5** | **3,064.2** | **2,788.8** | **-** | **1161.8** | **611.7** | **347.6** | **2,950.9** | **-** | **-** | **1,195.2** | **329.1** | **119.1** |
| **1.A.2.a - Iron and Steel** | 696.6 | 36.3 | 148.9 | 3,064.2 | 1,969.7 | - | 110.1 | 1.7 | 20.7 | 650.9 | - | - | 763.6 | 5.5 | - |
| **1.A.2.b - Non-Ferrous Metals** | - | - | - | - | - | - | 0.2 | 0.5 | 2.3 | - | - | - | 38.4 | 1.1 | - |
| **1.A.2.c - Chemicals** | - | - | - | - | 46.8 | - | 1.0 | 18.4 | 0.0 | - | - | - | 36.3 | - | - |
| **1.A.2.d - Pulp, Paper and Print** | 0.3 | - | 0.7 | - | 9.1 | - | 0.4 | 8.2 | 0.5 | - | - | - | 15.2 | 0.3 | - |
| **1.A.2.e - Food Processing, Beverages and Tobacco** | 0.4 | 3.4 | - | - | 272.6 | - | 7.9 | 283.4 | 100.2 | - | - | - | 203.4 | 202.9 | 57.1 |
| **1.A.2.f - Non-Metallic Minerals** | 0.1 | - | 17.9 | - | 368.0 | - | 27.9 | 86.4 | 189.6 | 2,300.0 | - | - | 38.7 | 0.6 | 0.3 |
| **1.A.2.h - Machinery** | 0.1 | - | - | - | 16.5 | - | 9.1 | 12.6 | 31.1 | - | - | - | 95.4 | 5.3 | 2.9 |
| **1.A.2.i - Mining (excluding fuels) and Quarrying** | - | - | - | - | - | - | 525.5 | 17.6 | 0.0 | - | - | - | - | 9.9 | - |
| **1.A.2.l - Textile and Leather** | 61.6 | - | - | - | 73.8 | - | - | 116.0 | 2.6 | - | - | - | 1.9 | 54.6 | 27.5 |
| **1.A.2.m - Non-specified Industry** | 0.2 | - | - | - | 32.4 | - | 479.7 | 66.8 | 0.5 | - | - | - | 2.2 | 49.1 | 31.4 |
| **1.A.3 - Transport** | **-** | **-** | **-** | **-** | **-** | **4,414.9** | **15868.9** | **-** | **1,873.0** | **-** | **-** | **2.6** | **6.2** | **-** | **-** |
| **1.A.3.a - Civil Aviation** | - | - | - | - | - | - | - | - | - | - | - | 2.6 | - | - | - |
| 1.A.3.a.ii - Domestic Aviation | - | - | - | - | - | - | - | - | - | - | - | 2.6 | - | - | - |
| **1.A.3.b - Road Transportation** | - | - | - | - | - | 4,414.9 | 15758.0 | - | 1,873.0 | - | - | - | 6.2 | - | - |
| **1.A.3.c - Railways** | - | - | - | - | - | - | 110.9 | - | - | - | - | - | - | - | - |
| **1.A.4 - Other Sectors** | **67.8** | **-** | **-** | **-** | **181.2** | **16.3** | **251.5** | **265.6** | **336.7** | **-** | **-** | **-** | **1.7** | **6,102.5** | **280.8** |
| **1.A.4.b - Residential** | 31.4 | - | - | - | - | - | - | 245.3 | 335.8 | - | - | - | 1.7 | 6,025.7 | 280.8 |
| **1.A.4.c - Agriculture/Forestry/ Fishing/Fish Farms** | 36.4 | - | - | - | 181.2 | 16.3 | 251.5 | 20.2 | 0.9 | - | - | - | - | 76.8 | - |
| 1.A.4.c.i - Stationary | 36.4 | - | - | - | 181.2 | 16.3 | 251.5 | 20.2 | 0.9 | - | - | - | - | 76.8 | - |
| **1.A.5 - Non-Specified** | **11.6** | **-** | **-** | **-** | **182.0** | **-** | **682.4** | **1,048.0** | **283.6** | **-** | **-** | **-** | **200.6** | **275.2** | **-** |
| **1.A.5.a - Stationary** | 11.6 | - | - | - | 182.0 | - | 682.4 | 1,048.0 | 283.6 | - | - | - | 200.6 | 275.2 | - |
| **Memo Items** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **International Bunkers** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **514.6** | **-** | **-** | **-** | **-** |
| 1.A.3.a.i - International Aviation (International Bunkers) | - | - | - | - | - | - | - | - | - | - | 514.6 | - | - | - | - |

## A II.1.2 IPPU

***Table 65. Activity data used in IPPU sector (in t)***

| Categories | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **2.A - Mineral Industry** | | | | | |
| 2.A.1 - Cement production | 767,817 | 915,553 | 683,134 | 730,000 | 686,497 |
| 2.A.2 - Lime production | 7,709 | 11 | | | |
| 2.A.3 - Glass Production | 134 | 97 | 43 | 38 | 34 |
| 2.A.4 - Other Process Uses of Carbonates | | | | | |
| 2.A.4.a - Ceramics | 437 | 328 | 275 | 264 | 254 |
| 2.A.4.b - Other Uses of Soda Ash | 4,946 | 5,195 | 5,351 | 5,386 | 5,419 |
| 2.A.4.c - Non Metallurgical Magnesia Production | | | | | |
| 2.A.4.d - Other (please specify) | 25,364 | 22,118 | 32,023 | 33,454 | 34,885 |
| **2.B - Chemical Industry** | | | | | |
| 2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production | - | - | - | - | - |
| 2.B.5 - Carbide Production | - | - | - | - | - |
| 2.B.6 - Titanium Dioxide Production | - | - | - | - | - |
| 2.B.7 - Soda Ash Production | 91 | 61 | 48 | 45 | 43 |
| **2.C - Metal Industry** | | | | | |
| 2.C.1 - Iron and Steel Production | 589,871 | 514,370 | 744,730 | 778,008 | 811,286 |
| 2.C.2 - Ferroalloys Production | 111,068 | 225,262 | 154,436 | 184,560 | 182,136 |
| 2.C.3 - Aluminium production | 11,379 | 45 | 1,278 | 303 | NO |
| 2.C.4 - Magnesium production | | | | | |
| 2.C.5 - Lead Production | 16,916 | - | - | - | - |
| 2.C.6 - Zinc Production | 49,347 | - | - | - | - |

## A II.1.3 AFOLU

***Table 66. Activity data used for GHG emissions inventory in Livestock (number of heads)***

| Sepcies and categories / Видови и категории | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Dairy Cows / Млечни крави | 160,810 | 147,519 | 161,012 | 154,487 | 155,432 |
| Other Cattle / Други Говеда | 99,166 | 105,954 | 90,228 | 83,846 | 86,175 |
| Sheep / Овци | 1,239,330 | 618,404 | 558,735 | 572,961 | 575,833 |
| Sheep <1 Y / Овци до 1 г. | N/A | 198,200 | 173,606 | 158,867 | 164,624 |
| Goats / Кози | N/A | 133,017 | 63,585 | 75,028 | 81,346 |
| Horses / Коњи | 42,883 | 30,936 | 21,676 | 20,682 | 19,371 |
| Swine / Свињи | 179,050 | 36,768 | 24,664 | 26,724 | 23,511 |
| Finishers / Гоеници | | 210,107 | 152,253 | 140,768 | 141,542 |
| Poultry / Живина | 2,417,362 | | | | |
| Layers / Несилки | N/A | 2,173,346 | 1,715,180 | 1,623,130 | 1,884,289 |
| Broylers / Бројлери | N/A | 1,597 | 5,046 | 90,184 | 4,355 |
| Turkey / Мисирки | N/A | 6,234 | 3,933 | 3,491 | 3,690 |
| Other poultry / Друга живина | N/A | 26,741 | 20,164 | 20,700 | 19,477 |

***Table 67. Activity data used for GHG emissions inventory in Forest land (ha)***

| | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Forest land (total)** | **966,663** | **952,182** | **1,104,549** | **1,104,152** | **1,131,151** |
| **Forest land Remaining Forest land** | **955,294** | **947,377** | **1,102,002** | **1,101,521** | **1,128,442** |
| **Land Converted to Forest land** | **11,369** | **4,805** | **2,547** | **2,631** | **2,709** |
| *Cropland converted to Forest Land* | *2,227* | *1,221* | *648* | *669* | *694* |
| *Grassland converted to Forest Land* | *8,848* | *3,417* | *1,812* | *1,871* | *1,943* |
| *Wetlands converted to Forest Land* | *162* | *54* | *29* | *30* | *27* |
| *Settlements converted to Forest Land* | *49* | *25* | *13* | *13* | *14* |
| *Other Land converted to Forest Land* | *83* | *88* | *45* | *48* | *31* |

***Table 68. Activity data used for GHG emissions inventory in Cropland (ha)***

| | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Cropland (total)** | **517,705** | **462,531** | **454622** | **454341** | **456794** |
| **Cropland Remaining Cropland** | **508,998** | **458,506** | **452,522** | **452,136** | **454,504** |
| **Land Converted to Cropland** | **8,707** | **4,026** | **2,100** | **2,205** | **2,289** |
| *Forest Land converted to Cropland* | *4611* | *2,139* | *1,116* | *1,172* | *1,217* |
| *Grassland converted to Cropland* | *2946* | *1,697* | *885* | *929* | *965* |
| *Wetlands converted to Cropland* | *914* | *85* | *44* | *46* | *48* |
| *Settlements converted to Cropland* | *131* | *71* | *37* | *39* | *40* |
| *Other Land converted to Cropland* | *105* | *34* | *18* | *19* | *19* |

***Table 69. Activity data used for GHG emissions inventory in Grassland (ha)***

| | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Grassland (total)** | **732,982** | **542,479** | **756,557** | **751,187** | **751,086** |
| **Grassland Remaining Grassland** | **723,495** | **537,621** | **753,981** | **748,526** | **748,324** |
| **Land Converted to Grassland** | **9,487** | **4,858** | **2,576** | **2,661** | **2,762** |
| *Forest Land converted to Grassland* | *6,181* | *2,610* | *1,384* | *1,430* | *1,484* |
| *Cropland converted to Grassland* | *2,603* | *1,974* | *1,047* | *1,081* | *1,122* |
| *Wetlands converted to Grassland* | *149* | *31* | *17* | *17* | *18* |
| *Settlements converted to Grassland* | *339* | *123* | *65* | *67* | *70* |
| *Other Land converted to Grassland* | *215* | *120* | *63* | *66* | *68* |

***Table 70. Activity data used for GHG emissions inventory in Wetlands (ha)***

| | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Wetlands (total)** | **1,892** | **1,939** | **1,997** | **2,012** | **2,026** |
| **Wetlands Remaining Wetlands** | **1,049** | **1,589** | **1,811** | **1,820** | **1,827** |
| **Land Converted to Wetlands** | **843** | **350** | **186** | **192** | **199** |
| *Forest Land converted to Wetlands* | *420* | *207* | *110* | *113* | *118* |
| *Cropland converted to Wetlands* | *218* | *78* | *41* | *43* | *44* |
| *Grassland converted to Wetlands* | *193* | *49* | *26* | *27* | *28* |
| *Settlements converted to Wetlands* | *6* | *6* | *3* | *3* | *3* |
| *Other Land converted to Wetlands* | *6* | *11* | *6* | *6* | *6* |

***Table 71. Activity data used for GHG emissions inventory in Settlements (ha)***

| | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Settlements (total)** | **31,293** | **32,384** | **32,848** | **32,973** | **33,090** |
| **Settlements Remaining Settlements** | **30,456** | **31,980** | **32,634** | **32,752** | **32,860** |
| **Land Converted to Settlements** | **837** | **404** | **214** | **221** | **230** |
| *Forest Land converted to Settlements* | *56* | *10* | *5* | *5* | *6* |
| *Cropland converted to Settlements* | *187* | *121* | *64* | *66* | *69* |
| *Grassland converted to Settlements* | *544* | *243* | *129* | *133* | *138* |
| *Wetlands converted to Settlements* | *15* | *4* | *2* | *2* | *2* |
| *Other Land converted to Settlements* | *35* | *26* | *14* | *14* | *15* |

***Table 72. Activity data used for GHG emissions inventory in Other Land (ha)***

| | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| **Other Land (total)** | **320,767** | **579,786** | **220,728** | **226,636** | **197,154** |
| **Other land Remaining Other land** | **320,026** | **578,880** | **220,147** | **226,039** | **196,610** |
| **Land Converted to Other land** | **741** | **907** | **581** | **597** | **544** |
| *Forest Land converted to Other Land* | *283* | *209* | *111* | *115* | *119* |
| *Cropland converted to Other Land* | *145* | *346* | *283* | *289* | *217* |
| *Grassland converted to Other Land* | *226* | *277* | *147* | *152* | *157* |
| *Wetlands converted to Other Land* | *28* | *37* | *19* | *20* | *29* |
| *Settlements converted to Other Land* | *58* | *38* | *20* | *21* | *22* |

## A II.1.4 Waste

***Table 73. Population used for estimation of GHG emission from Municipal Solid Waste and Domestic Wastewater Treatment and Discharge***

| Population (in millions) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **1950** | **1951** | **1952** | **1953** | **1954** | **1955** | **1956** | **1957** | **1958** | **1959** | **1960** | **1961** | **1962** | **1963** | **1964** |
| | 1.225 | 1.25151 | 1.27801 | 1.30451 | 1.3133 | 1.32208 | 1.33087 | 1.33965 | 1.34843 | 1.35722 | 1.366 | 1.406 | 1.43013 | 1.45426 | 1.4784 |
| **Year** | **1965** | **1966** | **1967** | **1968** | **1969** | **1970** | **1971** | **1972** | **1973** | **1974** | **1975** | **1976** | **1977** | **1978** | **1979** |
| | 1.50253 | 1.52666 | 1.55079 | 1.57492 | 1.59905 | 1.69151 | 1.70866 | 1.72345 | 1.73755 | 1.75334 | 1.77241 | 1.79556 | 1.82192 | 1.84932 | 1.87465 |
| **Year** | **1980** | **1981** | **1982** | **1983** | **1984** | **1985** | **1986** | **1987** | **1988** | **1989** | **1990** | **1991** | **1992** | **1993** | **1994** |
| | 1.89573 | 1.9115 | 1.92273 | 1.93128 | 1.93991 | 1.95049 | 1.96419 | 1.98006 | 1.99847 | 1.99934 | 1.99623 | 1.98846 | 1.97703 | 1.96492 | 1.94593 |
| **Year** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** |
| | 1.94382 | 1.94909 | 1.96064 | 1.97605 | 1.99168 | 2.00487 | 2.01492 | 2.02255 | 2.02677 | 2.03254 | 2.03686 | 2.04194 | 2.04518 | 2.04862 | 2.05272 |
| **Year** | **2010** | **2011** | **2012** | **2013** | **2014** | | | | | | | | | | |
| | 2.05728 | 2.05979 | 2.06229 | 2.06577 | 2.06917 | | | | | | | | | | |

