Third Biennial Update Report on Climate Change

NATIONAL INVENTORY REPORT

Republic of North Macedonia

December, 2019

UNFCCC National Focal Point

Dr. Teodora Obradovikj Grncharovska

Project Manager

B.Sc. Pavlina Zdraveva

Chief Techical Advisor

Prof. Dr. Natasa Markovska

GHG INVENTORY TEAM

ICEOR-MANU Team

Acad. Gligor Kanevce,

D.Sc. Verica Taseska-Gjorgievska

D.Sc. Aleksandar Dedinec

Ass. Prof. D.Sc. Aleksandra Dedinec

M.Sc. Vasil Bozhikaliev

B.Sc. Emilija Mihajloska

B.Sc. Lazar Aleksovski

AFOLU TEAM

UKIM - Institute of Agriculture

Prof. Dusko Mukaetov

D-r Hristina Poposka

D-r Dusko Nedelkovski

UKIM – Faculty of Agricultural Science and Food

Prof. D-r. Sretan Andonov

Prof. D-r. Ordan Chukaliev

Prof. D-r Vjekoslav Tanaskovic

UKIM – Faculty of Forestry

Prof. Dr. Ljupco Nestorovski

Prof. Dr. Nikola Nikolov

Prof. Dr. Ivan Mincev

QA Expert

M.Sc. Elena Gavrilova

QC Expert

M.Sc. Marjan Mihajlov

Gender Consultant

Olgica Apostolova

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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
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
EMEP	European Monitoring and Evaluation Programme
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 North Macedonia
MANU	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
NACE	Nomenclature of Economic Activities
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		Metric Symbol	Prefix	Factor
g	gram	mass		P	peta	10^{15}
W	watt	power		T	tera	10^{12}
J	joule	energy		G	giga	10^{9}
m	meter	length		M	mega	10^{6}
Wh	watt hour	energy		k	kilo	10^{3}
toe	ton of oil equivalent	energy		h	hecto	10^{2}
				da	deca	10^{1}
Mass Unit Conversion				d	deci	10^{-1}
1g				c	centi	10^{-2}
1kg	= 1 000 g			m	milli	10^{-3}
1t	= 1 000 kg	= 1 Mg		μ	micro	10^{-6}
1kt	= 1 000 t	= 1 Gg		n	nano	10^{-9}
1Mt	= 1 000 000 t	= 1 Tg		p	pico	10^{-12}

Executive summary

The Republic of North Macedonia (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 two Biennial Update Reports (2015 and 2018) 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 same approach was used in the Second Biennial Update Report (SBUR) and the emission trend was expanded by developing the GHG inventory for 2013 and 2014.

The inventory activities under the Third Biennial Update Report (3rd BUR) continue the work done in the previous BURs and include developing the GHG inventory for 2015 and 2016 in line with the IPCC 2006 Guidelines. The latest version of IPCC Inventory Software (version 2.54 – from July 6, 2017) is used in this process.

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 for the following GHGs: CO_2, CH_4, N_2O, PFCs and HFCs, as well as precursors and indirect emissions from: CO, NOx, NMVOC, SO_2 and NH_3. The emission of SF_6 is not estimated for Macedonia due to unavailability of activity data.

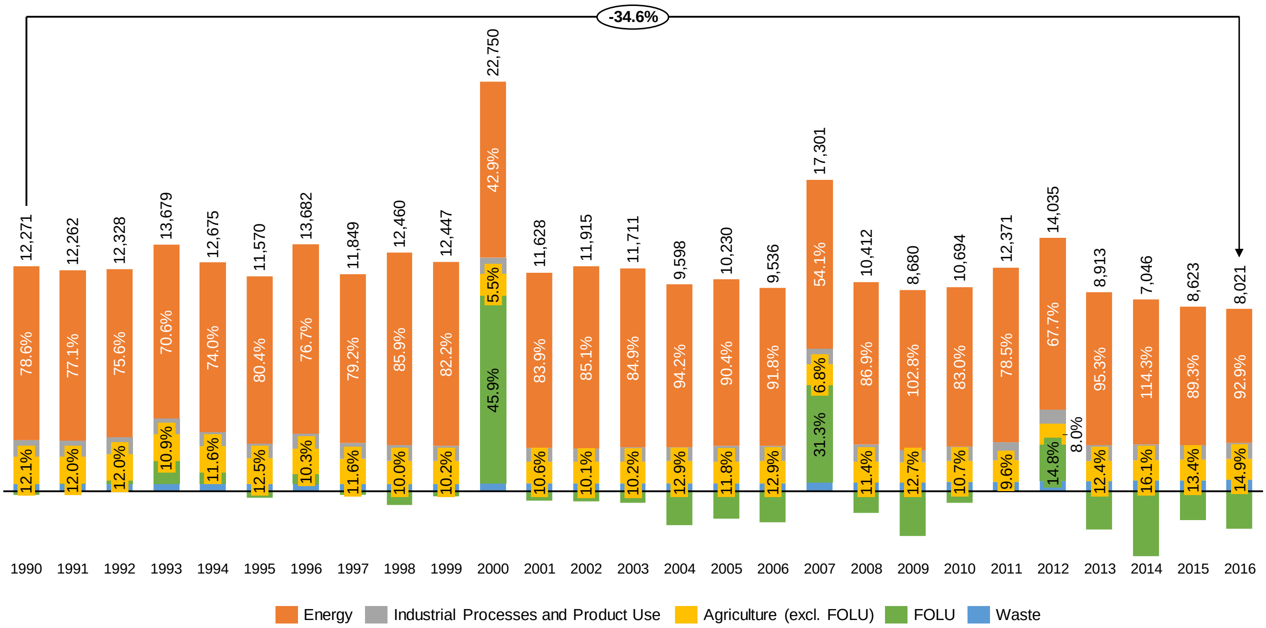
The national inventory process includes the following key players:

- **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 MANU team and AFOLU team with experts from University of Ss. Cyril and Methodius (UKIM) - Institute of Agriculture, Faculty of Forestry, Faculty of Agricultural Sciences and Food;
- **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 transparent and publicly available within the national climate change platform www.klimatskipromeni.mk, open data portal (data.gov.mk) and UNFCCC web site. This also contributes to transparency in reporting of climate data required under Article 13 of the Paris Agreement.

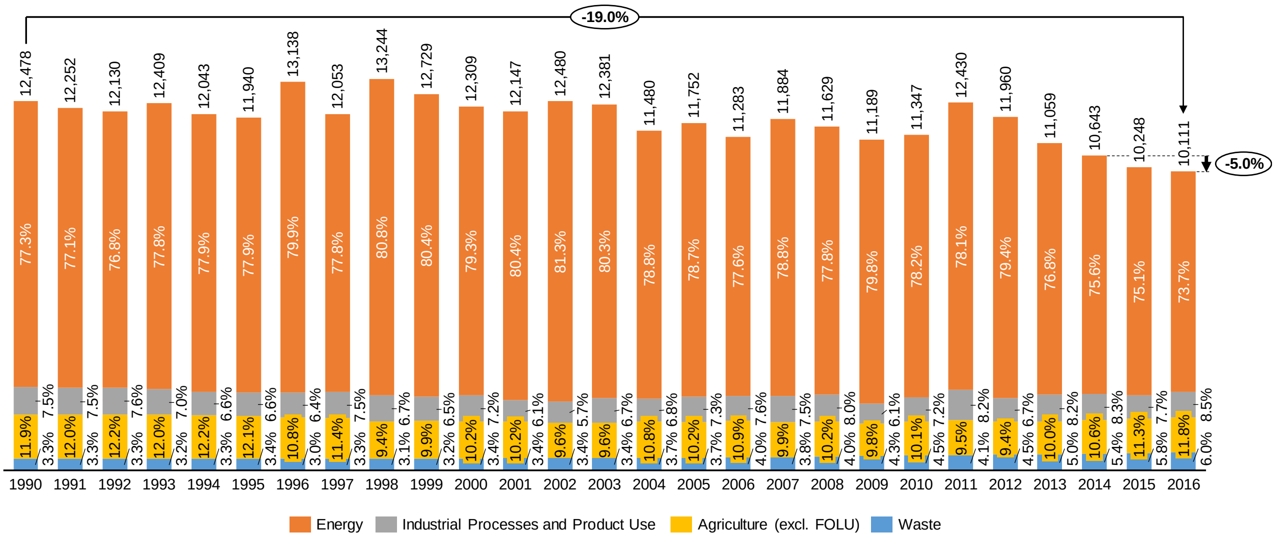
The aggregate GHG emissions and removals (net emissions) in 2016 are estimated to 8,020 Gg CO_2-eq (including the FOLU sector) (Figure 1). Figure 1 shows the time–series of emissions and removals, including the net emissions (in CO_2-eq), from 1990 to 2016. There are significant fluctuations in the net emissions in 2000, 2007 and 2012, where increased emissions can be noticed in the FOLU sector (instead of removals) as a result of the intensified forest fires/wildfires. The GHG emission in 2016 are reduced by 34.6% compared to 1990. This is mainly results of reduced electricity production from lignite, fuels switch (residual fuel oil for electricity and heat production is replaced with natural gas), and lower industrial production, which is decreasing after 2012.