***Table 74. Other activity data used for estimation of GHG emission from Municipal Solid Waste***

| | IPCC Regional Default | National | | | | |
|---|---|---|---|---|---|---|
| | | 2003 | 2008 | 2012 | 2013 | 2014 |
| **Waste per capita (kg/cap/yr)** | 520 | 197 | 349 | 382 | 384 | 370 |
| **% to SWDS** | 90 | 90 | 90 | 70.63 | 70 | 74.47 |

***Table 75. Composition of waste going to the Municipal solid waste disposal sites***

| food (%) | garden (%) | paper (%) | wood (%) | textile (%) | nappies (%) | other (%) |
|---|---|---|---|---|---|---|
| 30.1 | 0 | 21.8 | 7.5 | 4.7 | 0 | 35.9 |

***Table 76. GDP (in $ million) used for estimation of GHG emission from Industrial Waste***

| GDP ($ million) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **1970** | **1971** | **1972** | **1973** | **1974** | **1975** | **1976** | **1977** | **1978** | **1979** | **1980** | **1981** | **1982** | **1983** | **1984** |
| | 1,219 | 1,326 | 1,384 | 1,802 | 2,494 | 2,800 | 3,174 | 3,882 | 4,648 | 5,863 | 6,031 | 5,941 | 5,402 | 5,517 | 5,934 |
| **Year** | **1985** | **1986** | **1987** | **1988** | **1989** | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** |
| | 6,338 | 6,910 | 7,425 | 7,776 | 8,390 | 7,871 | 2,916 | 2,739 | 2,963 | 3,560 | 4,707 | 4,413 | 3,720 | 3,580 | 3,673 |
| **Year** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
| | 3,587 | 3,437 | 3,791 | 4,756 | 5,514 | 5,987 | 6,558 | 8,160 | 9,834 | 9,314 | 9,339 | 10,395 | 9,745 | 10,818 | 11,362 |

***Table 77. Other activity data used for estimation of GHG emission from Industrial Waste***

| | IPCC Regional Default |
|---|---|
| **Waste Generation Rate (Gg/$mGDP/yr)** | 0.5 |
| **% to SWDS** | 75.78 |

***Table 78. Total annual amount of solid waste treated by biological treatment facilities (in Gg)***

| Biological Treatment System | Waste Category | Type of Waste | Waste basis | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|
| Composting | Municipal Solid Waste | Total MSW | Dry | 0.947 | 0.738 | 0.441 | 1.945 |

***Table 79. Activity data used for estimation of the GHG emissions from Open burning of waste***

| Parametar | Unit | 2003 | 2008 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| Population - P | (Capita) | 2026773 | 2048619 | 2062294 | 2065769 | 2069172 |
| Fraction of Population Burning Waste - **P frac** | (Fraction) | 0.2422 | 0.2422 | 0.2937 | 0.3 | 0.2553 |
| Per Capita Waste Generation - **MSWp** | (kg waste/capita/day) | 0.54 | 0.96 | 1.05 | 1.05 | 1.05 |
| Fraction of the waste amount burned relative to the total amount of waste treated - **Bfrac** | (Fraction) | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Number of days by year | (Day) | 365 | 365 | 365 | 365 | 365 |

***Table 80. Parameters used for estimation of organically degradable material in domestic wastewater***

| Parametar | Unit | |
|---|---|---|
| **Degradable organic component - BOD** | (kg BOD/cap/yr) | 21.9 |
| **Correction factor for industrial BOD discharged in sewers** | (l) | 1 |

***Table 81. Parameters used for estimation of total organic degradable material in wastewater for each industry sector***

| Industry sectors | Total industry product (Pi) (t/yr) | | | | | Wastewater generated (Wi) (m3/t) | Chemical Oxygen Demand (CODi) (kg COD/m3) |
|---|---|---|---|---|---|---|---|
| | 2003 | 2008 | 2012 | 2013 | 2014 | | |
| **Alcohol Refining** | 278397 | 80217.125 | 103909.1516 | 126336.264 | 78526.9066 | 24 | 11 |
| **Beer & Malt** | 66797.3094 | 70519.7768 | 62221.5822 | 60982.691 | 62941.0936 | 6.3 | 2.9 |
| **Meat & Poultry** | 4513.843984 | 5107.655505 | 31648 | 32112 | 28047 | 13 | 4.1 |
| **Petroleum Refineries** | 681104 | 1049304 | 243533 | 78034 | 1474 | 0.6 | 1 |
| **Pulp & Paper (combined)** | 21424 | 27551.61956 | 15877 | 12209 | 35429 | 162 | 9 |
| **Vegetable Oils** | 25879 | 31211 | 32322 | 32439 | 33303 | 3.1 | 1 |

## A II.2 Methods applied

***Table 82. Methods and tiers applied in the preparation of the GHG Inventory (for 2014)***

| Categories | $CO_2$ | | $CH_4$ | | $N_2O$ | | HFCs | | PFCs | | $SF_6$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor |
| **1 - Energy** | **T1, T2** | **CS, DF** | **T1** | **DF** | **T1** | **DF** | | | | | | |
| **1.A - Fuel Combustion Activities** | T1, T2 | CS, DF | T1 | DF | T1 | DF | | | | | | |
| 1.A.1 - Energy Industries | T2 | CS | T1 | DF | T1 | DF | | | | | | |
| 1.A.2 - Manufacturing Industries and Construction | T1, T2 | CS, DF | T1 | DF | T1 | DF | | | | | | |
| 1.A.3 - Transport | T1, T2 | CS, DF | T1 | DF | T1 | DF | | | | | | |
| 1.A.4 - Other Sectors | T1, T2 | CS, DF | T1 | DF | T1 | DF | | | | | | |
| 1.A.5 - Non-Specified | T1, T2 | CS, DF | T1 | DF | T1 | DF | | | | | | |
| **1.B - Fugitive emissions from fuels** | T1 | DF | T1 | DF | | | | | | | | |
| 1.B.1 - Solid Fuels | | | T1 | DF | | | | | | | | |
| 1.B.2 - Oil and Natural Gas | T1 | DF | T1 | DF | | | | | | | | |
| **2 - Industrial Processes and Product Use** | **T1, T2** | **CS, DF** | | | | | **T1** | **DF** | **T1** | **DF** | **NO** | **NO** |
| **2.A - Mineral Industry** | T1, T2 | CS, DF | | | | | | | | | | |
| 2.A.1 - Cement production | T2 | CS | | | | | | | | | | |
| 2.A.2 - Lime production | T1 | DF | | | | | | | | | | |
| 2.A.3 - Glass Production | T1 | DF | | | | | | | | | | |
| 2.A.4 - Other Process Uses of Carbonates | T1 | DF | | | | | | | | | | |
| 2.A.5 - Other (please specify) | NO | NO | NO | NO | | | | | | | | |
| **2.B - Chemical Industry** | T1 | DF | | | | | | | | | | |
| 2.B.1 - Ammonia Production | NO | NO | | | | | | | | | | |
| 2.B.2 - Nitric Acid Production | | | | | NO | NO | | | | | | |
| 2.B.3 - Adipic Acid Production | | | | | NO | NO | | | | | | |
| 2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production | | | | | NO | NO | | | | | | |
| 2.B.5 - Carbide Production | NO | NO | NO | NO | | | | | | | | |
| 2.B.6 - Titanium Dioxide Production | NO | NO | | | | | | | | | | |
| 2.B.7 - Soda Ash Production | T1 | DF | | | | | | | | | | |
| 2.B.8 - Petrochemical and Carbon Black Production | NO | NO | | | | | | | | | | |
| 2.B.9 - Fluorochemical Production | | | | | | | | | | | | |
| 2.B.10 - Other (Please specify) | | | | | | | | | | | | |
| **2.C - Metal Industry** | T2 | CS | T1 | DF | | | | | NO | NO | | |
| 2.C.1 - Iron and Steel Production | T2 | CS | NO | NO | | | | | | | | |
| 2.C.2 - Ferroalloys Production | T2 | CS | T1 | DF | | | | | | | | |
| 2.C.3 - Aluminium production | NO | NO | | | | | | | NO | NO | | |
| 2.C.4 - Magnesium production | NO | NO | | | | | | | | | | |

| Categories | $CO_2$ | | $CH_4$ | | $N_2O$ | | HFCs | | PFCs | | $SF_6$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor |
| 2.C.5 - Lead Production | NO | NO | | | | | | | | | | |
| 2.C.6 - Zinc Production | NO | NO | | | | | | | | | | |
| 2.C.7 - Other (please specify) | | | | | | | | | | | | |
| **2.D - Non-Energy Products from Fuels and Solvent Use** | | | | | | | | | | | | |
| 2.D.1 - Lubricant Use | NO | NO | | | | | | | | | | |
| 2.D.2 - Paraffin Wax Use | NO | NO | | | | | | | | | | |
| 2.D.3 - Solvent Use | | | | | | | | | | | | |
| 2.D.4 - Other (please specify) | NO | NO | | | | | | | | | | |
| **2.E - Electronics Industry** | | | | | | | NO | NO | NO | NO | NO | NO |
| 2.E.1 - Integrated Circuit or Semiconductor | | | | | | | NO | NO | NO | NO | NO | NO |
| 2.E.2 - TFT Flat Panel Display | | | | | | | | | NO | NO | NO | NO |
| 2.E.3 - Photovoltaics | | | | | | | | | NO | | | |
| 2.E.4 - Heat Transfer Fluid | | | | | | | | | NO | | | |
| 2.E.5 - Other (please specify) | | | | | | | NO | NO | NO | NO | NO | NO |
| **2.F - Product Uses as Substitutes for Ozone Depleting Substances** | | | | | | | **T1** | **DF** | | | | |
| 2.F.1 - Refrigeration and Air Conditioning | | | | | | | T1 | DF | | | | |
| 2.F.2 - Foam Blowing Agents | | | | | | | NO | NO | | | | |
| 2.F.3 - Fire Protection | | | | | | | NO | NO | NO | NO | | |
| 2.F.4 - Aerosols | | | | | | | NO | NO | | | | |
| 2.F.5 - Solvents | | | | | | | NO | NO | NO | NO | | |
| 2.F.6 - Other Applications (please specify) | | | | | | | | | | | | |
| **2.G - Other Product Manufacture and Use** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | | |
| 2.G.1 - Electrical Equipment | | | | | | | | | NE | NE | | |
| 2.G.2 - SF6 and PFCs from Other Product Uses | | | | | | | | | NO | NO | | |
| 2.G.3 - N2O from Product Uses | | | | | NO | NO | | | | | | |
| 2.G.4 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | | |
| **2.H - Other** | | | | | | | | | | | | |
| 2.H.1 - Pulp and Paper Industry | | | | | | | | | | | | |
| 2.H.2 - Food and Beverages Industry | | | | | | | | | | | | |
| 2.H.3 - Other (please specify) | | | | | | | | | | | | |
| **3 - Agriculture, Forestry, and Other Land Use** | **T1** | **DF** | **T1** | **DF** | **T1** | **DF** | | | | | | |
| **3.A - Livestock** | NO | NO | T1 | DF | T1 | DF | | | | | | |
| 3.A.1 - Enteric Fermentation | | | T1 | DF | NO | NO | | | | | | |
| 3.A.2 - Manure Management | | | T1 | DF | T1 | DF | | | | | | |
| **3.B - Land** | T1 | DF | | | | | | | | | | |
| 3.B.1 - Forest land | T1 | DF | | | | | | | | | | |

| Categories | $CO_2$ | | $CH_4$ | | $N_2O$ | | HFCs | | PFCs | | $SF_6$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor | Method used | Emission factor |
| 3.B.2 - Cropland | T1 | DF | | | | | | | | | | |
| 3.B.3 - Grassland | T1 | DF | | | | | | | | | | |
| 3.B.4 - Wetlands | NO | NO | | | | | | | | | | |
| 3.B.5 - Settlements | T1 | DF | | | | | | | | | | |
| 3.B.6 - Other Land | T1 | DF | | | | | | | | | | |
| **3.C - Aggregate sources and non-$CO_2$ emissions sources on land** | T1 | DF | T1 | DF | T1 | DF | | | | | | |
| 3.C.1 - Emissions from biomass burning | | | | | | | | | | | | |
| 3.C.2 - Liming | | | | | | | | | | | | |
| 3.C.3 - Urea application | | | | | T1 | DF | | | | | | |
| 3.C.4 - Direct $N_2O$ emissions from managed soils | | | | | T1 | DF | | | | | | |
| 3.C.5 - Indirect $N_2O$ emissions from managed soils | | | | | T1 | DF | | | | | | |
| 3.C.6 - Indirect $N_2O$ emissions from manure management | | | | | T1 | DF | | | | | | |
| 3.C.7 - Rice cultivations | | | T1 | DF | | | | | | | | |
| 3.C.8 - Other (please specify) | | | | | | | | | | | | |
| **3.D - Other** | T1 | DF | | | | | | | | | | |
| 3.D.1 - Harvested Wood Products | T1 | DF | | | | | | | | | | |
| 3.D.2 - Other (please specify) | | | | | | | | | | | | |
| **4 - Waste** | **T1** | **DF** | **T1, T2** | **DF** | **T1** | **DF** | | | | | | |
| **4.A - Solid Waste Disposal** | | | T2 | DF | | | | | | | | |
| **4.B - Biological Treatment of Solid Waste** | | | T1 | DF | | | | | | | | |
| **4.C - Incineration and Open Burning of Waste** | T1 | DF | T1 | DF | T1 | DF | | | | | | |
| **4.D - Wastewater Treatment and Discharge** | | | T1 | DF | T1 | DF | | | | | | |
| **4.E - Other (please specify)** | | | | | | | | | | | | |
| **5 - Other** | | | | | | | | | | | | |
| **5.A - Indirect $N_2O$ emissions from the atmospheric deposition of nitrogen in NOx and NH3** | | | | | | | | | | | | |
| **5.B - Other (please specify)** | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Memo Items** | | | | | | | | | | | | |
| **International Bunkers** | | | | | | | | | | | | |
| 1.A.3.a.i - International Aviation (International Bunkers) | T1 | DF | T1 | DF | T1 | DF | | | | | | |
| 1.A.3.d.i - International water-borne navigation (International bunkers) | NO | NO | NO | NO | NO | NO | | | | | | |

*T1 - Tier1 approach, T2 - Tier2 approach, CS - Country specific, DF – Default factor, NO - Not occurring, NE - Not estimated*