Figure 1. GHG emissions and removals by sector (in Gg CO2-eq)



If the removals from FOLU sector are not accounted for, then the total GHG emissions in 2016 are 10,111 Gg CO_2-eq (Figure 2). The greatest share of emissions is from the Energy sector, accounting for 73.7% in 2016, followed by the Agriculture (excluding FOLU) with 11.8% and IPPU sector with 8.5% and Waste sector with 6% share. The dominant share of emissions for the Energy sector is evident throughout the whole time series. Excluding FOLU the emissions in 2016 are reduced by 19% compared to 1990.

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

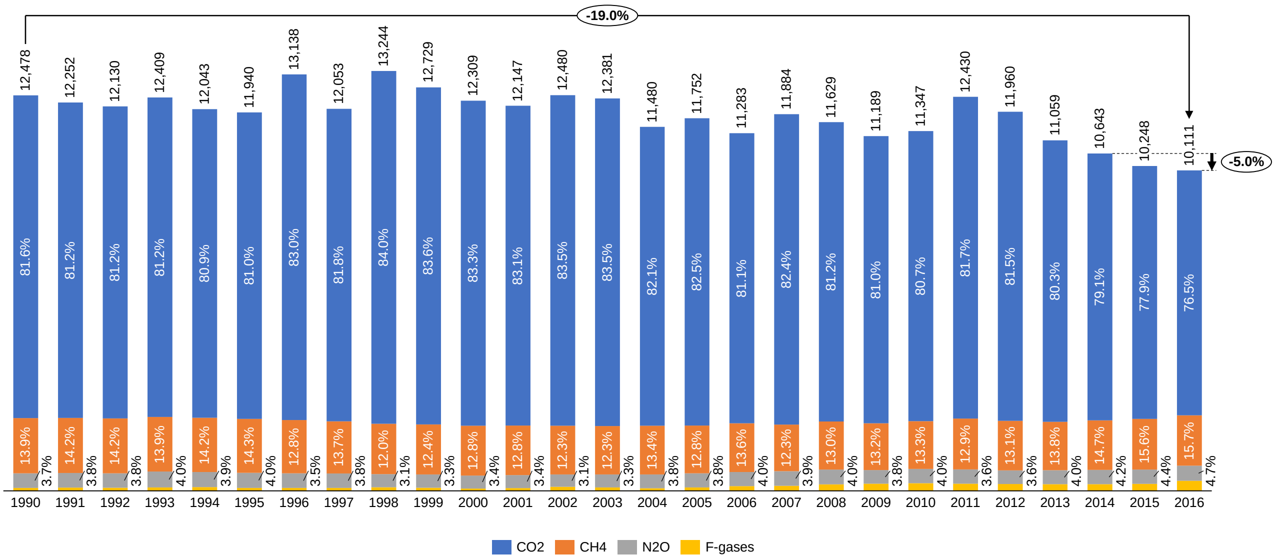


Analyzing the GHG emissions by gas (excluding FOLU sector), it is evident that across the series the most dominant are the CO_2 emissions (Figure 3). Their share accounts for 76.5% in 2016, followed by the CH_4 emissions with 15.7%, then N_2O emissions with 4.7% and all F-gasses with 3.1%.

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 7,396 Gg CO_2 in 2015 and 7,175 Gg CO_2 in 2016.

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 7,701 Gg CO_2-eq in 2015 and 7,449 Gg CO_2-eq in 2016. Most of the GHG emissions in 2016 occur in the category Energy Industries (51.0%), followed by Transport (28.1%) and Manufacturing Industries and Construction (13.9%). The other two categories together account for 5% of the total emissions in 2016 and the remaining around 2% are Fugitive emissions. Almost all of the GHG emissions in 2016 are CO_2 emissions (96.4%), and CH_4 and N_2O emissions amount to only 2.8% and 0.8%, respectively.

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



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. Until 2000, the metal industry was prevailing source of the emissions, mostly from the ferroalloy production. After 2000, when ODS substitutes usage in the country have started to increase, the share of the GHG emissions from the Metal industry in total emissions from IPPU sector have decreased considerably (from 64% in 1990 to 19% in 2016), while the emissions from the Mineral industry have been fluctuating over the inventory period. In the last three reporting years the product uses as substitutes for ODS had grown for around 50%, resulting with share of almost 37% of the IPPU emissions in 2016. However, the dominant share in 2016 had the Mineral industry with 44%, while the share of the Metal industry was reduced to 19%. Emissions from the other categories, like Chemical industry, Non-Energy Products from Fuels and Solvent Use, Electronics Industry and Other Product Manufacture and Use do not occur in the country.

The level of the overall greenhouse emissions from this sector is consistent throughout the entire period of 1990 – 2016. The overall emission in 2016 achieved 850 Gg CO_2-eq, which is 3.2% lower compared to 2014 or 8% less compared to 1990.

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). The total emissions due to livestock activity in 2015 were 821.5 Gg CO_2-eq, while in 2016, 833.5 Gg CO_2-eq. This increase of about 4-5% compared to 2014 (792.7 Gg CO_2-eq) is due to increase in number of heads in cattle (for about 5%) and swine (for 34%), but decrease in sheep, horses and poultry

Forestry sector is the major contributor of GHG sinks in Macedonia within the Land subsector of AFOLU, with exception of several years when the amount of forest fires (burned areas) were significantly above the annual average. The area of forestland, the species composition (conifers, broadleaved, mixed), as well as the annual increment and removals from the forests are relatively stable. The estimated GHG sinks in this sector for 2015 is estimated on 1,608.3 and in 2016 2,120.6 Gg CO_2 eq.

The other land use like Cropland, Grassland, Settlements and Other land, participate in the emission of CO_2, and in some years can be considered as a significant source of emissions of this GHG. This emission is mainly result to the conversion of one to another category of land use, when significant amounts of above and below ground biomass is rapidly removed and is considered as a direct loss. For the other areas, which remains under same category of land use, gains and losses, are in balance (Tier 1) and are considered as carbon neutral.

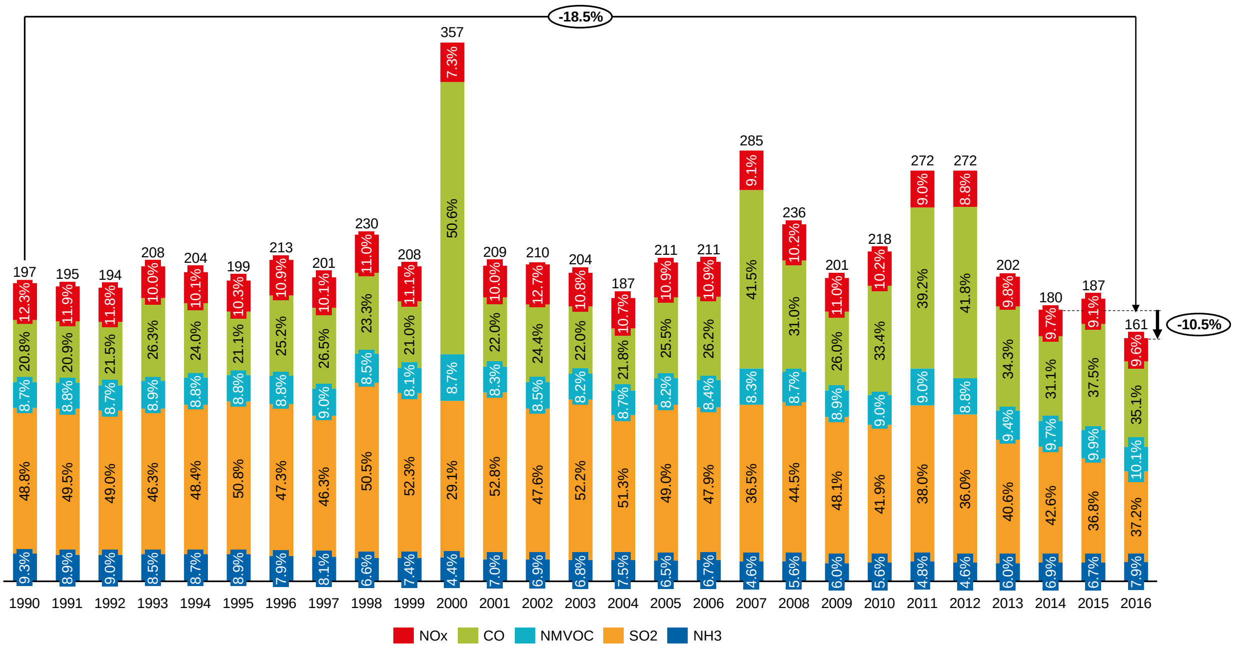
For the non-CO_2 sources of GHG, it can be concluded that there are numerous management practices and inputs resulting in a significant amount of GHG emissions, which when summed up, differ in a small range of 313.1 Gg CO_2-eq in the year 2000 up to 382.3 Gg CO_2-eq, in 1990. The managed soils are a major source of non-CO_2 emissions, which in 1990 contribute with 55.4% in the total emissions, and up to 62.4 % in 2016.

The categories reported under waste sector 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.

The calculations show that the Waste sector is one of the sectors with an increasing trend of GHG emissions achieving 610 Gg CO_2-eq in 2016, which is doubled compared to 1990 or 6.3% more compared to 2014. Out of all the sectors, the emission from Solid Waste Disposal category are most significant participating with 77.5% in the total GHG emission in 2016. Second category with significant amount of GHG emissions is Wastewater Treatment and Discharge participating with around 19% in 2016. Incineration and open burning of waste category contribute with around 4% in the last three reported years. The CH_4 and N_2O emissions from the Biological Treatment of Solid Waste category do not contribute largely to the overall emissions due to the small amount of reported composted waste. Around 92% of the GHG emissions in the last three years of the reporting period are CH_4, while N_2O and CO_2 participates with 7.2%, 1% respectively.

The Precursors and indirect emissions have been estimated in line with the EMEP/EEA Emission Inventory Guidebook, in a consistent, complete and comparable manner for the entire inventory period 1990 – 2016. The results for precursors and indirect emissions show that they are reduced by 18.5% and 10.5% in 2016 compared to 1990 and 2014 respectively (Figure 4). At average the emission are around 200 Gg/year, but there are peaks in 2000, 2007, 2008, 2011 and 2012 mainly as a results of forest fires. The highest numbers are estimated for 2000, 357 Gg. SO_2 participates with around 50% over the entry reporting period, but in the last five years it shares is below 40%, as a result of reduction in electricity production from lignite, as well as fuel change (oil for heat production is replaced with natural gas). CO is the second contributor, participating with around 30%, with peak in the years with more forest fires. NH_3 as a new gas that is introduced in this inventory, participate with around 8% during the reporting period.

Figure 4. Emissions of NOx, CO, NMVOC, SO_2 and NH_3 (in Gg)



The assessment of the sectoral precursors and indirect emissions, shows that during the entire reporting period, Energy sector is the most significant contributor in all of them except in NH_3. In 2016, this sector is a source of almost all SO_2 and NO_x emissions, 99.8 and 95.6%, respectively. At the same time the energy sector participate with 74% in CO and 66% in NMVOC. AFOLU is the second contributor with around 96% share in NH_3, 33.4% in NMVOC and 17.6% in CO. Waste participate with 7.7% in CO most as a result of open burning of waste.

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 2016, as the latest analyzed year. The top five categories with the highest values of both emissions and removals (sinks) represented in Gg CO_2-eq are: Energy Industries – Solid Fuels (27.4%) (Energy sector), Forest Land Remaining Forest Land (17.5%) (AFOLU sector), Road Transportation (16.6%) (Energy sector), Enteric Fermentation from Livestock (5.3%) (AFOLU sector) and Manufacturing Industries and Construction – Solid Fuels (4.1%) (Energy sector). The Forest land category is relevant for sinks, while the other categories for GHG emissions.

The trend assessment of source categories is also executed, taking 1990 as base year and 2016 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%) show that Forest Land Remaining Forest Land category participates with 27.4% (AFOLU sector) , followed by Road Transportation with 22.8% (Energy sector), Energy Industries-solid fuels with 5% (Energy sector), Manufacturing Industries and Construction – Liquid Fuels (Energy sector) with 4.8% and Refrigeration and Air Conditioning with 4.6% (IPPU sector).

The uncertainty analysis is again conducted using **both methods**, Approach 1 (Error Propagation method) and Approach 2 (which is actually an implementation of the Monte Carlo method), for **each sector** of the inventory for 2014, 2015 and 2016. IPCC software was used for the first approach, while for the second one, the MATLAB model developed in SBUR was applied.

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.

This report also outlines by sector the **good practices, improvements and recommendations for future inventories**, 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.

The national GHG inventory development process incorporated well balanced gender team: 43% women and 57% men. Additional efforts have been made to integrate gender responsive considerations into the GHG inventory to the extent possible, following the national Action plan on gender and climate change and the UNDP Gender Responsive National Communications Toolkit. The results of the assessments indicate that at this time the GHG Inventory cannot reflect the gender dimension, due to the absence of official statistical gender disaggregated data in the analyzed sectors: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU) and Waste, disaggregated by categories and subcategories on the percentage of female and male participation in the production of the GHG emissions (more details in Chapter 11).

The official statistical agencies are recommended to start collecting gender disaggregated data in the listed sectors.

1 Introduction

The Republic of North Macedonia (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 two Biennial Update Reports (2015 and 2018) 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 same approach was used in the Second Biennial Update Report (SBUR) and the emission trend was expanded by developing the GHG inventory for 2013 and 2014.

The inventory activities under the Third Biennial Update Report (3rd BUR) continue the work done in the previous BURs and include developing the GHG inventory for 2015 and 2016 in line with the IPCC 2006 Guidelines. The latest version of IPCC Inventory Software (version 2.54 – from July 6, 2017) is used in this process.

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 for the following GHGs: CO_2, CH_4, N_2O, PFCs and HFCs, as well as precursors and indirect emissions from: CO, NOx, NMVOC, SO_2 and NH_3. 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 of emissions and removals (level and trend assessment) was also conducted, and presented in Chapter 8. Both methods, Error Propagation method and the Monte Carlo method for uncertainty analysis were applied for each sector of the inventory for 2014, 2015 and 2016. IPCC software was used for the first approach, while for the second one, the MATLAB model developed in SBUR was applied (Chapter 9).