# A II.3 Emission factors

## A II.3.1 Energy

***Table 83. Emission factors used in Energy sector (in kg/TJ)***

| Fuel | $CO_2$ | $CH_4$ | $N_2O$ |
|---|---|---|---|
| Coking coal | 94,600 | 10 | 1.5 |
| Other Bituminous Coal | 94,600 | 10 | 1.5 |
| Sub-bituminous Coal | 96,100 | 10 | 1.5 |
| Lignite | 107,879* | 1(10)** | 1.5 |
| Crude oil | 73,333 | | |
| Residual fuel oil | 78,049* | 3 | 0.6 |
| Gas / Diesel oil | 74,100 | 3 | 0.6 |
| Motor gasoline | 69,300 | 0.5 | 2 |
| Jet kerosene | 71,500 | 0.5 | 2 |
| LPG | 63,100 | 1 | 0.1 |
| Petroleum coke | 97,500 | 3 | 0.6 |
| Natural gas | 55,066* | 1 | 0.1 |
| Biomass | 112,000 | 30 | 4 |

* Country Specific Emission Factor (CS EF)

**Default $CH_4$ EF for lignite in Energy industries is 1 kg/TJ and in Manufacturing Industries and Construction is 10 kg/TJ

*Note: The default IPCC EF for $CH_4$ and $N_2O$ are used. For some of the fuels, the values differ between the IPCC categories in the Energy sector (not all are included in table above).*

## A II.3.2 IPPU

***Table 84. Emission factors used for IPPU sector***

| Categories | $CO_2$ (t gas/ t product) | $CH_4$ (kg gas/ t product) | $CF_4$ (kg gas/ t product) | $C_2F_6$ (kg gas/ t product) |
|---|---|---|---|---|
| **Mineral Industry** | | | | |
| Cement production | 0.54 | | | |
| Lime production | 0.75 | | | |
| Glass Production | 0.20 | | | |
| Other Process Uses of Carbonates | | | | |
| Ceramics | 0.44 | | | |
| Other Uses of Soda Ash | 0.41 | | | |
| Other (please specify) | 0.43 | | | |
| **Chemical Industry** | | | | |
| Soda Ash Production | 0.14 | | | |
| **Metal Industry** | | | | |
| Iron and Steel Production | 0.09 | | | |
| Ferroalloys Production | 4.16 | 1.00 | | |
| Aluminium production | 1.60 | | 1.60 | 0.40 |
| Lead Production | 0.52; 0.25 | | | |
| Zinc Production | 1.72 | | | |

## A II.3.3 AFOLU

***Table 85. Emission factors used for GHG emissions inventory in Livestock***

| Emission factor | FBUR | SBUR | Comment |
|---|---|---|---|
| **Livestock** | | | |
| **Dairy cows (enteric - $CH_4$)** | 99 kg/head/year | 99 kg/head/year | |
| **Other cattle (enteric- $CH_4$)** | 58 kg/head/year | 58 kg/head/year | |
| **Sheep (enteric- $CH_4$)** | 5 kg/head/year | 5 kg/head/year | 40kg live weight |
| **Sheep < 1 Y (enteric- $CH_4$)** | - | 5 kg/head/year | Sheep < 1 Y with 28kg live weight |
| **Goat (enteric- $CH_4$)** | 5 kg/head/year | 5 kg/head/year | |
| **Horses (enteric- $CH_4$)** | 18 kg/head/year | 18 kg/head/year | |
| **Swine (enteric- $CH_4$)** | 1 kg/head/year | 1 kg/head/year | 180 kg live weight |
| **Finishers (enteric- $CH_4$)** | - | 1 kg/head/year | Finishers 50 kg live weight |
| **Dairy cows (manure - $CH_4$)** | 20 kg/head/year | 20 kg/head/year | |
| **Dairy cows (manure - $N_2O$)** | 0.35 kg/1000 kg/day<br>18% liquid slurry (40% N loss);<br>67% solid storage slurry (40% N loss);<br>1% daily spread slurry (22% N loss)<br>13% pasture<br>0.005 Direct $N_2O$ - N | 0.35 kg/1000 kg/day<br>18% liquid slurry (40% N loss);<br>67% solid storage slurry (40% N loss);<br>1% daily spread slurry (22% N loss)<br>13% pasture<br>0.005 Direct $N_2O$ - N | |
| **Other cattle (manure- $CH_4$)** | 9 kg/head/year | 9 kg/head/year | |
| **Other cattle (manure- $N_2O$)** | 0.35 kg/1000 kg/day<br>18% liquid slurry (40% N loss);<br>67% solid storage slurry (40% N loss);<br>1% daily spread slurry (22% N loss)<br>13% pasture<br>0.005 Direct $N_2O$ - N | 0.35 kg/1000 kg/day<br>18% liquid slurry (40% N loss);<br>67% solid storage slurry (40% N loss);<br>1% daily spread slurry (22% N loss)<br>13% pasture<br>0.005 Direct $N_2O$ - N | |
| **Sheep (manure- $CH_4$)** | 0.15 kg/head/year | 0.15 kg/head/year | t |
| **Sheep (manure- $N_2O$)** | 0.9 kg/1000 kg/day<br>20% solid storage<br>80% pasture<br>0.005 Direct $N_2O$ - N | 0.9 kg/1000 kg/day<br>20% solid storage<br>80% pasture<br>0.005 Direct $N_2O$ - N | 40 kg live weigh |
| **Sheep < 1 Y (manure- $CH_4$)** | - | 0.15 kg/head/year | Sheep < 1 Y with 28kg live weight |
| **Sheep < 1 Y (manure- $N_2O$)** | - | 0.9 kg/1000 kg/day<br>20% solid storage<br>80% pasture<br>0.005 Direct $N_2O$ - N | Sheep < 1 Y with 28kg live weight |
| **Goat (manure- $CH_4$)** | 0.17 kg/head/year | 0.17 kg/head/year | |
| **Goat (manure- $N_2O$)** | 1.28 kg/1000 kg/day<br>20% solid storage<br>80% pasture<br>0.005 Direct $N_2O$ - N | 1.28 kg/1000 kg/day<br>20% solid storage<br>80% pasture<br>0.005 Direct $N_2O$ - N | |
| **Horses (manure- $CH_4$)** | 1.64 kg/head/year | 1.64 kg/head/year | |
| **Horses (manure- $N_2O$)** | 100% pasture | 100% pasture | |
| **Swine (manure- $CH_4$)** | 6 kg/head/year | 6 kg/head/year | 180 kg live weight |
| **Swine (manure- $N_2O$)** | 0.46 kg/1000 kg/day<br>60% Pit storage (25% N loss);<br>0.002 Direct $N_2O$ – N<br>40% solid storage (50% N loss);<br>0.005 Direct $N_2O$ - N | 0.46 kg/1000 kg/day<br>60% Pit storage (25% N loss);<br>0.002 Direct $N_2O$ – N<br>40% solid storage (50% N loss);<br>0.005 Direct $N_2O$ - N | 180 kg live weight |
| **Finishers (manure- $CH_4$)** | - | 6 kg/head/year | Finishers 50 kg live weight |
| **Finishers (manure-$N_2O$)** | - | 0.55 kg/1000 kg/day<br>60% Pit storage (25% N loss);<br>0.002 Direct $N_2O$ – N | Finishers 50 kg live weight |

| Emission factor | FBUR | SBUR | Comment |
|---|---|---|---|
| | | 40% solid storage (50% N loss); 0.005 Direct $N_2O$ - N | |
| **Poultry (manure- $CH_4$)** | 0.2 kg/head/year | - | 1.8 kg live weight |
| **Poultry (manure- $N_2O$)** | 0.82 kg/1000 kg/day 100% Poultry litter (50% N loss); 0.001 Direct $N_2O$ - N | - | 1.8 kg live weight |
| **Layers (manure- $CH_4$)** | - | 0.2 kg/head/year | 1.8 kg live weight |
| **Layers (manure- $N_2O$)** | - | 0.82 kg/1000 kg/day 100% Poultry litter (50% N loss); 0.001 Direct $N_2O$ - N | 1.8 kg live weight |
| **Broilers (manure- $CH_4$)** | - | 0.2 kg/head/year | 0.9 kg live weight |
| **Broilers (manure- $N_2O$)** | - | 1.1 kg/1000 kg/day 100% Poultry litter (50% N loss); 0.001 Direct $N_2O$ - N | 0.9 kg live weight, specific factors for broilers were used |
| **Turkey (manure- $CH_4$)** | - | 0.9 kg/head/year | 6.8 kg live weight, specific factors for Turkey were used |
| **Turkey (manure- $N_2O$)** | - | 0.74 kg/1000 kg/day 100% Poultry litter (50% N loss); 0.001 Direct $N_2O$ - N | 6.8 kg live weight, specific factors for Turkey were used |
| **Other (manure- $CH_4$)** | - | 0.2 kg/head/year | 1.8 kg live weight |
| **Other (manure- $N_2O$)** | - | 0.82 kg/1000 kg/day 100% Poultry litter (50% N loss); 0.001 Direct $N_2O$ - N | 1.8 kg live weight |

## A II.3.4 Waste

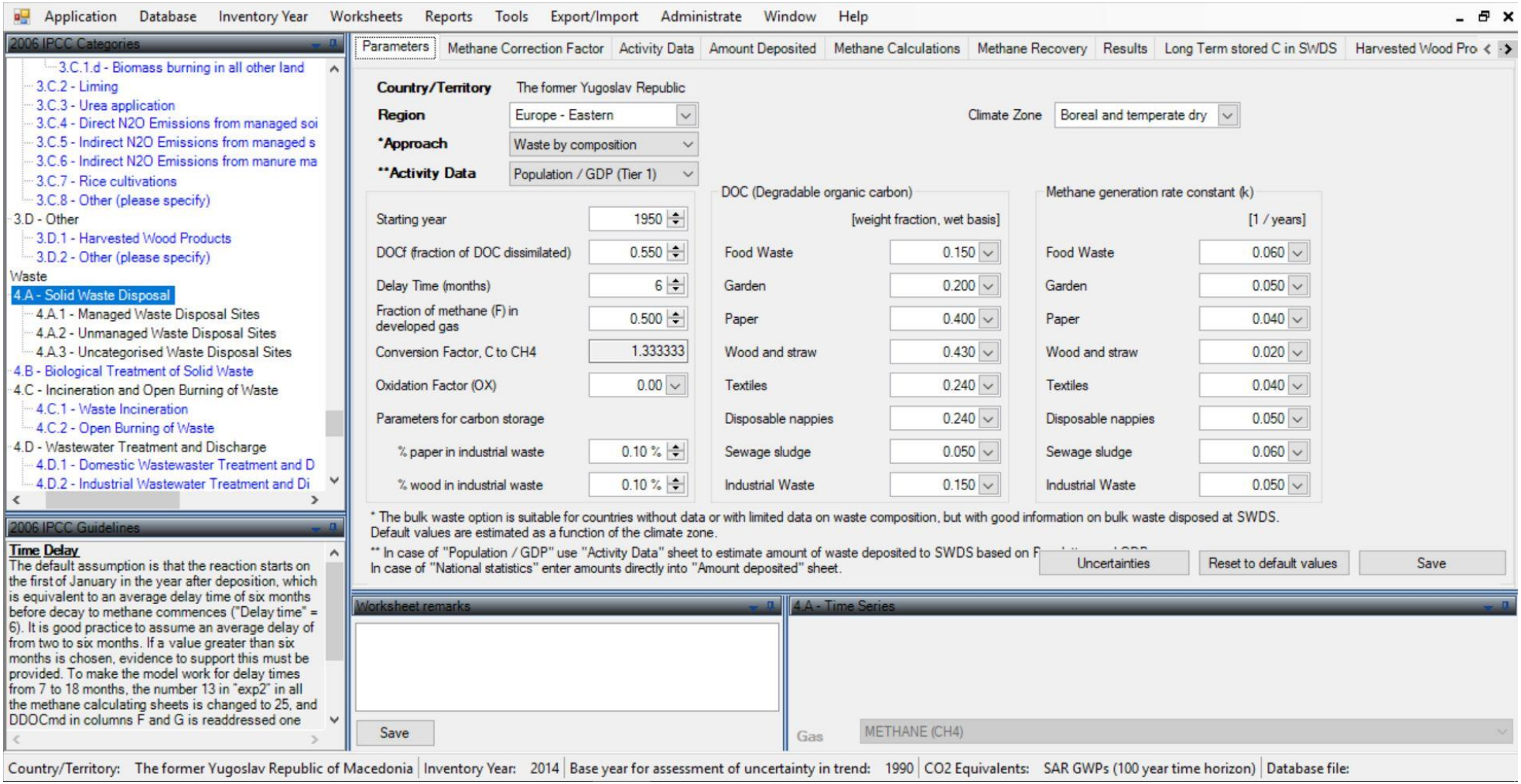



***Figure 69. Parameters used for methane calculations from Solid Waste Disposal***

***Table 86. Methane correction factor and distribution of waste by type of SWDS***

| | Unmanaged – shallow | Unmanaged – deep | Managed – anaerobic | Managed – semi-aerobic | Uncategorised SWDS |
|---|---|---|---|---|---|
| Methane correction factor (MCF) | 0.4 | 0.8 | 1 | 0.5 | 0.6 |
| Fixed distribution (%) | 12 | 46 | 16 | 0 | 26 |

***Table 87. Emission factors used for biological treatment of solid waste***

| | Emission Factor (g/ kg waste treated) | |
|---|---|---|
| | $CH_4$ | $N_2O$ |
| Composting/Total MSW | 10 | 0.6 |

***Table 88. Parameters used for estimation of GHG emissions from Open burning of waste***

| Parameter | Unit | |
|---|---|---|
| Dry Matter Content - dm | (Fraction) | 0.97 |
| Fraction of Carbon in Dry Matter - CF | (Fraction) | 0.38 |
| Fraction of Fossil Carbon in Total Carbon - FCF | (Fraction) | 0.1 |
| Oxidation Factor - OF | (Fraction) | 0.58 |
| Methane Emission Factor | (kg $CH_4$/Gg Wet Waste) | 6500 |
| Nitrous Oxide Emission Factor | (kg $N_2O$/Gg Dry Waste) | 150 |

***Table 89. Parameters used for estimation of emissions from Domestic and Industrial Wastewater Treatment and Discharge***

| Estimation of CH4 emission factor for Domestic Wastewater | |
|---|---|
| Type of treatment or discharge | Sea, river and lake discharge |
| Maximum methane producing capacity - B0 (kg CH4/kg BOD) | 0.6 |
| Methane correction factor for each treatment system - MCFj | 0.1 |
| Fraction of Population Income Group - Ui (Fraction) | Rural 0.4; Urban 0.6 |
| Degree of utilization - Tij (Fraction) | 0.3 |
| | |
| **Estimation of emissions of indirect N2O from Domestic Wastewater** | |
| Estimation of nitrogen in effluent | |
| Per capita protein consumption (Protein) (kg/person/Year) | 28.91 |
| Fraction of nitrogen in protein (Fnpr) (kg N/kg Protein) | 0.16 |
| Fraction of non-consumption protein (Fnon-con) (-) | 1.4 |
| Fraction of industrial and commercial co-discharged protein (Find-com) (-) | 1.25 |
| Emission Factor (kg N2O-N/kg N) | 0.005 |
| | |
| **Estimation of CH4 emission factor for Industrial Wastewater** | |
| Type of treatment or discharge | Sea, river and lake discharge |
| Maximum Methane Producing Capacity (B0) (kg CH4/kg COD) | 0.25 |