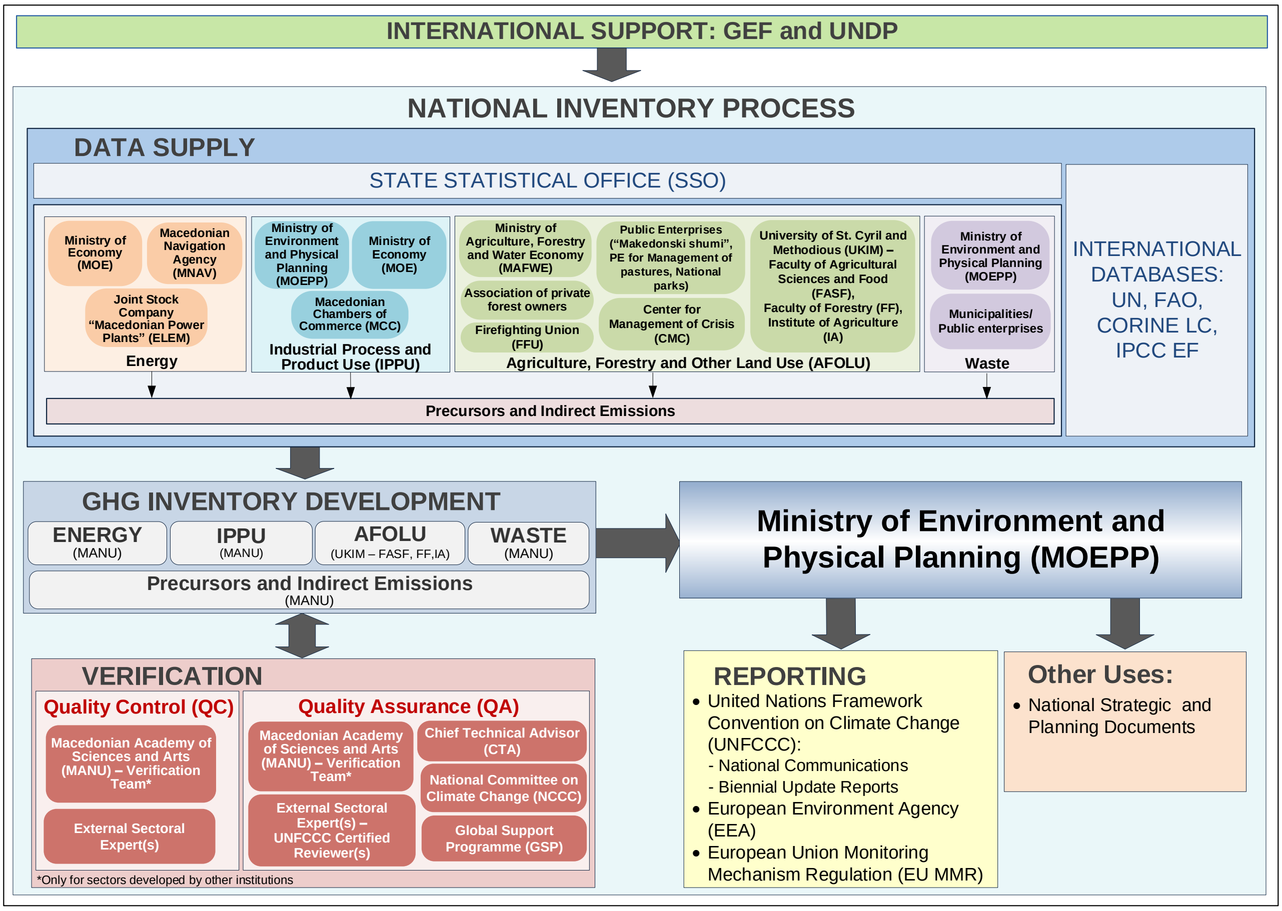
The Macedonian approach towards QA/QC activities in the national GHG inventory process is based on the in-depth analyses of the current practices of the inventory compilation in the country and the relevant international best practices. The QA/QC plan developed within the FBUR with the extension of QA activities within the energy sector from the SBUR, is applied in the same manner over the Inventory process of the 3rd BUR. Detailed information on the QA/QC procedures is provided in Chapter 10.

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 MANU team and team and AFOLU team with experts from University of Ss. Cyril and Methodius (UKIM) - Institute of Agriculture, Faculty of Forestry, Faculty of Agricultural Sciences and Food;
- **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 Programme (UNDP). The estimated emissions in the inventory are publicly available within the national climate change platform www.klimatskipromeni.mk, open data portal (data.gov.mk) and UNFCCC web site. Also, detailed Sectoral MRV schemes the relevant processes are being developed in the framework of 3rd BUR, including the inventory process.

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 2015 and 2016 are reported. Additionally, the emissions for 1990, 2000, 2005 and 2014 are given, as a years reported in the previous submissions (NCs and BURs) to UNFCCC. 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, SO_2 and NH_3. 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 (version 2.54 – from July 6, 2017). 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 3rd BUR, are summarized in A I.2, Table 80.

To facilitate aggregate reporting of GHG values, expressed as carbon dioxide equivalents (CO_2-eq) the global warming potentials (GWPs) values provided in the IPCC AR4 (temporal horizon 100 years) were used (see Table 1). According to the Decision 17/CP.8, all non-Annex-I countries should estimate their GHG emissions using GWPs from the IPCC Second Assessment Report, since Macedonia is EU-candidate country, it was decided to use GWPs from IPCC AR4.

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

Gas	CO_2 equivalent	Gas	CO_2 equivalent
CO_2	1	HFC-125	3,500
CH_4	25	HFC-143a	4,470
N_2O	298	HFC-134a	1,430
		HFC-32	675
		HFC-227ea	3,220
		CF_4	7,390
		C_2F_6	12,200

Source: IPCC Fourth Assessment Report (AR4), 2007

The estimates of precursors and indirect emissions (including indirect NH_3 emissions) are based on the EMEP/EEA Emission Inventory Guidebook, 2019. The calculation is performed using the same activity data as for GHG estimations. The tables used for the emission factors are referenced in the subchapters by sectors in Chapter 7. The estimations for all sectors is done using the Tier 1 approach, except for the category Biological treatment of waste – composting in the Waste sector for which Tier 2 emission factors are applied. The higher Tier methodologies require detailed characteristics of the fuels used in combination with onsite measurements or other detailed parameters, which were not available at the time of preparation of the 3rd BUR.