# Appendix III Detailed tables of the GHG Inventory

***Table 90. GHG Inventory table for 1990***

| | Emissions (Gg) | | | Emissions CO2 Equivalents (Gg) | | | Emissions (Gg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Categories | Net $CO_2$* | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | NOx | CO | NMVOCs | $SO_2$ |
| **Total National Emissions and Removals** | 9,814.66 | 117.00 | 1.52 | 0.00 | 114.46 | 0.00 | 24.73 | 64.85 | 17.68 | 116.27 |
| **1 - Energy** | 9,201.23 | 8.03 | 0.15 | NO | NO | NO | 23.07 | 7.04 | 6.62 | 94.49 |
| **1.A - Fuel Combustion Activities** | 9,201.23 | 0.52 | 0.15 | NO | NO | NO | 23.07 | 7.04 | 1.04 | 94.49 |
| 1.A.1 - Energy Industries | 6,179.59 | 0.07 | 0.08 | | | | 13.51 | 0.54 | 0.09 | 88.96 |
| 1.A.2 - Manufacturing Industries and Construction | 1,669.98 | 0.09 | 0.02 | | | | 8.22 | 5.33 | 0.81 | 4.86 |
| 1.A.3 - Transport | 771.48 | 0.25 | 0.05 | | | | 0.44 | 0.09 | 0.04 | 0.01 |
| 1.A.4 - Other Sectors | 580.17 | 0.11 | 0.00 | | | | 0.89 | 1.08 | 0.10 | 0.66 |
| 1.A.5 - Non-Specified | 0.00 | 0.00 | 0.00 | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| **1.B - Fugitive emissions from fuels** | 0.00 | 7.51 | 0.00 | NO | NO | NO | 24.73 | 64.85 | 17.68 | 116.27 |
| 1.B.1 - Solid Fuels | 0.00 | 7.48 | NA | | | | 23.07 | 7.04 | 6.62 | 94.49 |
| 1.B.2 - Oil and Natural Gas | 0.00 | 0.03 | NA | | | | 23.07 | 7.04 | 1.04 | 94.49 |
| 1.B.3 - Other emissions from Energy Production | 0.00 | 0.00 | NA | | | | 13.51 | 0.54 | 0.09 | 88.96 |
| **1.C - Carbon dioxide Transport and Storage** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1.C.1 - Transport of CO2 | NO | | | | | | NO | NO | NO | NO |
| 1.C.2 - Injection and Storage | NO | | | | | | NO | NO | NO | NO |
| 1.C.3 - Other | NO | | | | | | NO | NO | NO | NO |
| **2 - Industrial Processes and Product Use** | 825.59 | 0.09 | 0.00 | 0.00 | 114.46 | NO | 0.88 | 0.10 | 0.65 | 10.44 |
| **2.A - Mineral Industry** | 286.13 | NO | NO | NO | NO | NO | 0.86 | 0.00 | 0.15 | 3.26 |
| 2.A.1 - Cement production | 249.37 | | | | | | 0.86 | 0.00 | 0.15 | 3.26 |
| 2.A.2 - Lime production | 28.09 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.A.3 - Glass Production | 0.09 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.A.4 - Other Process Uses of Carbonates | 8.58 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.A.5 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **2.B - Chemical Industry** | 0.31 | 0.00 | NO | NO | NO | NO | 0.00 | 0.03 | 0.00 | 0.00 |
| 2.B.1 - Ammonia Production | NO | | | | | | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.B.2 - Nitric Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.3 - Adipic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.5 - Carbide Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.6 - Titanium Dioxide Production | NO | | | | | | NO | NO | NO | NO |
| 2.B.7 - Soda Ash Production | 0.31 | | | | | | 0.00 | 0.03 | 0.00 | 0.00 |
| 2.B.8 - Petrochemical and Carbon Black Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.9 - Fluorochemical Production | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.B.10 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.C - Metal Industry** | 539.15 | 0.09 | 0.00 | 0.00 | 114.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.C.1 - Iron and Steel Production | 22.20 | 0.00 | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.C.2 - Ferroalloys Production | 354.22 | 0.09 | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.C.3 - Aluminium production | 13.01 | | | | 114.46 | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.C.4 - Magnesium production | NO | | | | | NO | NO | NO | NO | NO |
| 2.C.5 - Lead Production | 22.24 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.C.6 - Zinc Production | 127.48 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.C.7 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.D - Non-Energy Products from Fuels and Solvent Use** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.D.1 - Lubricant Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.2 - Paraffin Wax Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.3 - Solvent Use | | | | | | | NO | NO | NO | NO |
| 2.D.4 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **2.E - Electronics Industry** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.E.1 - Integrated Circuit or Semiconductor | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.E.2 - TFT Flat Panel Display | | | | | NO | NO | NO | NO | NO | NO |
| 2.E.3 - Photovoltaics | | | | | NO | | NO | NO | NO | NO |
| 2.E.4 - Heat Transfer Fluid | | | | | NO | | NO | NO | NO | NO |
| 2.E.5 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.F - Product Uses as Substitutes for Ozone Depleting Substances** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.F.1 - Refrigeration and Air Conditioning | | | | NO | | | NO | NO | NO | NO |
| 2.F.2 - Foam Blowing Agents | | | | NO | | | NO | NO | NO | NO |
| 2.F.3 - Fire Protection | | | | NO | NO | | NO | NO | NO | NO |
| 2.F.4 - Aerosols | | | | NO | | | NO | NO | NO | NO |
| 2.F.5 - Solvents | | | | NO | NO | | NO | NO | NO | NO |
| 2.F.6 - Other Applications (please specify) | | | | NO | NO | | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.G - Other Product Manufacture and Use** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.G.1 - Electrical Equipment | | | | | NO | NO | NO | NO | NO | NO |
| 2.G.2 - SF6 and PFCs from Other Product Uses | | | | | NO | NO | NO | NO | NO | NO |
| 2.G.3 - N2O from Product Uses | | | NO | | | | NO | NO | NO | NO |
| 2.G.4 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.H - Other** | NO | NO | NO | NO | NO | NO | 0.01 | 0.07 | 0.50 | 7.18 |
| 2.H.1 - Pulp and Paper Industry | NO | NO | | | | | 0.01 | 0.07 | 0.03 | 0.03 |
| 2.H.2 - Food and Beverages Industry | NO | NO | | | | | NO | NO | 0.48 | 7.16 |
| 2.H.3 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **3 - Agriculture, Forestry, and Other Land Use** | -216.30 | 44.45 | 1.26 | NA | NA | NA | 0.61 | 2.28 | 6.11 | 0.02 |
| **3.A - Livestock** | 0.00 | 42.36 | 0.16 | NA | NA | NA | 0.11 | 0.00 | 5.87 | 0.00 |
| 3.A.1 - Enteric Fermentation | | 36.33 | | | | | NO | NO | NO | NO |
| 3.A.2 - Manure Management | | 6.03 | 0.16 | | | | 0.11 | NO | 5.87 | NO |
| **3.B - Land** | -206.31 | NA | NE0 | NA | NA | NA | NO | NO | NO | NO |
| 3.B.1 - Forest land | -206.31 | | | | | | NO | NO | NO | NO |
| 3.B.2 - Cropland | NE | | | | | | NO | NO | NO | NO |
| 3.B.3 - Grassland | NE | | | | | | NO | NO | NO | NO |
| 3.B.4 - Wetlands | NE | | NE | | | | NO | NO | NO | NO |
| 3.B.5 - Settlements | NE | | | | | | NO | NO | NO | NO |
| 3.B.6 - Other Land | NE | | | | | | NO | NO | NO | NO |
| **3.C - Aggregate sources and non-CO2 emissions sources on land** | 3.74 | 2.09 | 1.09 | NA | NA | NA | 0.50 | 2.28 | 0.25 | 0.02 |
| 3.C.1 - Emissions from biomass burning | | NE | NE | | | | 0.08 | 2.28 | 0.23 | 0.02 |
| 3.C.2 - Liming | NO | | | | | | NO | NO | NO | NO |
| 3.C.3 - Urea application | 3.74 | | | | | | NO | NO | NO | NO |
| 3.C.4 - Direct N2O Emissions from managed soils | | | 0.71 | | | | 0.42 | NO | 0.02 | NO |
| 3.C.5 - Indirect N2O Emissions from managed soils | | | 0.28 | | | | NO | NO | NO | NO |
| 3.C.6 - Indirect N2O Emissions from manure management | | | 0.11 | | | | NO | NO | NO | NO |
| 3.C.7 - Rice cultivations | | 2.09 | | | | | NO | NO | NO | NO |
| 3.C.8 - Other (please specify) | | NO | NO | | | | NO | NO | NO | NO |
| **3.D - Other** | -13.73 | NA | NA | NA | NA | NA | NO | NO | NO | NO |
| 3.D.1 - Harvested Wood Products | -13.73 | | | | | | NO | NO | NO | NO |
| 3.D.2 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **4 - Waste** | 4.15 | 64.43 | 0.11 | NA | NA | NA | 0.17 | 2.96 | 0.07 | 0.01 |
| **4.A - Solid Waste Disposal** | 0.00 | 62.32 | 0.00 | NA | NA | NA | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.B - Biological Treatment of Solid Waste** | 0.00 | 0.00 | 0.00 | NA | NA | NA | 0.00 | 0.00 | 0.00 | 0.00 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4.C - Incineration and Open Burning of Waste | 4.15 | 0.34 | 0.00 | NA | NA | NA | 0.17 | 2.96 | 0.07 | 0.01 |
| 4.D - Wastewater Treatment and Discharge | 0.00 | 1.77 | 0.11 | NA | NA | NA | NE | NE | 0.00 | NE |
| 4.E - Other (please specify) | NO | NO | NO | NA | NA | NA | NO | NO | NO | NO |
| 5 - Other | NO | NO | NO | NA | NA | NA | NO | NO | NO | NO |
| 5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3 | NO | NO | NO | NA | NA | NA | NO | NO | NO | NO |
| 5.B - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| | | | | | | | | | | |
| Memo Items (5) | | | | | | | | | | |
| International Bunkers | 15.77 | | | NO | NO | NO | NO | NO | NO | NO |
| 1.A.3.a.i - International Aviation (International Bunkers) | 15.77 | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| 1.A.3.d.i - International water-borne navigation (International bunkers) | NO | NO | NO | | | | NO | NO | NO | NO |