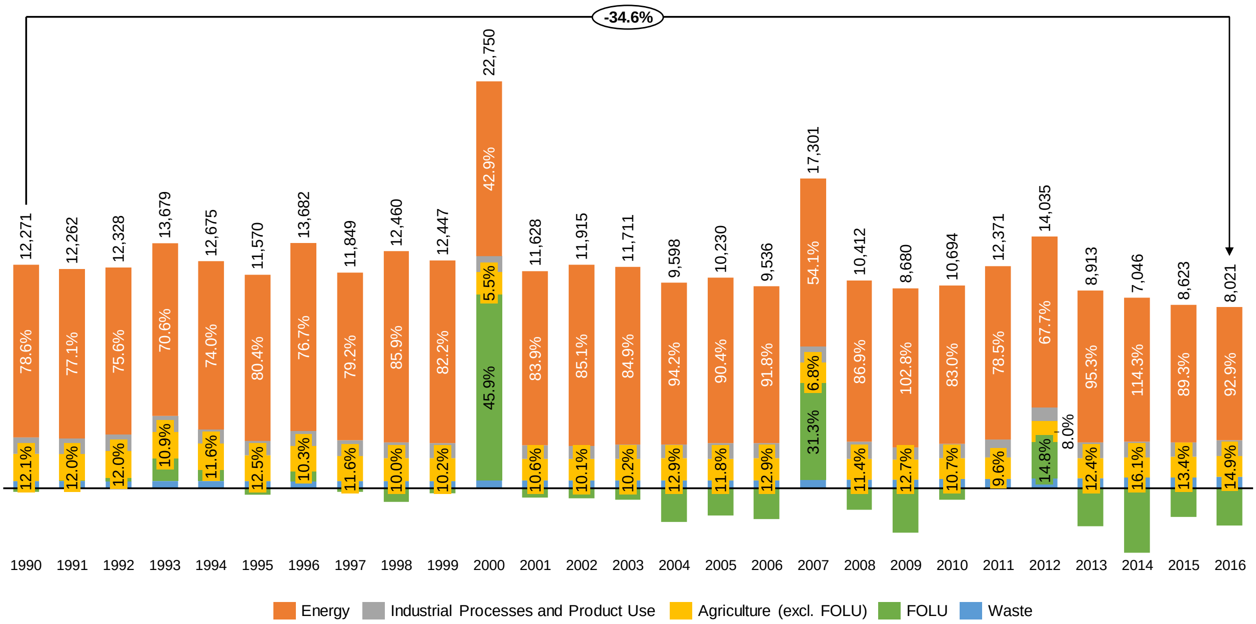
2.2 Aggregate GHG emissions

The aggregate GHG emissions and removals (net emissions) in 2016 are estimated to 8,020 Gg CO_2-eq (including the FOLU sector) (Table 2 and Figure 6). Figure 6 shows the time–series of emissions and removals, (in CO_2-eq), from 1990 to 2016. There are significant fluctuations in the net emissions in 2000, 2007 and 2012, where increased emissions can be noticed in the FOLU sector (instead of removals) as a result of the intensified forest fires/wildfires. The GHG emissions in 2016 are reduced by 34.6% compared to 1990. This is mainly result of reduced electricity production from lignite, fuels switch (residual fuel oil for electricity and heat production is replaced with natural gas), and lower industrial production, which is decreasing after 2012.

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

Sector	1990	2000	2005	2014	2015	2016
Energy	9,648.9	9,757.9	9,251.1	8,051.3	7,701.3	7,449.3
Industrial Processes and Product Use	932.2	888.4	861.7	886.2	790.5	858.0
Agriculture (without FOLU)	1,490.4	1,249.6	1,204.1	1,131.5	1,159.4	1,193.2
FOLU*	-207.0	10,441.4	-1,522.1	-3597.4	-1,625.4	-2,090.1
Waste	406.7	412.7	435.2	574.3	596.7	610.2
Total (incl. FOLU) – Net emissions	**12,271.2**	**22,749.9**	**10,230.0**	**7,045.9**	**8,622.6**	**8,020.6**
Total (excl. FOLU)	**12,478.2**	**12,308.6**	**11,752.1**	**10,643.3**	**10,247.9**	**10,110.8**

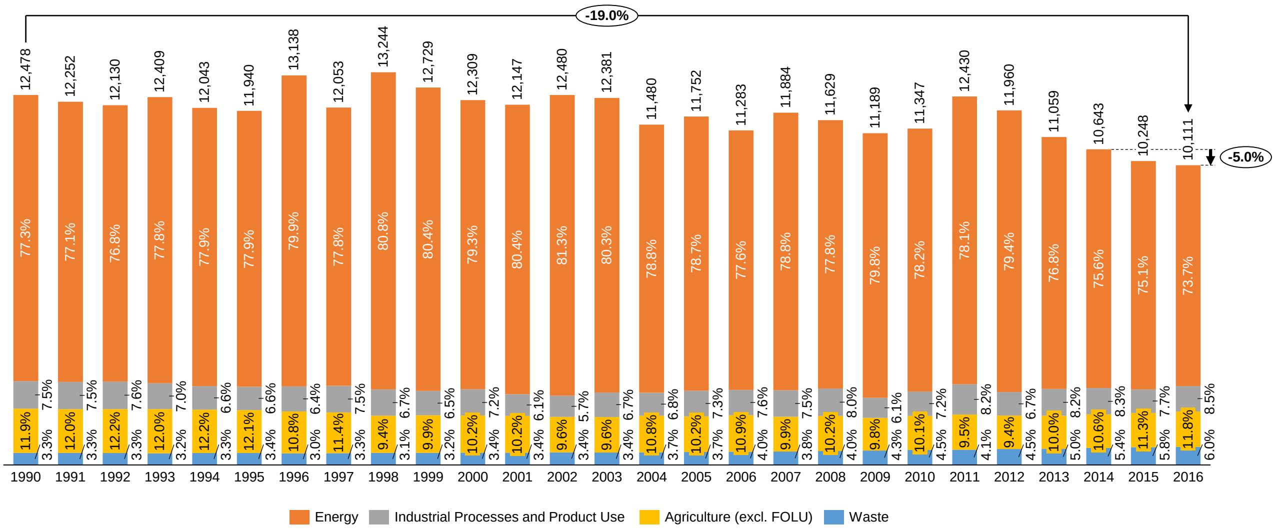
Figure 6. GHG emissions and removals by sector (in Gg CO2-eq)



If the removals from FOLU sector are not accounted for, then the total GHG emissions in 2016 are 10,111 Gg CO_2-eq (Figure 7). The greatest share of emissions is from the Energy sector, accounting for 73.7% in 2016, followed by the Agriculture (excluding FOLU) with 11.8% and IPPU sector with 8.5% and Waste sector with 6% share. The dominant share of emissions for the Energy sector is evident throughout the whole time series. Excluding FOLU, the emissions in 2016 are reduced by 19% competed to 1990.

* The value for 1990 does not include the emissions/sinks from land use changes that are reported in the AFOLU chapter (Table 18).

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



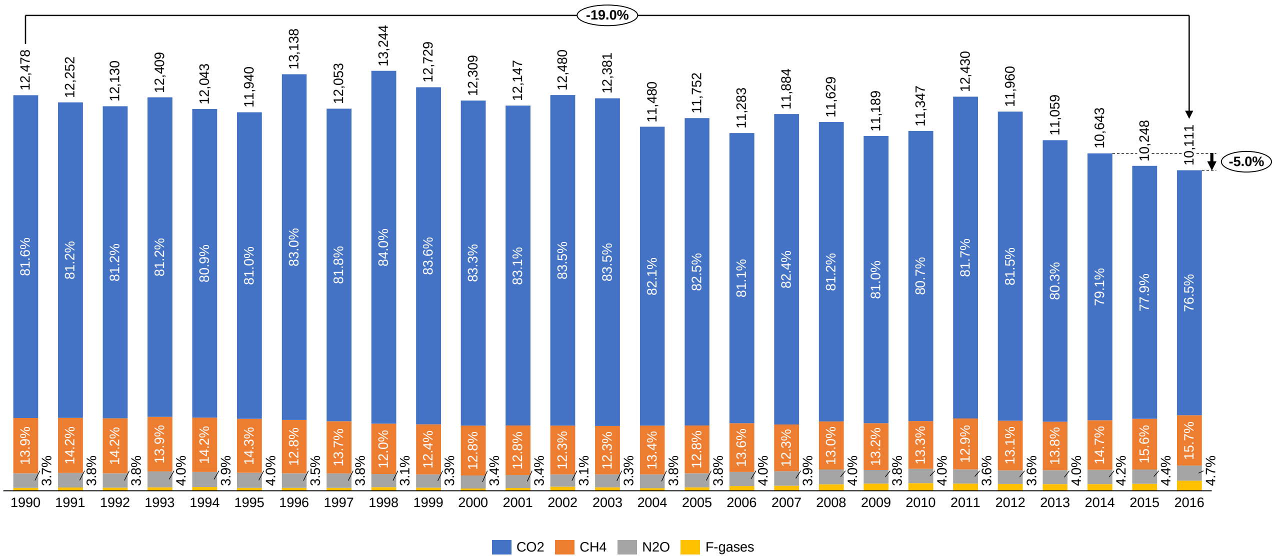
2.3 GHG emissions by gas

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 76.5% in 2016, followed by the CH_4 emissions with 15.7%, then N_2O emissions with 4.7% and all F-gasses with 3.1%.