**$CO_2$ net emissions (emission minus removals)*

***Table 91. GHG Inventory table for 2003***

| | Emissions (Gg) | | | Emissions CO2 Equivalents (Gg) | | | Emissions (Gg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Categories | Net $CO_2$* | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | NOx | CO | NMVOCs | $SO_2$ |
| Total National Emissions and Removals | 5,554.54 | 117.86 | 1.37 | 89.79 | 53.41 | 0.00 | 22.16 | 64.85 | 17.68 | 116.27 |
| 1 - Energy | 8,602.13 | 10.93 | 0.18 | NO | NO | NO | 20.18 | 33.60 | 11.09 | 103.74 |
| 1.A - Fuel Combustion Activities | 8,602.13 | 2.60 | 0.18 | NO | NO | NO | 20.18 | 33.60 | 4.89 | 103.74 |
| 1.A.1 - Energy Industries | 6,157.55 | 0.08 | 0.09 | | | | 14.99 | 0.66 | 0.10 | 98.30 |
| 1.A.2 - Manufacturing Industries and Construction | 832.32 | 0.06 | 0.01 | | | | 2.62 | 5.12 | 0.59 | 4.83 |
| 1.A.3 - Transport | 998.89 | 0.27 | 0.05 | | | | 0.05 | 0.33 | 0.01 | 0.00 |
| 1.A.4 - Other Sectors | 613.36 | 2.19 | 0.03 | | | | 2.51 | 27.49 | 4.19 | 0.60 |
| 1.A.5 - Non-Specified | 0.00 | 0.00 | 0.00 | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.B - Fugitive emissions from fuels | 0.00 | 8.33 | 0.00 | NO | NO | NO | 0.00 | 0.00 | 6.20 | 0.00 |
| 1.B.1 - Solid Fuels | 0.00 | 8.31 | 0.00 | | | | NO | NO | 6.20 | NO |
| 1.B.2 - Oil and Natural Gas | 0.00 | 0.02 | 0.00 | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.B.3 - Other emissions from Energy Production | 0.00 | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| 1.C - Carbon dioxide Transport and Storage | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1.C.1 - Transport of CO2 | NO | | | | | | NO | NO | NO | NO |
| 1.C.2 - Injection and Storage | NO | | | | | | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.C.3 - Other | NO | | | | | | NO | NO | NO | NO |
| **2 - Industrial Processes and Product Use** | 700.84 | 0.06 | 0.00 | 89.79 | 53.41 | 0.00 | 1.18 | 6.02 | 0.97 | 14.53 |
| **2.A - Mineral Industry** | 318.60 | NO | NO | NO | NO | NO | 1.04 | 0.00 | 0.18 | 3.92 |
| 2.A.1 - Cement production | 299.63 | | | | | | 1.04 | NE | 0.18 | 3.92 |
| 2.A.2 - Lime production | 5.54 | | | | | | NO | NO | NO | NO |
| 2.A.3 - Glass Production | 0.03 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.A.4 - Other Process Uses of Carbonates | 13.40 | | | | | | NO | NO | NO | NO |
| 2.A.5 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **2.B - Chemical Industry** | 0.01 | NO | NO | NO | NO | NO | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.1 - Ammonia Production | NO | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.2 - Nitric Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.3 - Adipic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.5 - Carbide Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.6 - Titanium Dioxide Production | NO | | | | | | NO | NO | NO | NO |
| 2.B.7 - Soda Ash Production | 0.01 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.8 - Petrochemical and Carbon Black Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.9 - Fluorochemical Production | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.B.10 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.C - Metal Industry** | 382.23 | 0.06 | NO | 0.00 | 53.41 | 0.00 | 0.12 | 5.90 | 0.05 | 0.08 |
| 2.C.1 - Iron and Steel Production | 53.09 | 0.00 | | | | | 0.12 | 5.90 | 0.05 | 0.08 |
| 2.C.2 - Ferroalloys Production | 231.12 | 0.06 | | | | | NO | NO | NO | NO |
| 2.C.3 - Aluminium production | 6.07 | | | | 53.41 | | NO | NO | NO | NO |
| 2.C.4 - Magnesium production | 0.00 | | | | | 0.00 | NO | NO | NO | NO |
| 2.C.5 - Lead Production | 7.08 | | | | | | NO | NO | NO | NO |
| 2.C.6 - Zinc Production | 84.88 | | | | | | NO | NO | NO | NO |
| 2.C.7 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.D - Non-Energy Products from Fuels and Solvent Use** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.D.1 - Lubricant Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.2 - Paraffin Wax Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.3 - Solvent Use | | | | | | | NO | NO | NO | NO |
| 2.D.4 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **2.E - Electronics Industry** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.E.1 - Integrated Circuit or Semiconductor | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.E.2 - TFT Flat Panel Display | | | | | NO | NO | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.E.3 - Photovoltaics | | | | | NO | | NO | NO | NO | NO |
| 2.E.4 - Heat Transfer Fluid | | | | | NO | | NO | NO | NO | NO |
| 2.E.5 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.F - Product Uses as Substitutes for Ozone Depleting Substances** | NO | NO | NO | 89.79 | NO, NE | NO | NO | NO | NO | NO |
| 2.F.1 - Refrigeration and Air Conditioning | | | | 89.79 | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.F.2 - Foam Blowing Agents | | | | NO | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.F.3 - Fire Protection | | | | NO | NE | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.F.4 - Aerosols | | | | NO | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.F.5 - Solvents | | | | NO | NE | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.F.6 - Other Applications (please specify) | | | | NO | NE | | 0.00 | 0.00 | 0.00 | 0.00 |
| **2.G - Other Product Manufacture and Use** | NO | NO | NO | NO | NO | NO, NE | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.G.1 - Electrical Equipment | | | | | NO | NE | NO | NO | NO | NO |
| 2.G.2 - SF6 and PFCs from Other Product Uses | | | | | NO | NE | NO | NO | NO | NO |
| 2.G.3 - N2O from Product Uses | | | NO | | | | NO | NO | NO | NO |
| 2.G.4 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.H - Other** | NO | NO | NO | NO | NO | NO | 0.02 | 0.12 | 0.74 | 10.53 |
| 2.H.1 - Pulp and Paper Industry | NO | NO | | | | | 0.02 | 0.12 | 0.04 | 0.04 |
| 2.H.2 - Food and Beverages Industry | NO | NO | | | | | NE | NE | 0.70 | 10.49 |
| 2.H.3 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **3 - Agriculture, Forestry, and Other Land Use** | -3,752.98 | 35.01 | 1.07 | 0.00 | 0.00 | 0.00 | 0.62 | 3.21 | 5.12 | 0.02 |
| **3.A - Livestock** | 0.00 | 34.31 | 0.13 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 4.79 | 0.00 |
| 3.A.1 - Enteric Fermentation | | 28.82 | | | | | NO | NO | NO | NO |
| 3.A.2 - Manure Management | | 5.49 | 0.13 | | | | 0.09 | NO | 4.79 | NO |
| **3.B - Land** | -3,741.63 | NO | NE | NO | NO | NO | NO | NO | NO | NO |
| 3.B.1 - Forest land | -4,647.55 | | | | | | NO | NO | NO | NO |
| 3.B.2 - Cropland | 466.66 | | | | | | NO | NO | NO | NO |
| 3.B.3 - Grassland | 344.13 | | | | | | NO | NO | NO | NO |
| 3.B.4 - Wetlands | 0.00 | | 0.00 | | | | NO | NO | NO | NO |
| 3.B.5 - Settlements | 90.05 | | | | | | NO | NO | NO | NO |
| 3.B.6 - Other Land | 5.08 | | | | | | NO | NO | NO | NO |
| **3.C - Aggregate sources and non-CO2 emissions sources on land** | 4.90 | 0.71 | 0.94 | 0.00 | 0.00 | 0.00 | 0.53 | 3.21 | 0.33 | 0.02 |
| 3.C.1 - Emissions from biomass burning | | NO | NO | | | | 0.11 | 3.21 | 0.32 | 0.02 |
| 3.C.2 - Liming | NO | | | | | | NO | NO | NO | NO |
| 3.C.3 - Urea application | 4.90 | | | | | | NO | NO | NO | NO |
| 3.C.4 - Direct N2O Emissions from managed soils | | | 0.62 | | | | 0.42 | NO | 0.01 | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.C.5 - Indirect N2O Emissions from managed soils | | | 0.23 | | | | NO | NO | NO | NO |
| 3.C.6 - Indirect N2O Emissions from manure management | | | 0.09 | | | | NO | NO | NO | NO |
| 3.C.7 - Rice cultivations | | 0.71 | | | | | NO | NO | NO | NO |
| 3.C.8 - Other (please specify) | | NO | NO | | | | NO | NO | NO | NO |
| **3.D - Other** | -16.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.D.1 - Harvested Wood Products | -16.25 | | | | | | NO | NO | NO | NO |
| 3.D.2 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **4 - Waste** | 4.55 | 71.86 | 0.12 | 0.00 | 0.00 | 0.00 | 0.19 | 3.24 | 0.07 | 0.01 |
| **4.A - Solid Waste Disposal** | 0.00 | 68.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.B - Biological Treatment of Solid Waste** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.C - Incineration and Open Burning of Waste** | 4.55 | 0.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 3.24 | 0.07 | 0.01 |
| **4.D - Wastewater Treatment and Discharge** | 0.00 | 3.47 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.E - Other (please specify)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5 - Other** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5.B - Other (please specify)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| | | | | | | | | | | |
| **Memo Items (5)** | | | | | | | | | | |
| **International Bunkers** | 38.59 | 0.00 | 0.00 | NO | NO | NO | NO | NO | NO | NO |
| 1.A.3.a.i - International Aviation (International Bunkers) | 38.59 | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| 1.A.3.d.i - International water-borne navigation (International bunkers) | NO | NO | NO | | | | NO | NO | NO | NO |

**$CO_2$ net emissions (emission minus removals)*

***Table 92. GHG Inventory table for 2008***

| | Emissions (Gg) | | | Emissions CO2 Equivalents (Gg) | | | Emissions (Gg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Categories | Net $CO_2$* | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | NOx | CO | NMVOCs | $SO_2$ |
| **Total National Emissions and Removals** | 10,832.41 | 125.73 | 1.56 | 390.06 | 0.21 | 0.00 | 25.35 | 64.85 | 17.68 | 116.27 |
| **1 - Energy** | 8,729.22 | 11.31 | 0.19 | NO | NO | NO | 22.40 | 32.13 | 11.28 | 106.43 |
| **1.A - Fuel Combustion Activities** | 8,729.22 | 2.70 | 0.19 | NO | NO | NO | 22.40 | 32.13 | 4.87 | 106.43 |
| 1.A.1 - Energy Industries | 6,064.61 | 0.08 | 0.09 | | | | 15.61 | 0.70 | 0.10 | 102.49 |
| 1.A.2 - Manufacturing Industries and Construction | 1,048.65 | 0.06 | 0.01 | | | | 4.92 | 3.87 | 0.56 | 3.54 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.3 - Transport | 1,210.59 | 0.34 | 0.06 | | | | 0.20 | 0.39 | 0.02 | 0.00 |
| 1.A.4 - Other Sectors | 182.71 | 2.04 | 0.03 | | | | 0.80 | 26.74 | 4.00 | 0.27 |
| 1.A.5 - Non-Specified | 222.67 | 0.18 | 0.00 | | | | 0.88 | 0.42 | 0.18 | 0.12 |
| **1.B - Fugitive emissions from fuels** | 0.00 | 8.61 | NA | NO | NO | NO | 0.00 | 0.00 | 6.41 | 0.00 |
| 1.B.1 - Solid Fuels | 0.00 | 8.59 | NA | | | | NO | NO | 6.41 | NO |
| 1.B.2 - Oil and Natural Gas | 0.00 | 0.03 | NA | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.B.3 - Other emissions from Energy Production | NO | NO | NA | | | | NO | NO | NO | NO |
| **1.C - Carbon dioxide Transport and Storage** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1.C.1 - Transport of CO2 | NO | | | | | | NO | NO | NO | NO |
| 1.C.2 - Injection and Storage | NO | | | | | | NO | NO | NO | NO |
| 1.C.3 - Other | NO | | | | | | NO | NO | NO | NO |
| **2 - Industrial Processes and Product Use** | 739.51 | 0.11 | 0.00 | 390.06 | 0.21 | 0.00 | 1.37 | 5.30 | 0.62 | 9.47 |
| **2.A - Mineral Industry** | 369.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.24 | 0.00 | 0.21 | 4.67 |
| 2.A.1 - Cement production | 357.29 | | | | | | 1.24 | NE | 0.21 | 4.67 |
| 2.A.2 - Lime production | 0.01 | | | | | | NO | NO | NO | NO |
| 2.A.3 - Glass Production | 0.02 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.A.4 - Other Process Uses of Carbonates | 12.03 | | | | | | NO | NO | NO | NO |
| 2.A.5 - Other (please specify) | 0.00 | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| **2.B - Chemical Industry** | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.1 - Ammonia Production | NO | | | | | | NO | NO | NO | NO |
| 2.B.2 - Nitric Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.3 - Adipic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.5 - Carbide Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.6 - Titanium Dioxide Production | NO | | | | | | NO | NO | NO | NO |
| 2.B.7 - Soda Ash Production | 0.01 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.8 - Petrochemical and Carbon Black Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.9 - Fluorochemical Production | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.B.10 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.C - Metal Industry** | 370.16 | 0.11 | 0.00 | 0.00 | 0.21 | 0.00 | 0.10 | 5.14 | 0.05 | 0.07 |
| 2.C.1 - Iron and Steel Production | 46.29 | 0.00 | | | | | 0.10 | 5.14 | 0.05 | 0.07 |
| 2.C.2 - Ferroalloys Production | 323.85 | 0.11 | | | | | NO | NO | NO | NO |
| 2.C.3 - Aluminium production | 0.02 | | | | 0.21 | | NO | NO | NO | NO |
| 2.C.4 - Magnesium production | NO | | | | | NO | NO | NO | NO | NO |
| 2.C.5 - Lead Production | NO | | | | | | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.C.6 - Zinc Production | NO | | | | | | NO | NO | NO | NO |
| 2.C.7 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.D - Non-Energy Products from Fuels and Solvent Use** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.D.1 - Lubricant Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.2 - Paraffin Wax Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.3 - Solvent Use | | | | | | | NO | NO | NO | NO |
| 2.D.4 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **2.E - Electronics Industry** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.E.1 - Integrated Circuit or Semiconductor | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.E.2 - TFT Flat Panel Display | | | | | NO | NO | NO | NO | NO | NO |
| 2.E.3 - Photovoltaics | | | | | NO | | NO | NO | NO | NO |
| 2.E.4 - Heat Transfer Fluid | | | | | NO | | NO | NO | NO | NO |
| 2.E.5 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.F - Product Uses as Substitutes for Ozone Depleting Substances** | NO | NO | NO | 390.06 | NO, NE | NO | NO | NO | NO | NO |
| 2.F.1 - Refrigeration and Air Conditioning | | | | 390.06 | | | NO | NO | NO | NO |
| 2.F.2 - Foam Blowing Agents | | | | NO | | | NO | NO | NO | NO |
| 2.F.3 - Fire Protection | | | | NO | NE | | NO | NO | NO | NO |
| 2.F.4 - Aerosols | | | | NO | | | NO | NO | NO | NO |
| 2.F.5 - Solvents | | | | NO | NO | | NO | NO | NO | NO |
| 2.F.6 - Other Applications (please specify) | | | | NO | NO | | NO | NO | NO | NO |
| **2.G - Other Product Manufacture and Use** | NO | NO | NO | NO | NO | NO, NE | NO | NO | NO | NO |
| 2.G.1 - Electrical Equipment | | | | | NO | NO | NO | NO | NO | NO |
| 2.G.2 - SF6 and PFCs from Other Product Uses | | | | | NO | NE | NO | NO | NO | NO |
| 2.G.3 - N2O from Product Uses | | | NO | | | | NO | NO | NO | NO |
| 2.G.4 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.H - Other** | NO | NO | NO | NO | NO | NO | 0.03 | 0.15 | 0.37 | 4.73 |
| 2.H.1 - Pulp and Paper Industry | NO | NO | | | | | 0.03 | 0.15 | 0.06 | 0.06 |
| 2.H.2 - Food and Beverages Industry | NO | NO | | | | | NE | NE | 0.31 | 4.68 |
| 2.H.3 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **3 - Agriculture, Forestry, and Other Land Use** | 1,355.51 | 32.53 | 1.24 | NO | NO | NO | 1.25 | 22.24 | 6.73 | 0.15 |
| **3.A - Livestock** | NO | 31.93 | 0.14 | NO | NO | NO | 0.09 | 0.00 | 4.50 | 0.00 |
| 3.A.1 - Enteric Fermentation | | 26.30 | | | | | NO | NO | NO | NO |
| 3.A.2 - Manure Management | | 5.63 | 0.14 | | | | 0.09 | 0.00 | 4.50 | 0.00 |
| **3.B - Land** | 1,376.50 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3.B.1 - Forest land | 864.96 | | | | | | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.B.2 - Cropland | 219.70 | | | | | | NO | NO | NO | NO |
| 3.B.3 - Grassland | 237.26 | | | | | | NO | NO | NO | NO |
| 3.B.4 - Wetlands | 0.00 | | 0.00 | | | | NO | NO | NO | NO |
| 3.B.5 - Settlements | 45.55 | | | | | | NO | NO | NO | NO |
| 3.B.6 - Other Land | 9.03 | | | | | | NO | NO | NO | NO |
| **3.C - Aggregate sources and non-CO2 emissions sources on land** | 4.48 | 0.60 | 1.10 | 0.00 | 0.00 | 0.00 | 1.17 | 22.24 | 2.24 | 0.15 |
| 3.C.1 - Emissions from biomass burning | | NO | NO | | | | 0.74 | 22.24 | 2.22 | 0.15 |
| 3.C.2 - Liming | NO | | | | | | NO | NO | NO | NO |
| 3.C.3 - Urea application | 4.48 | | | | | | NO | NO | NO | NO |
| 3.C.4 - Direct N2O Emissions from managed soils | | | 0.73 | | | | 0.42 | NO | 0.01 | NO |
| 3.C.5 - Indirect N2O Emissions from managed soils | | | 0.27 | | | | NO | NO | NO | NO |
| 3.C.6 - Indirect N2O Emissions from manure management | | | 0.10 | | | | NO | NO | NO | NO |
| 3.C.7 - Rice cultivations | | 0.60 | | | | | NO | NO | NO | NO |
| 3.C.8 - Other (please specify) | | NO | NO | | | | NO | NO | NO | NO |
| **3.D - Other** | -25.47 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.D.1 - Harvested Wood Products | -25.47 | | | | | | NO | NO | NO | NO |
| 3.D.2 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **4 - Waste** | 8.18 | 81.78 | 0.13 | 0.00 | 0.00 | 0.00 | 0.33 | 5.82 | 0.13 | 0.01 |
| **4.A - Solid Waste Disposal** | 0.00 | 78.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.B - Biological Treatment of Solid Waste** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.C - Incineration and Open Burning of Waste** | 8.18 | 0.68 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 5.82 | 0.13 | 0.01 |
| **4.D - Wastewater Treatment and Discharge** | 0.00 | 2.40 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.E - Other (please specify)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5 - Other** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5.B - Other (please specify)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| | | | | | | | | | | |
| **Memo Items (5)** | | | | | | | | | | |
| **International Bunkers** | 18.86 | 0.00 | 0.00 | NO | NO | NO | NO | NO | NO | NO |
| 1.A.3.a.i - International Aviation (International Bunkers) | 18.86 | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| 1.A.3.d.i - International water-borne navigation (International bunkers) | NO | NO | NO | | | | NO | NO | NO | NO |

**$CO_2$ net emissions (emission minus removals)*

***Table 93. GHG Inventory table for 2012***

| | Emissions (Gg) | | | Emissions CO2 Equivalents (Gg) | | | Emissions (Gg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Categories | Net $CO_2$* | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | NOx | CO | NMVOCs | $SO_2$ |
| **Total National Emissions and Removals** | 11,766.20 | 142.38 | 1.45 | 96.69 | 6.00 | 0.00 | 24.92 | 64.85 | 17.68 | 116.27 |
| **1 - Energy** | 9,162.82 | 10.77 | 0.20 | NO | NO | NO | 21.21 | 37.79 | 11.53 | 95.05 |
| **1.A - Fuel Combustion Activities** | 9,162.82 | 2.92 | 0.20 | NO | NO | NO | 21.21 | 37.79 | 5.68 | 95.05 |
| 1.A.1 - Energy Industries | 6,039.58 | 0.06 | 0.08 | | | | 13.60 | 0.64 | 0.09 | 88.92 |
| 1.A.2 - Manufacturing Industries and Construction | 1,367.07 | 0.10 | 0.02 | | | | 5.64 | 6.34 | 0.86 | 5.80 |
| 1.A.3 - Transport | 1,374.81 | 0.30 | 0.07 | | | | 0.16 | 0.09 | 0.02 | 0.00 |
| 1.A.4 - Other Sectors | 130.11 | 2.29 | 0.03 | | | | 0.83 | 30.30 | 4.54 | 0.21 |
| 1.A.5 - Non-Specified | 251.26 | 0.17 | 0.00 | | | | 0.98 | 0.41 | 0.17 | 0.13 |
| **1.B - Fugitive emissions from fuels** | 0.00 | 7.84 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.85 | 0.00 |
| 1.B.1 - Solid Fuels | 0.00 | 7.84 | 0.00 | | | | NO | NO | 5.85 | NO |
| 1.B.2 - Oil and Natural Gas | 0.00 | 0.01 | 0.00 | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.B.3 - Other emissions from Energy Production | NO | NO | NO | | | | NO | NO | NO | NO |
| **1.C - Carbon dioxide Transport and Storage** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1.C.1 - Transport of CO2 | NO | | | | | | NO | NO | NO | NO |
| 1.C.2 - Injection and Storage | NO | | | | | | NO | NO | NO | NO |
| 1.C.3 - Other | NO | | | | | | NO | NO | NO | NO |
| **2 - Industrial Processes and Product Use** | 671.96 | 0.08 | 0.00 | 96.69 | 6.00 | 0.00 | 1.09 | 7.54 | 0.65 | 9.55 |
| **2.A - Mineral Industry** | 283.02 | NO | NO | NO | NO | NO | 0.92 | 0.00 | 0.16 | 3.48 |
| 2.A.1 - Cement production | 266.59 | | | | | | 0.92 | NE | 0.16 | 3.48 |
| 2.A.2 - Lime production | NO | | | | | | NO | NO | NO | NO |
| 2.A.3 - Glass Production | 0.01 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.A.4 - Other Process Uses of Carbonates | 16.42 | | | | | | NO | NO | NO | NO |
| 2.A.5 - Other (please specify) | 0.00 | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| **2.B - Chemical Industry** | 0.01 | NO | NO | NO | NO | NO | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.1 - Ammonia Production | NO | | | | | | NO | NO | NO | NO |
| 2.B.2 - Nitric Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.3 - Adipic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production | | | NO | | | | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.B.5 - Carbide Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.6 - Titanium Dioxide Production | NO | | | | | | NO | NO | NO | NO |
| 2.B.7 - Soda Ash Production | 0.01 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.8 - Petrochemical and Carbon Black Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.9 - Fluorochemical Production | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.B.10 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.C - Metal Industry** | 388.93 | 0.08 | 0.00 | 0.00 | 6.00 | 0.00 | 0.15 | 7.45 | 0.07 | 0.10 |
| 2.C.1 - Iron and Steel Production | 67.03 | 0.00 | | | | | 0.15 | 7.45 | 0.07 | 0.10 |
| 2.C.2 - Ferroalloys Production | 321.23 | 0.08 | | | | | NO | NO | NO | NO |
| 2.C.3 - Aluminium production | 0.68 | | | | 6.00 | | NO | NO | NO | NO |
| 2.C.4 - Magnesium production | NO | | | | | NO | NO | NO | NO | NO |
| 2.C.5 - Lead Production | NO | | | | | | NO | NO | NO | NO |
| 2.C.6 - Zinc Production | NO | | | | | | NO | NO | NO | NO |
| 2.C.7 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.D - Non-Energy Products from Fuels and Solvent Use** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.D.1 - Lubricant Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.2 - Paraffin Wax Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.3 - Solvent Use | | | | | | | NO | NO | NO | NO |
| 2.D.4 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **2.E - Electronics Industry** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.E.1 - Integrated Circuit or Semiconductor | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.E.2 - TFT Flat Panel Display | | | | | NO | NO | NO | NO | NO | NO |
| 2.E.3 - Photovoltaics | | | | | NO | | NO | NO | NO | NO |
| 2.E.4 - Heat Transfer Fluid | | | | | NO | | NO | NO | NO | NO |
| 2.E.5 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.F - Product Uses as Substitutes for Ozone Depleting Substances** | NO | NO | NO | 96.69 | NO, NE | NO | NO | NO | NO | NO |
| 2.F.1 - Refrigeration and Air Conditioning | | | | 96.69 | | | NO | NO | NO | NO |
| 2.F.2 - Foam Blowing Agents | | | | NO | | | NO | NO | NO | NO |
| 2.F.3 - Fire Protection | | | | NO | NE | | NO | NO | NO | NO |
| 2.F.4 - Aerosols | | | | NO | | | NO | NO | NO | NO |
| 2.F.5 - Solvents | | | | NO | NO | | NO | NO | NO | NO |
| 2.F.6 - Other Applications (please specify) | | | | NO | NO | | NO | NO | NO | NO |
| **2.G - Other Product Manufacture and Use** | NO | NO | NO | NO | NO | NO, NE | NO | NO | NO | NO |
| 2.G.1 - Electrical Equipment | | | | | NO | NO | NO | NO | NO | NO |
| 2.G.2 - SF6 and PFCs from Other Product Uses | | | | | NO | NE | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.G.3 - N2O from Product Uses | | | NO | | | | NO | NO | NO | NO |
| 2.G.4 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.H - Other** | NO | NO | NO | NO | NO | NO | 0.02 | 0.09 | 0.43 | 5.97 |
| 2.H.1 - Pulp and Paper Industry | NO | NO | | | | | 0.02 | 0.09 | 0.03 | 0.03 |
| 2.H.2 - Food and Beverages Industry | NO | NO | | | | | NE | NE | 0.40 | 5.93 |
| 2.H.3 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **3 - Agriculture, Forestry, and Other Land Use** | 1,920.50 | 32.09 | 1.10 | 0.00 | 0.00 | 0.00 | 2.17 | 50.15 | 9.40 | 0.33 |
| **3.A - Livestock** | NO | 31.01 | 0.13 | NO | NO | NO | 0.08 | 0.00 | 4.38 | 0.00 |
| 3.A.1 - Enteric Fermentation | | 25.72 | | | | | NO | NO | NO | NO |
| 3.A.2 - Manure Management | | 5.29 | 0.13 | | | | 0.08 | 0.00 | 4.38 | 0.00 |
| **3.B - Land** | 1,936.38 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3.B.1 - Forest land | 1,664.96 | | | | | | NO | NO | NO | NO |
| 3.B.2 - Cropland | 114.93 | | | | | | NO | NO | NO | NO |
| 3.B.3 - Grassland | 125.85 | | | | | | NO | NO | NO | NO |
| 3.B.4 - Wetlands | 0.00 | | 0.00 | | | | NO | NO | NO | NO |
| 3.B.5 - Settlements | 24.16 | | | | | | NO | NO | NO | NO |
| 3.B.6 - Other Land | 6.48 | | | | | | NO | NO | NO | NO |
| **3.C - Aggregate sources and non-CO2 emissions sources on land** | 5.75 | 1.09 | 0.96 | 0.00 | 0.00 | 0.00 | 2.10 | 50.15 | 5.02 | 0.33 |
| 3.C.1 - Emissions from biomass burning | | NO | NO | | | | 1.67 | 50.15 | 5.01 | 0.33 |
| 3.C.2 - Liming | NO | | | | | | NO | NO | NO | NO |
| 3.C.3 - Urea application | 5.75 | | | | | | NO | NO | NO | NO |
| 3.C.4 - Direct N2O Emissions from managed soils | | | 0.64 | | | | 0.42 | NO | 0.01 | NO |
| 3.C.5 - Indirect N2O Emissions from managed soils | | | 0.23 | | | | NO | NO | NO | NO |
| 3.C.6 - Indirect N2O Emissions from manure management | | | 0.09 | | | | NO | NO | NO | NO |
| 3.C.7 - Rice cultivations | | 1.09 | | | | | NO | NO | NO | NO |
| 3.C.8 - Other (please specify) | | NO | NO | | | | NO | NO | NO | NO |
| **3.D - Other** | -21.63 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3.D.1 - Harvested Wood Products | -21.63 | | | | | | NO | NO | NO | NO |
| 3.D.2 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **4 - Waste** | 10.92 | 99.43 | 0.15 | 0.00 | 0.00 | 0.00 | 0.44 | 7.78 | 0.17 | 0.02 |
| **4.A - Solid Waste Disposal** | 0.00 | 96.36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.B - Biological Treatment of Solid Waste** | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.C - Incineration and Open Burning of Waste** | 10.92 | 0.91 | 0.02 | 0.00 | 0.00 | 0.00 | 0.44 | 7.78 | 0.17 | 0.02 |
| **4.D - Wastewater Treatment and Discharge** | 0.00 | 2.15 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.E - Other (please specify)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 - Other | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 5.B - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| | | | | | | | | | | |
| Memo Items (5) | | | | | | | | | | |
| International Bunkers | 25.46 | 0.00 | 0.00 | NO | NO | NO | NO | NO | NO | NO |
| 1.A.3.a.i - International Aviation (International Bunkers) | 25.46 | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| 1.A.3.d.i - International water-borne navigation (International bunkers) | NO | NO | NO | | | | NO | NO | NO | NO |