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

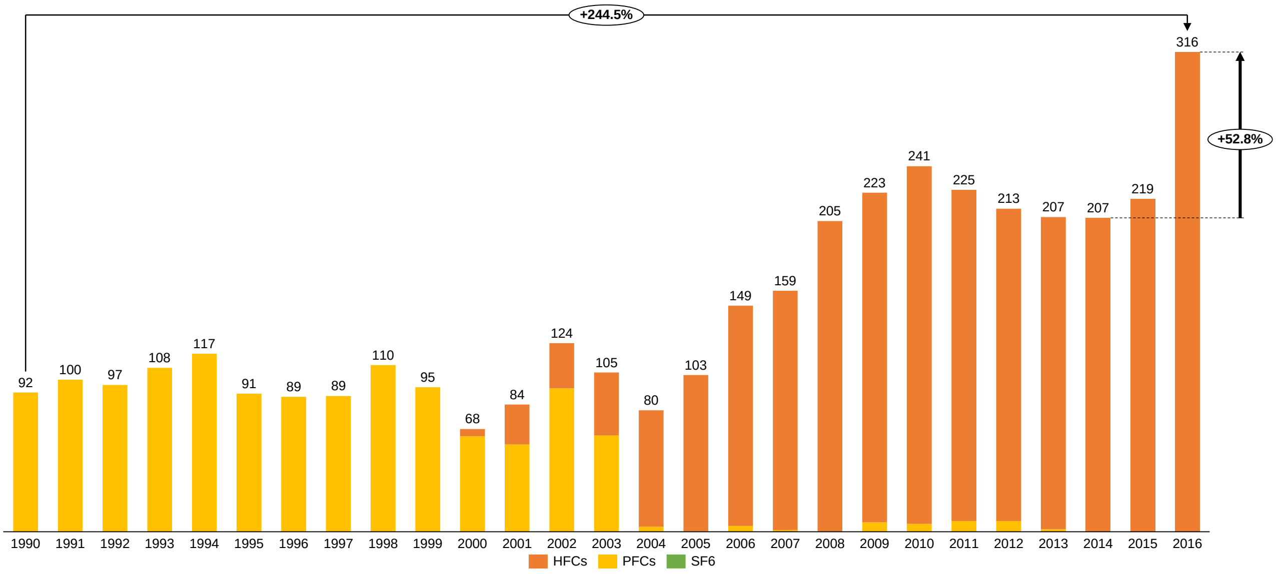
Gas	1990	2000	2005	2014	2015	2016
CO_2 (incl. FOLU)	9978.1	20697.0	8171.2	4825.0	6355.9	5641.0
CO_2 (excl. FOLU)	10185.1	10255.6	9693.3	8422.3	7981.3	7731.1
CH_4	1740.3	1571.1	1509.4	1563.3	1595.2	1588.3
N_2O	461.1	414.2	446.2	451.0	452.4	475.6
HFCs	0.0	4.8	102.8	206.6	219.1	315.7
PFCs	91.7	62.9	0.3	0.0	0.0	0.0
SF_6	0.0	0.0	0.0	0.0	0.0	0.0
Total (incl. FOLU) - Net emissions	**12271.2**	**22749.9**	**10230.0**	**7045.9**	**8622.6**	**8020.6**
Total (excl. FOLU)	**12478.2**	**12308.6**	**11752.1**	**10643.3**	**10247.9**	**10110.8**

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 achieving 316 Gg CO_2-eq in 2016, while the emissions of the PFCs are considerably decreasing after 2003. The significant growth in import of gases (blends) used for refrigeration and air-conditioning results with increase of HFCs emissions in 2016 compared to 2015.

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



3 Energy

The gross inland consumption in Macedonia is still dominated by fossil fuels, although their share is decreasing over the reported period, from 92% in 1990 to 79% in 2016 (Figure 10**Error! Reference source not found.**). At the same time, the share of renewable energy sources has doubled (7.5% in 1990 to around 15% in 2016). The rest of the gross inland consumption is covered by the electricity import, which increased from insignificant 0.2% in 1990 to 6.5% in 2016. The gross inland consumption in total in 2016 is 7% lower compared to the consumption in 1990.

Historically, the most dominant fuel in Macedonia is coal (predominantly lignite) which has accounted for about 45% of the gross inland consumption. The situation is changed in 2016 because the oil products participated with 40%, while share of coal is reduced to 33% (Figure 10).

The final energy consumption does not follow the same trend line as the gross inland consumption (Figure 11). The highest consumption of 1,861 ktoe, in the reported period, is recorded in 2016 which is 7.8% higher compared to the consumption in 1990. In 2016, oil products account for the largest share of final energy consumption (49%), while electricity is next (29%), followed by biomass with 10%, coal with 7% and heat and natural gas with 2% each. The efficiency of the energy system, represented with the ratio of final energy consumption per gross inland consumption, has increased to nearly 70% in 2016 which is 10 percentage points more compared to 1990.

Figure 10. Gross inland consumption (in ktoe)

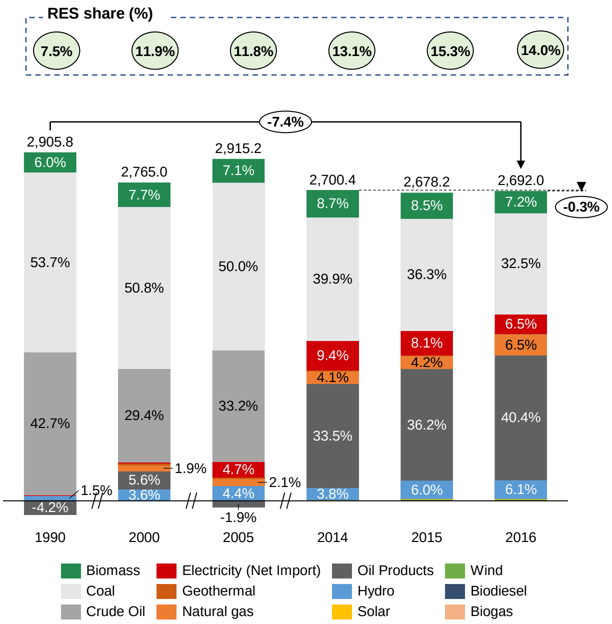
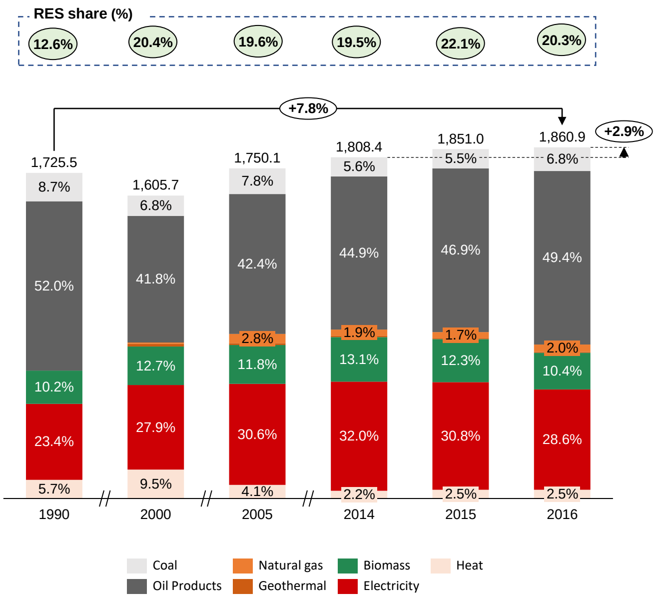


Figure 11. Final energy consumption (in ktoe)