**$CO_2$ net emissions (emission minus removals)*

***Table 94. GHG Inventory table for 2013***

| | Emissions (Gg) | | | Emissions CO2 Equivalents (Gg) | | | Emissions (Gg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Categories | Net $CO_2$* | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | NOx | CO | NMVOCs | $SO_2$ |
| Total National Emissions and Removals | 7,097.03 | 143.71 | 1.42 | 165.24 | 1.42 | 0.00 | 20.77 | 64.85 | 17.68 | 116.27 |
| 1 - Energy | 8,162.67 | 9.52 | 0.18 | NO | NO | NO | 18.15 | 29.75 | 9.82 | 79.24 |
| 1.A - Fuel Combustion Activities | 8,162.67 | 2.35 | 0.18 | NO | NO | NO | 18.15 | 29.75 | 4.47 | 79.24 |
| 1.A.1 - Energy Industries | 5,074.61 | 0.05 | 0.07 | | | | 11.39 | 0.57 | 0.08 | 74.04 |
| 1.A.2 - Manufacturing Industries and Construction | 1,271.79 | 0.09 | 0.01 | | | | 5.27 | 5.44 | 0.78 | 4.91 |
| 1.A.3 - Transport | 1,544.49 | 0.32 | 0.08 | | | | 0.13 | 0.17 | 0.01 | 0.00 |
| 1.A.4 - Other Sectors | 83.45 | 1.78 | 0.02 | | | | 0.65 | 23.30 | 3.50 | 0.18 |
| 1.A.5 - Non-Specified | 188.34 | 0.10 | 0.00 | | | | 0.70 | 0.27 | 0.10 | 0.11 |
| 1.B - Fugitive emissions from fuels | 0.00 | 7.17 | 0.00 | NO | NO | NO | 0.00 | 0.00 | 5.35 | 0.00 |
| 1.B.1 - Solid Fuels | 0.00 | 7.17 | 0.00 | | | | NO | NO | 5.35 | NO |
| 1.B.2 - Oil and Natural Gas | 0.00 | 0.00 | 0.00 | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.B.3 - Other emissions from Energy Production | 0.00 | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| 1.C - Carbon dioxide Transport and Storage | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1.C.1 - Transport of CO2 | NO | | | | | | NO | NO | NO | NO |
| 1.C.2 - Injection and Storage | NO | | | | | | NO | NO | NO | NO |
| 1.C.3 - Other | NO | | | | | | NO | NO | NO | NO |
| 2 - Industrial Processes and Product Use | 754.45 | 0.09 | 0.00 | 165.24 | 1.42 | 0.00 | 1.15 | 7.85 | 0.70 | 10.43 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.A - Mineral Industry** | 301.94 | NO | NO | NO | NO | NO | 0.99 | 0.00 | 0.17 | 3.72 |
| 2.A.1 - Cement production | 284.88 | | | | | | 0.99 | NE | 0.17 | 3.72 |
| 2.A.2 - Lime production | NO | | | | | | NO | NO | NO | NO |
| 2.A.3 - Glass Production | 0.01 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.A.4 - Other Process Uses of Carbonates | 17.06 | | | | | | NO | NO | NO | NO |
| 2.A.5 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **2.B - Chemical Industry** | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.1 - Ammonia Production | NO | | | | | | NO | NO | NO | NO |
| 2.B.2 - Nitric Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.3 - Adipic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.5 - Carbide Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.6 - Titanium Dioxide Production | NO | | | | | | NO | NO | NO | NO |
| 2.B.7 - Soda Ash Production | 0.01 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.8 - Petrochemical and Carbon Black Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.9 - Fluorochemical Production | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.B.10 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.C - Metal Industry** | 452.50 | 0.09 | 0.00 | 0.00 | 1.42 | 0.00 | 0.16 | 7.78 | 0.07 | 0.10 |
| 2.C.1 - Iron and Steel Production | 70.02 | 0.00 | | | | | 0.16 | 7.78 | 0.07 | 0.10 |
| 2.C.2 - Ferroalloys Production | 382.32 | 0.09 | | | | | NO | NO | NO | NO |
| 2.C.3 - Aluminium production | 0.16 | | | | 1.42 | | NO | NO | NO | NO |
| 2.C.4 - Magnesium production | NO | | | | | NO | NO | NO | NO | NO |
| 2.C.5 - Lead Production | NO | | | | | | NO | NO | NO | NO |
| 2.C.6 - Zinc Production | NO | | | | | | NO | NO | NO | NO |
| 2.C.7 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.D - Non-Energy Products from Fuels and Solvent Use** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.D.1 - Lubricant Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.2 - Paraffin Wax Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.3 - Solvent Use | | | | | | | NO | NO | NO | NO |
| 2.D.4 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **2.E - Electronics Industry** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.E.1 - Integrated Circuit or Semiconductor | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.E.2 - TFT Flat Panel Display | | | | | NO | NO | NO | NO | NO | NO |
| 2.E.3 - Photovoltaics | | | | | NO | | NO | NO | NO | NO |
| 2.E.4 - Heat Transfer Fluid | | | | | NO | | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.E.5 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.F - Product Uses as Substitutes for Ozone Depleting Substances** | NO | NO | NO | 165.24 | NO | NO | NO | NO | NO | NO |
| 2.F.1 - Refrigeration and Air Conditioning | | | | 165.24 | | | NO | NO | NO | NO |
| 2.F.2 - Foam Blowing Agents | | | | NO | | | NO | NO | NO | NO |
| 2.F.3 - Fire Protection | | | | NO | NO | | NO | NO | NO | NO |
| 2.F.4 - Aerosols | | | | NO | | | NO | NO | NO | NO |
| 2.F.5 - Solvents | | | | NO | NO | | NO | NO | NO | NO |
| 2.F.6 - Other Applications (please specify) | | | | NO | NO | | NO | NO | NO | NO |
| **2.G - Other Product Manufacture and Use** | NO | NO | NO | NO | NO | NO, NE | NO | NO | NO | NO |
| 2.G.1 - Electrical Equipment | | | | | NO | NO | NO | NO | NO | NO |
| 2.G.2 - SF6 and PFCs from Other Product Uses | | | | | NO | NE | NO | NO | NO | NO |
| 2.G.3 - N2O from Product Uses | | | NO | | | | NO | NO | NO | NO |
| 2.G.4 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.H - Other** | NO | NO | NO | NO | NO | NO | 0.01 | 0.07 | 0.46 | 6.61 |
| 2.H.1 - Pulp and Paper Industry | NO | NO | | | | | 0.01 | 0.07 | 0.02 | 0.02 |
| 2.H.2 - Food and Beverages Industry | NO | NO | | | | | NE | NE | 0.44 | 6.58 |
| 2.H.3 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **3 - Agriculture, Forestry, and Other Land Use** | -1,831.26 | 30.92 | 1.08 | 0.00 | 0.00 | 0.00 | 1.01 | 15.21 | 5.73 | 0.10 |
| **3.A - Livestock** | 0.00 | 29.83 | 0.13 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 4.20 | 0.00 |
| 3.A.1 - Enteric Fermentation | | 24.73 | | | | | NO | NO | NO | NO |
| 3.A.2 - Manure Management | | 5.10 | 0.13 | | | | 0.07 | 0.00 | 4.20 | 0.00 |
| **3.B - Land** | -1,814.80 | 0.00 | 0.00 | NO | NO | NO | NO | NO | NO | NO |
| 3.B.1 - Forest land | -2,097.01 | | | | | | NO | NO | NO | NO |
| 3.B.2 - Cropland | 120.65 | | | | | | NO | NO | NO | NO |
| 3.B.3 - Grassland | 129.98 | | | | | | NO | NO | NO | NO |
| 3.B.4 - Wetlands | 0.00 | | 0.00 | | | | NO | NO | NO | NO |
| 3.B.5 - Settlements | 24.95 | | | | | | NO | NO | NO | NO |
| 3.B.6 - Other Land | 6.63 | | | | | | NO | NO | NO | NO |
| **3.C - Aggregate sources and non-CO2 emissions sources on land** | 5.75 | 1.09 | 0.95 | 0.00 | 0.00 | 0.00 | 0.93 | 15.21 | 1.53 | 0.10 |
| 3.C.1 - Emissions from biomass burning | | NO | NO | | | | 0.51 | 15.21 | 1.52 | 0.10 |
| 3.C.2 - Liming | NO | | | | | | NO | NO | NO | NO |
| 3.C.3 - Urea application | 5.75 | | | | | | NO | NO | NO | NO |
| 3.C.4 - Direct N2O Emissions from managed soils | | | 0.63 | | | | 0.42 | NO | 0.01 | NO |
| 3.C.5 - Indirect N2O Emissions from managed soils | | | 0.23 | | | | NO | NO | NO | NO |
| 3.C.6 - Indirect N2O Emissions from manure management | | | 0.09 | | | | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.C.7 - Rice cultivations | | 1.09 | | | | | NO | NO | NO | NO |
| 3.C.8 - Other (please specify) | | NO | NO | | | | NO | NO | NO | NO |
| 3.D - Other | -22.21 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3.D.1 - Harvested Wood Products | -22.21 | | | | | | NO | NO | NO | NO |
| 3.D.2 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| 4 - Waste | 11.17 | 103.19 | 0.15 | 0.00 | 0.00 | 0.00 | 0.45 | 7.96 | 0.18 | 0.02 |
| 4.A - Solid Waste Disposal | 0.00 | 100.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4.B - Biological Treatment of Solid Waste | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4.C - Incineration and Open Burning of Waste | 11.17 | 0.93 | 0.02 | 0.00 | 0.00 | 0.00 | 0.45 | 7.96 | 0.18 | 0.02 |
| 4.D - Wastewater Treatment and Discharge | 0.00 | 2.17 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4.E - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 5 - Other | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3 | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 5.B - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| | | | | | | | | | | |
| Memo Items (5) | | | | | | | | | | |
| International Bunkers | 31.48 | 0.00 | 0.00 | NO | NO | NO | NO | NO | NO | NO |
| 1.A.3.a.i - International Aviation (International Bunkers) | 31.48 | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| 1.A.3.d.i - International water-borne navigation (International bunkers) | NO | NO | NO | | | | NO | NO | NO | NO |

**$CO_2$ net emissions (emission minus removals),*

***Table 95. GHG Inventory table for 2014***

| | Emissions (Gg) | | | Emissions CO2 Equivalents (Gg) | | | Emissions (Gg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Categories | Net $CO_2$* | $CH_4$ | $N_2O$ | HFCs | PFCs | $SF_6$ | NOx | CO | NMVOCs | $SO_2$ |
| Total National Emissions and Removals | 5,272.73 | 148.84 | 1.42 | 183.47 | 0.00 | 0.00 | 18.90 | 64.85 | 17.68 | 116.27 |
| 1 - Energy | 7,702.36 | 9.45 | 0.18 | NO | NO | NO | 16.81 | 30.90 | 9.94 | 73.71 |
| 1.A - Fuel Combustion Activities | 7,702.36 | 2.50 | 0.18 | NO | NO | NO | 16.81 | 30.90 | 4.75 | 73.71 |
| 1.A.1 - Energy Industries | 4,726.38 | 0.05 | 0.06 | | | | 10.63 | 0.51 | 0.07 | 69.50 |
| 1.A.2 - Manufacturing Industries and Construction | 1,120.56 | 0.08 | 0.01 | | | | 4.71 | 4.55 | 0.72 | 3.99 |
| 1.A.3 - Transport | 1,600.55 | 0.32 | 0.08 | | | | 0.14 | 0.10 | 0.01 | 0.00 |
| 1.A.4 - Other Sectors | 82.24 | 1.94 | 0.03 | | | | 0.69 | 25.49 | 3.83 | 0.16 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.A.5 - Non-Specified | 172.63 | 0.11 | 0.00 | | | | 0.64 | 0.26 | 0.12 | 0.06 |
| **1.B - Fugitive emissions from fuels** | 0.00 | 6.95 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.19 | 0.00 |
| 1.B.1 - Solid Fuels | 0.00 | 6.95 | 0.00 | | | | NO | NO | 5.19 | NO |
| 1.B.2 - Oil and Natural Gas | 0.00 | 0.00 | 0.00 | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.B.3 - Other emissions from Energy Production | NO | NO | NO | | | | NO | NO | NO | NO |
| **1.C - Carbon dioxide Transport and Storage** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 1.C.1 - Transport of CO2 | NO | | | | | | NO | NO | NO | NO |
| 1.C.2 - Injection and Storage | NO | | | | | | NO | NO | NO | NO |
| 1.C.3 - Other | NO | | | | | | NO | NO | NO | NO |
| **2 - Industrial Processes and Product Use** | 736.20 | 0.09 | 0.00 | 183.47 | 0.00 | 0.00 | 1.12 | 8.31 | 0.64 | 8.76 |
| **2.A - Mineral Industry** | 285.61 | NO | NO | NO | NO | NO | 0.93 | 0.00 | 0.16 | 3.50 |
| 2.A.1 - Cement production | 267.90 | | | | | | 0.93 | NE | 0.16 | 3.50 |
| 2.A.2 - Lime production | NO | | | | | | NO | NO | NO | NO |
| 2.A.3 - Glass Production | 0.01 | | | | | | NO | NO | NO | NO |
| 2.A.4 - Other Process Uses of Carbonates | 17.70 | | | | | | NO | NO | NO | NO |
| 2.A.5 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **2.B - Chemical Industry** | 0.01 | NO | NO | NO | NO | NO | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.1 - Ammonia Production | NO | | | | | | NO | NO | NO | NO |
| 2.B.2 - Nitric Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.3 - Adipic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production | | | NO | | | | NO | NO | NO | NO |
| 2.B.5 - Carbide Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.6 - Titanium Dioxide Production | NO | | | | | | NO | NO | NO | NO |
| 2.B.7 - Soda Ash Production | 0.01 | | | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.B.8 - Petrochemical and Carbon Black Production | NO | NO | | | | | NO | NO | NO | NO |
| 2.B.9 - Fluorochemical Production | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.B.10 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.C - Metal Industry** | 450.58 | 0.09 | NO | NO | NO | NO | 0.16 | 8.11 | 0.07 | 0.11 |
| 2.C.1 - Iron and Steel Production | 73.02 | 0.00 | | | | | 0.16 | 8.11 | 0.07 | 0.11 |
| 2.C.2 - Ferroalloys Production | 377.57 | 0.09 | | | | | NO | NO | NO | NO |
| 2.C.3 - Aluminium production | NO | | | | NO | | NO | NO | NO | NO |
| 2.C.4 - Magnesium production | NO | | | | | NO | NO | NO | NO | NO |
| 2.C.5 - Lead Production | NO | | | | | | NO | NO | NO | NO |
| 2.C.6 - Zinc Production | NO | | | | | | NO | NO | NO | NO |
| 2.C.7 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **2.D - Non-Energy Products from Fuels and Solvent Use** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.D.1 - Lubricant Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.2 - Paraffin Wax Use | NO | | | | | | NO | NO | NO | NO |
| 2.D.3 - Solvent Use | | | | | | | NO | NO | NO | NO |
| 2.D.4 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **2.E - Electronics Industry** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 2.E.1 - Integrated Circuit or Semiconductor | | | | NO | NO | NO | NO | NO | NO | NO |
| 2.E.2 - TFT Flat Panel Display | | | | | NO | NO | NO | NO | NO | NO |
| 2.E.3 - Photovoltaics | | | | | NO | | NO | NO | NO | NO |
| 2.E.4 - Heat Transfer Fluid | | | | | NO | | NO | NO | NO | NO |
| 2.E.5 - Other (please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.F - Product Uses as Substitutes for Ozone Depleting Substances** | NO | NO | NO | 183.47 | NO | NO | NO | NO | NO | NO |
| 2.F.1 - Refrigeration and Air Conditioning | | | | 183.47 | | | NO | NO | NO | NO |
| 2.F.2 - Foam Blowing Agents | | | | NO | | | NO | NO | NO | NO |
| 2.F.3 - Fire Protection | | | | NO | NO | | NO | NO | NO | NO |
| 2.F.4 - Aerosols | | | | NO | | | NO | NO | NO | NO |
| 2.F.5 - Solvents | | | | NO | NO | | NO | NO | NO | NO |
| 2.F.6 - Other Applications (please specify) | | | | NO | NO | | NO | NO | NO | NO |
| **2.G - Other Product Manufacture and Use** | NO | NO | NO | NO | NO | NO, NE | NO | NO | NO | NO |
| 2.G.1 - Electrical Equipment | | | | | NO | NO | NO | NO | NO | NO |
| 2.G.2 - SF6 and PFCs from Other Product Uses | | | | | NO | NE | NO | NO | NO | NO |
| 2.G.3 - N2O from Product Uses | | | NO | | | | NO | NO | NO | NO |
| 2.G.4 - Other (Please specify) | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **2.H - Other** | NO | NO | NO | NO | NO | NO | 0.04 | 0.19 | 0.41 | 5.16 |
| 2.H.1 - Pulp and Paper Industry | NO | NO | | | | | 0.04 | 0.19 | 0.07 | 0.07 |
| 2.H.2 - Food and Beverages Industry | NO | NO | | | | | NE | NE | 0.34 | 5.09 |
| 2.H.3 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **3 - Agriculture, Forestry, and Other Land Use** | -3,175.35 | 31.36 | 1.09 | NO | NO | NO | 0.58 | 2.46 | 4.51 | 0.02 |
| **3.A - Livestock** | 0.00 | 30.15 | 0.13 | NO | NO | NO | 0.08 | 0.00 | 4.25 | 0.00 |
| 3.A.1 - Enteric Fermentation | | 25.01 | | | | | NO | NO | NO | NO |
| 3.A.2 - Manure Management | | 5.14 | 0.13 | | | | 0.08 | 0.00 | 4.25 | 0.00 |
| **3.B - Land** | -3,181.09 | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3.B.1 - Forest land | -3,471.18 | | | | | | NO | NO | NO | NO |
| 3.B.2 - Cropland | 123.78 | | | | | | NO | NO | NO | NO |
| 3.B.3 - Grassland | 134.93 | | | | | | NO | NO | NO | NO |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.B.4 - Wetlands | 0.00 | | 0.00 | | | | NO | NO | NO | NO |
| 3.B.5 - Settlements | 25.90 | | | | | | NO | NO | NO | NO |
| 3.B.6 - Other Land | 5.47 | | | | | | NO | NO | NO | NO |
| **3.C - Aggregate sources and non-CO2 emissions sources on land** | 5.75 | 1.21 | 0.96 | 0.00 | 0.00 | 0.00 | 0.51 | 2.46 | 0.25 | 0.02 |
| 3.C.1 - Emissions from biomass burning | | NO | NO | | | | 0.08 | 2.46 | 0.25 | 0.02 |
| 3.C.2 - Liming | NO | | | | | | NO | NO | NO | NO |
| 3.C.3 - Urea application | 5.75 | | | | | | NO | NO | NO | NO |
| 3.C.4 - Direct N2O Emissions from managed soils | | | 0.64 | | | | 0.42 | NO | 0.01 | NO |
| 3.C.5 - Indirect N2O Emissions from managed soils | | | 0.23 | | | | NO | NO | NO | NO |
| 3.C.6 - Indirect N2O Emissions from manure management | | | 0.09 | | | | NO | NO | NO | NO |
| 3.C.7 - Rice cultivations | | 1.21 | | | | | NO | NO | NO | NO |
| 3.C.8 - Other (please specify) | | NO | NO | | | | NO | NO | NO | NO |
| **3.D - Other** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| 3.D.1 - Harvested Wood Products | NO | | | | | | NO | NO | NO | NO |
| 3.D.2 - Other (please specify) | NO | NO | NO | | | | NO | NO | NO | NO |
| **4 - Waste** | 9.52 | 107.93 | 0.15 | 0.00 | 0.00 | 0.00 | 0.39 | 6.78 | 0.15 | 0.01 |
| **4.A - Solid Waste Disposal** | 0.00 | 104.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.B - Biological Treatment of Solid Waste** | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.C - Incineration and Open Burning of Waste** | 9.52 | 0.79 | 0.02 | 0.00 | 0.00 | 0.00 | 0.39 | 6.78 | 0.15 | 0.01 |
| **4.D - Wastewater Treatment and Discharge** | 0.00 | 2.69 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **4.E - Other (please specify)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5 - Other** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| **5.B - Other (please specify)** | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| | | | | | | | | | | |
| **Memo Items (5)** | | | | | | | | | | |
| **International Bunkers** | 36.79 | 0.00 | 0.00 | NO | NO | NO | NO | NO | NO | NO |
| 1.A.3.a.i - International Aviation (International Bunkers) | 36.79 | 0.00 | 0.00 | | | | NO | NO | NO | NO |
| 1.A.3.d.i - International water-borne navigation (International bunkers) | NO | NO | NO | | | | NO | NO | NO | NO |