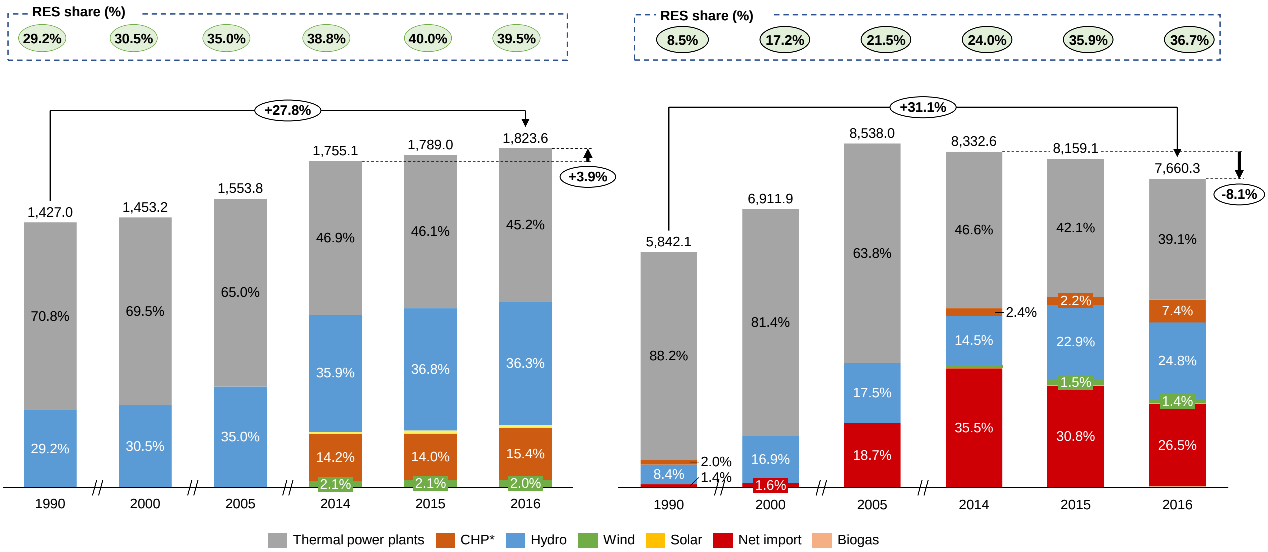
Electricity together with biomass are very important commodities for Macedonia, as domestic resources. In 2016, the electricity available for final energy consumption accounted for 6,191 GWh (532.4 ktoe). Although, in the reported years, the share of electricity in final energy consumption has increased from 23.4% in 1990 up to 32% in 2014, but in the last two years has decreased to 28.6% in 2016, most probably as a result of energy efficiency measures as well as weather conditions.

The installed capacity for electricity production is mainly composed of thermal power plants, 71% in 1990 and 45% in 2016 (Figure 12). They are followed by hydropower plants with 29% in 1990 and 36% in 2016. Technologies such as PV, wind and combined heat and power plants have also been deployed during the reported years and their shares in 2016 were 1%, 2% and 15% of the total installed capacity, respectively. The RES installed capacity in total participate with 39% in 2016 which is 10 percentage points more compare to 1990.

Considering these installed capacities, the electricity is mainly produced in the thermal power plants, i.e. 88% in 1990 and 39% in 2016 (Figure 13), followed by the production from hydropower plants, which is 8% in 1990 and 25% in 2016. Although, 15% of the installed capacity in Macedonia is from CHPs, their production in 2016 accounts for only 7%. Electricity net import has significant share and was about 27% in 2016.

Figure 12. Installed capacity of power plants (only PP that produced electricity in the certain year) (in MW)

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



Note: In 1990 the value is for Autoproducers' CHP

3.1 Emission trends – Reference approach

In this chapter, the emissions have been calculated using the Reference approach, which is a top-down and straightforward approach applied on the basis of relatively easily available energy supply statistics. 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. Compared to 2014 the numbers in 2015 and 2016 show that:

- the gaseous fuel consumption has increased by 0.4% and 57.3%, respectively,
- the liquid fuel consumption has increasing by 7.2% and 20.2%, respectively,
- the solid fuels consumption has decreased by 9.8% and 18.7%, respectively,

The fuels changes resulted in reduction of the total CO_2 emissions by 4.3% and 7.2% in 2015 and 2016, respectively.

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

	1990		2000		2005		2014		2015		2016	
	App. cons.* (TJ)	CO_2 Emiss. (Gg)	App. cons.* (TJ)	CO_2 Emiss. (Gg)	App. cons.* (TJ)	CO_2 Emiss. (Gg)	App. cons.* (TJ)	CO_2 Emiss. (Gg)	App. cons.* (TJ)	CO_2 Emiss. (Gg)	App. cons.* (TJ)	CO_2 Emiss. (Gg)
Liquid Fuels	42328.1	3085.8	37102.5	2703.1	36462.1	2731.4	35270.6	2646.2	37401.0	2793.8	39036.5	2875.6
Solid Fuels	55281.7	6101.2	58862.4	6519.1	61091.8	6165.1	45112.4	4826.7	40675.6	4346.0	36685.2	3898.2
Gaseous Fuels	0.0	0.0	2277.3	125.4	2637.9	145.3	4638.3	255.4	4658.0	256.5	7297.5	401.8
Total	**97609.8**	**9187.0**	**98242.2**	**9347.6**	**100191.4**	**9041.8**	**85021.4**	**7728.3**	**82734.6**	**7396.2**	**83019.2**	**7175.6**

Note: *App. cons. *-Apparent consumption;*

3.2 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 due to reduced electricity production from the Energy Industries, replaced mainly with electricity import. Overall, the emissions in 2016 have 7.5% lower values compared with the ones in 2014 and 22.8% compared with 1990.

Most of the GHG emissions in 2016 occur in the category Energy Industries (51.0%), followed by Transport (28.1%) and Manufacturing Industries and Construction (13.9%). The other two categories together account for 5% of the total emissions in 2016 and the remaining around 2% are Fugitive emissions.

Furthermore, the overall GHG emissions in Energy sector by gas (in Gg of CO_2-eq) for the reporting years, are given in Figure 15, notably, almost all of the GHG emissions in 2016 are actually CO_2 emissions (96.4%), and CH_4 and N_2O emissions amount to only 2.8% and 0.8%, respectively.

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

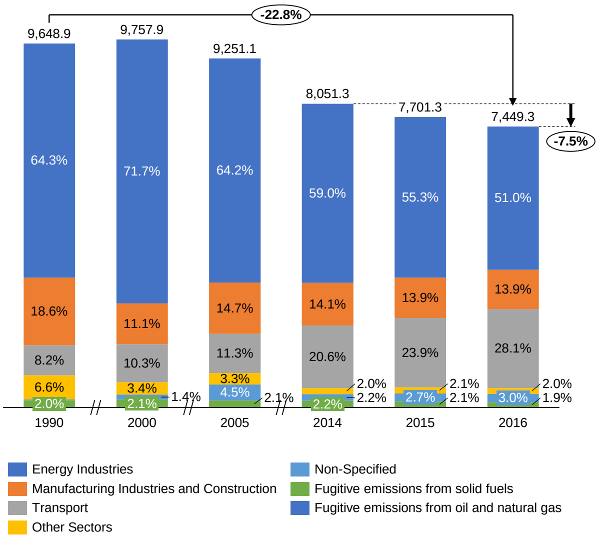
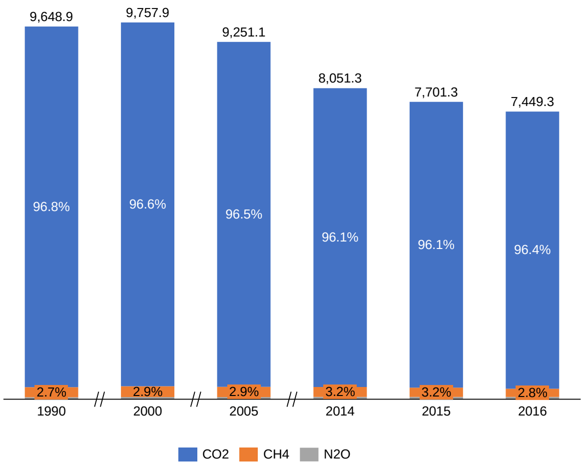


Figure 15. GHG emissions in Energy sector, by gas (in Gg of CO_2-eq)



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	1990	2000	2005	2014	2015	2016
Energy	**9648.9**	**9757.9**	**9251.1**	**8051.3**	**7701.3**	**7449.3**
Fuel Combustion Activities	**9455.5**	**9549.9**	**9060.6**	**7872.4**	**7537.4**	**7307.1**
Energy Industries	6205.3	6998.3	5940.5	4747.4	4260.6	3801.2
Manufacturing Industries and Construction	1796.5	1080.6	1356.2	1132.8	1067.1	1037.4
Transport	791.1	1006.5	1043.5	1656.4	1837.8	2096.7
Other Sectors	637.3	328.4	302.7	158.7	162.2	149.9
Non-Specified	25.4	136.1	417.8	177.2	209.6	222.0
Fugitive emissions from fuels	**193.3**	**208.0**	**190.5**	**178.9**	**163.9**	**142.2**
Solid Fuels / Цврсти горива	192.6	207.5	189.9	178.9	163.9	142.2
Oil and Natural Gas / Нафта и природен гас	0.7	0.5	0.6	0.0	0.0	0.0