**$CO_2$ net emissions (emission minus removals)*

# Appendix IV Detailed tables of the key category analysis

Table 96 and Table 97 present the level assessment of key categories in 1990 (base year) and 2014 in details, where:

- **|Ex,t|** is absolute value of emission or removal estimate of source or sink category *x* in year *t*
- **Lx,t** is level assessment for source or sink *x* in latest inventory year (year *t*).

Table 98 gives an overview of the trend assessment relating to 1990 and 2014, where:

- **Ex,t** and **Ex,0** is real values of estimates of source or sink category *x* in years *t* and 0, respectively
- **Tx,t** is trend assessment of source or sink category *x* in year *t* as compared to the base year (year 0)

***Table 96. Level assessment of key categories in 1990 (base year)***

| IPCC Category Code / Код | IPCC Category / IPCC категорија | Greenhouse gas Стакленички гас | \|Ex,t\| (Gg $CO_2$ Eq) | Lx,t | Cumulative Total of Lx,t Кумулативен збир на Lx,t |
|---|---|---|---|---|---|
| 3.B.1.a | Forest land Remaining Forest land<br>Шумско земјиште во континуитет | $CO_2$ | 10,381.9 | 0.4423 | 0.4423 |
| 1.A.1 | Energy Industries - Solid Fuels<br>Енергетски индустрии – Цврсти горива | $CO_2$ | 5,698.0 | 0.2428 | 0.6851 |
| 4.A | Solid Waste Disposal<br>Депонии за цврст отпад | $CH_4$ | 1,308.6 | 0.0558 | 0.7408 |
| 1.A.2 | Manufacturing Industries and Construction - Liquid Fuels<br>Производствени индустрии и градежништво – течни горива | $CO_2$ | 1,211.1 | 0.0516 | 0.7924 |
| 3.A.1 | Enteric Fermentation<br>Ентерична ферментација | $CH_4$ | 762.9 | 0.0325 | 0.8249 |
| 1.A.3.b | Road Transportation<br>Патен сообраќај | $CO_2$ | 744.5 | 0.0317 | 0.8566 |
| 1.A.4 | Other Sectors - Liquid Fuels*<br>Други сектори – течни горива | $CO_2$ | 550.6 | 0.0235 | 0.8801 |
| 1.A.1 | Energy Industries - Liquid Fuels<br>Енергетски индустрии – течни горива | $CO_2$ | 481.6 | 0.0205 | 0.9006 |
| 1.A.2 | Manufacturing Industries and Construction - Solid Fuels<br>Производствени индустрии и градежништво – цврсти горива | $CO_2$ | 458.9 | 0.0195 | 0.9202 |
| 2.C.2 | Ferroalloys Production<br>Производство на феролегури | $CO_2$ | 354.2 | 0.0151 | 0.9352 |
| 2.A.1 | Cement production<br>Производство на цемент | $CO_2$ | 249.4 | 0.0106 | 0.9459 |
| 3.C.4 | Direct $N_2O$ emissions from managed soils<br>Директни емисии на $N_2O$ од обработени почви | $N_2O$ | 220.5 | 0.0094 | 0.9553 |

**Other sectors – as a category under the Fuel combustion activities in Energy sector, consisted of the subcategories Commercial/Institutional, Residential and Agriculture/Forestry/Fishing/Fish farms*

***Table 97. Level assessment of key categories in 2014***

| IPCC Category Code / Код | IPCC Category / IPCC категорија | Greenhouse gas Стакленички гас | \|Ex,t\| (Gg $CO_2$ Eq) | Lx,t | Cumulative Total of Lx,t Кумулативен збир на Lx,t |
|---|---|---|---|---|---|
| 3.B.1.a | Forest land Remaining Forest land<br>Шумско земјиште во континуитет | $CO_2$ | 6,771.7 | 0.3507 | 0.3507 |
| 1.A.1 | Energy Industries - Solid Fuels<br>Енергетски индустрии – Цврсти горива | $CO_2$ | 4,406.8 | 0.2282 | 0.5788 |
| 4.A | Solid Waste Disposal<br>Депонии за цврст отпад | $CH_4$ | 2,193.0 | 0.1136 | 0.6924 |
| 1.A.3.b | Road Transportation<br>Патен сообраќај | $CO_2$ | 1,592.2 | 0.0824 | 0.7748 |
| 1.A.2 | Manufacturing Industries and Construction - Liquid Fuels<br>Производствени индустрии и градежништво – течни горива | $CO_2$ | 658.7 | 0.0341 | 0.8090 |
| 3.A.1 | Enteric Fermentation<br>Ентерична ферментација | $CH_4$ | 525.2 | 0.0272 | 0.8362 |
| 1.A.2 | Manufacturing Industries and Construction - Solid Fuels<br>Производствени индустрии и градежништво – цврсти горива | $CO_2$ | 396.0 | 0.0205 | 0.8567 |
| 2.C.2 | Ferroalloys Production<br>Производство на феролегури | $CO_2$ | 377.6 | 0.0196 | 0.8762 |
| 2.A.1 | Cement production<br>Производство на цемент | $CO_2$ | 267.9 | 0.0139 | 0.8901 |
| 3.C.4 | Direct $N_2O$ emissions from managed soils<br>Директни емисии на $N_2O$ од обработени почви | $N_2O$ | 197.7 | 0.0102 | 0.9003 |
| 2.F.1 | Refrigeration and Air Conditioning<br>Уреди за разладување | HFCs, PFCs | 183.5 | 0.0095 | 0.9098 |
| 1.A.1 | Energy Industries - Gaseous Fuels<br>Енергетски индустрии – гасовити горива | $CO_2$ | 177.2 | 0.0092 | 0.9190 |
| 1.A.5 | Non-Specified - Liquid Fuels*<br>Неспецифицирани индустрии – течни горива | $CO_2$ | 160.3 | 0.0083 | 0.9273 |
| 1.B.1 | Fugitive emissions - Solid Fuels<br>Фугитивни емисии - Цврсти горива | $CH_4$ | 145.9 | 0.0076 | 0.9349 |
| 1.A.1 | Energy Industries - Liquid Fuels<br>Енергетски индустрии – течни горива | $CO_2$ | 142.3 | 0.0074 | 0.9422 |
| 3.B.3.b | Land Converted to Grassland<br>Земјиште претворено во пасишта | $CO_2$ | 141.1 | 0.0073 | 0.9495 |
| 3.B.2.b | Land Converted to Cropland<br>Земјиште претворено во обработливо земјиште | $CO_2$ | 123.8 | 0.0064 | 0.9559 |

**Non-specified - as a subcategory under the Manufacturing Industries and Construction in Fuel combustion activities in Energy sector*

*Table 98. Trend assessment of key categories (1990, 2014)*

| Code/ Код | IPCC Category / IPCCкатегорија | Greenhouse gas / Стакленички гас | 1990 Year Estimate / Пресметка за 1990 година Ex0 (Gg CO2 Eq) | 2014 Year Estimate / Пресметка за 2014 година Ext (Gg CO2 Eq) | Trend Assessment / Проценка на тренд (Txt) | % Contribution to Trend / Придонес во трендот во % | Cumulative Total of Contrib. to Trend / Кумулативен збир на придонесот во трендот |
|---|---|---|---|---|---|---|---|
| 4.A | Solid Waste Disposal<br>Отстранување на цврст отпад | $CH_4$ | 1,308.6 | 2,193.0 | 0.0543 | 0.2352 | 0.2352 |
| 1.A.3.b | Road Transportation<br>Патнички сообраќај | $CO_2$ | 744.5 | 1,592.2 | 0.0456 | 0.1974 | 0.4326 |
| 1.A.1 | Energy Industries - Solid Fuels<br>Енергетски индустрии – цврсти горива | $CO_2$ | 5,698.0 | 4,406.8 | 0.0174 | 0.0752 | 0.5078 |
| 1.A.4 | Other Sectors - Liquid Fuels<br>Други сектори – течни горива | $CO_2$ | 550.6 | 74.8 | 0.0133 | 0.0575 | 0.5653 |
| 1.A.1 | Energy Industries - Liquid Fuels<br>Енергетски индустрии – течни горива | $CO_2$ | 481.6 | 142.3 | 0.0083 | 0.0361 | 0.6014 |
| 1.A.2 | Manufacturing Industries and Construction - Liquid Fuels<br>Производствени индустрии и градежништво – течни горива | $CO_2$ | 1,211.1 | 658.7 | 0.0081 | 0.0353 | 0.6367 |
| 2.F.1 | Refrigeration and Air Conditioning<br>Ладење и климатизирање | HFCs, PFCs | 0.0 | 183.5 | 0.0078 | 0.0339 | 0.6705 |
| 1.A.1 | Energy Industries - Gaseous Fuels<br>Енергетски индустрии – гасовити горива | $CO_2$ | 0.0 | 177.2 | 0.0076 | 0.0327 | 0.7032 |
| 1.A.5 | Non-Specified - Liquid Fuels*<br>Неспецифицирани индустрии – течни горива | $CO_2$ | 0.0 | 160.3 | 0.0068 | 0.0296 | 0.7328 |
| 3.B.3.b | Land Converted to Grassland<br>Земјишта преобразени во пасишта | $CO_2$ | 0.0 | 134.9 | 0.0057 | 0.0249 | 0.7577 |
| 3.B.1.a | Forest land Remaining Forest land<br>Шумски земјишта и останати шумски земјишта | $CO_2$ | -206.3 | -3,432.4 | 0.0056 | 0.0241 | 0.7818 |
| 2.C.2 | Ferroalloys Production<br>Производство на феролегури | $CO_2$ | 354.2 | 377.6 | 0.0055 | 0.0238 | 0.8056 |
| 3.B.2.b | Land Converted to Cropland<br>Земјишта преобразени во земјоделски земјишта | $CO_2$ | 0.0 | 123.8 | 0.0053 | 0.0228 | 0.8284 |
| 2.A.1 | Cement production<br>Производство на цемент | $CO_2$ | 249.4 | 267.9 | 0.0040 | 0.0171 | 0.8456 |
| 2.C.6 | Zinc Production<br>Производство на цинк | $CO_2$ | 127.5 | 0.0 | 0.0038 | 0.0165 | 0.8621 |
| 2.C.3 | Aluminum production<br>Производство на алуминиум | PFCs (PFCs) | 114.5 | 0.0 | 0.0034 | 0.0148 | 0.8769 |
| 1.A.2 | Manufacturing Industries and Construction - Solid Fuels<br>Производствени индустрии и градежништво – цврсти горива | $CO_2$ | 458.9 | 396.0 | 0.0031 | 0.0136 | 0.8905 |

| Code/ Код | IPCC Category / IPCCкатегорија | Greenhouse gas / Стакленички гас | 1990 Year Estimate / Пресметка за 1990 година Ex0 (Gg CO2 Eq) | 2014 Year Estimate / Пресметка за 2014 година Ext (Gg CO2 Eq) | Trend Assessment / Проценка на тренд (Txt) | % Contribution to Trend / Придонес во трендот во % | Cumulative Total of Contrib. to Trend / Кумулативен збир на придонесот во трендот |
|---|---|---|---|---|---|---|---|
| 1.A.2 | Manufacturing Industries and Construction - Gaseous Fuels<br>Производствени индустрии и градежништво – гасовити горива | $CO_2$ | 0.0 | 65.9 | 0.0028 | 0.0122 | 0.9027 |
| 2.C.1 | Iron and Steel Production<br>Производство на железо и челик | $CO_2$ | 22.2 | 73.0 | 0.0024 | 0.0106 | 0.9133 |
| 3.C.4 | Direct $N_2O$ emissions from managed soils<br>Директни емисии на $N_2O$ од обработливи почви | $N_2O$ | 220.5 | 197.7 | 0.0018 | 0.0079 | 0.9212 |
| 1.A.4 | Other Sectors – Biomass**<br>Други сектори – биомаса | $CH_4$ | 0.0 | 40.2 | 0.0017 | 0.0074 | 0.9286 |
| 3.B.1.b | Land Converted to Forest land<br>Земјишта преобразени во шумски земјишта | $CO_2$ | 0.0 | -38.8 | 0.0017 | 0.0072 | 0.9358 |
| 1.B.1 | Fugitive emissions - Solid Fuels<br>Фугитивни емисии - Цврсти горива | $CH_4$ | 157.0 | 145.9 | 0.0015 | 0.0066 | 0.9424 |
| 4.D | Wastewater Treatment and Discharge<br>Обработка и испуштање на отпадни води | $CH_4$ | 37.2 | 56.6 | 0.0013 | 0.0056 | 0.9480 |
| 3.B.5.b | Land Converted to Settlements<br>Земјишта преобразени во населени места | $CO_2$ | 0.0 | 25.9 | 0.0011 | 0.0048 | 0.9528 |

**Non-specified - as a subcategory under the Manufacturing Industries and Construction in Fuel combustion activities in Energy sector*

***Other sectors – as a category under the Fuel combustion activities in Energy sector, consisted of the subcategories Commercial/Institutional, Residential and Agriculture/Forestry/Fishing/Fish farms*