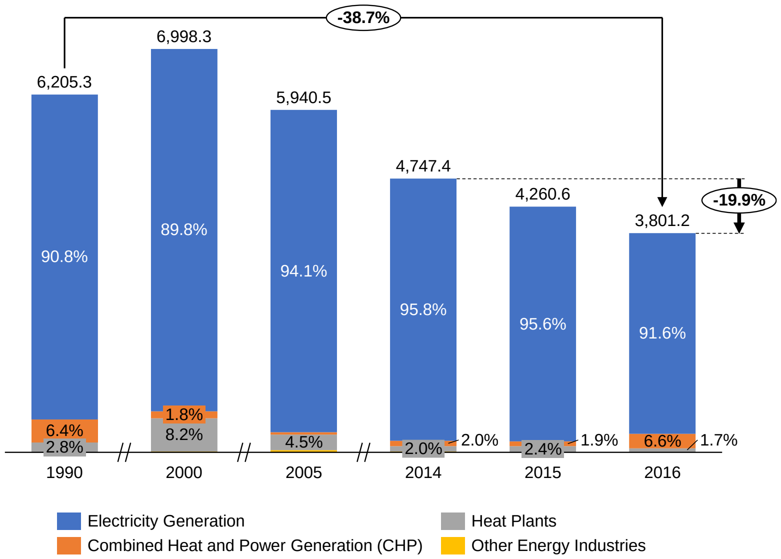
3.2.1 Energy industries

The Energy Industries cover the following subcategories:

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

The Electricity Generation is the biggest contributor within the category with 91.6% of the emissions in 2016 as well as within the Energy sector as a whole with 46.7% in 2016 (Figure 16). Lignite (as a domestic source) and natural gas are the main energy sources for electricity production in the country. In the previous years, the residual fuel oil was one of the main energy sources used in the Energy Industries, but it was gradually replaced by the natural gas especially for electricity and heat production. As a result of fuel switch and mostly on reduction in electricity production from lignite, the emissions from this category in 2016 are lower by 19.9% compared to 2014 and 38.7% compared to 1990.

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 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	1990			2000			2005			2014			2015			2016		
	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	CO_2	CH_4	N_2O
Energy Industries	**6179.6**	**1.7**	**24.0**	**6969.2**	**2.5**	**26.6**	**5913.4**	**1.7**	**25.4**	**4727.5**	**1.2**	**18.7**	**4242.8**	**1.1**	**16.7**	**3785.8**	**1.0**	**14.4**
Main Activity Electricity and Heat Production	**6179.6**	**1.7**	**24.0**	**6956.5**	**2.4**	**26.6**	**5875.3**	**1.6**	**25.3**	**4713.6**	**1.2**	**18.7**	**4237.7**	**1.1**	**16.7**	**3780.2**	**1.0**	**14.4**
Electricity Generation	5613.2	1.3	22.5	6259.8	1.6	24.5	5566.9	1.4	24.6	4527.5	1.1	18.5	4054.6	1.0	16.6	3466.3	0.9	14.2
Combined Heat and Power Generation (CHP)	394.4	0.3	1.1	122.4	0.1	0.3	39.5	0.01	0.2	93.5	0.04	0.1	81.0	0.04	0.04	250.9	0.1	0.1
Heat Plants	172.0	0.2	0.4	574.3	0.7	1.7	268.9	0.2	0.6	92.6	0.04	0.1	102.1	0.05	0.1	63.1	0.03	0.03
Manufacture of Solid Fuels and Other Energy Industries	**NA**	**NA**	**NA**	**12.7**	**0.01**	**0.03**	**38.1**	**0.04**	**0.1**	**13.9**	**0.02**	**0.04**	**5.1**	**0.01**	**0.01**	**5.5**	**0.01**	**0.01**
Other Energy Industries	NA	NA	NA	12.7	0.01	0.03	38.1	0.04	0.1	13.9	0.02	0.04	5.1	0.01	0.01	5.5	0.01	0.01

Note: *NA – Not Applicable*

3.2.2 Manufacturing industries and construction

Manufacturing Industries and Construction as an Energy category had a portion of 13.9% in the overall Energy sector emissions in 2016.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).

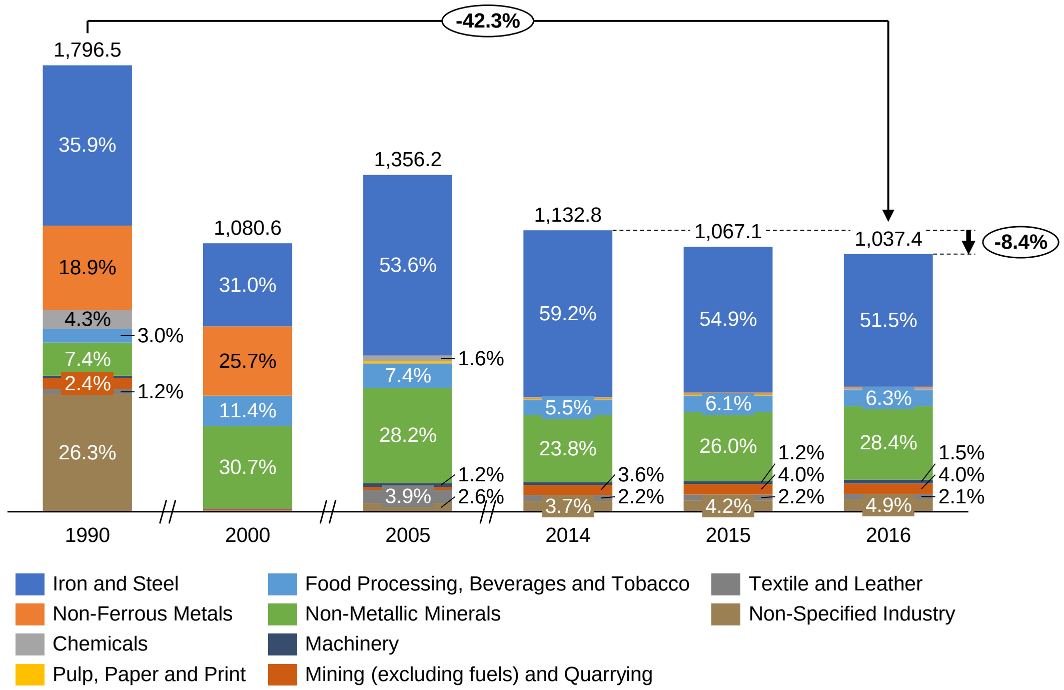
The category itself includes the following subcategories:

- 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 (51.5% of the emissions in 2016), Non-Metallic Minerals (28.4% of the emissions in 2016) and Food Processing, Beverages and Tobacco (6.3% of the emissions in 2016). If the declining trend of the total category emissions is quantified, one can calculate 2.8% when comparing 2016 with 2015, and 8.4% when comparing 2016 with 2014. 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)



Note: In 1990 the categories Non-Specified Industry include more industry branches compare to the other years.

In the previous reports (FBUR and SBUR) the total emissions from Manufacturing industries and construction for the period 1990 - 2004 were reported only under the category Non-specified Industries. In this report, using IEA data and SSO energy balances this is corrected, and the subcategory Non-Specified Industry is disaggregated by different subcategories, thus maintaining a consistency with the emissions reported from 2005 to 2016 in the inventory database.

Table 7. GHG emissions in Manufacturing Industries and Construction, by category and by gas (in Gg CO2-eq)

Categories	1990			2000			2005			2014			2015			2016		
	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	CO_2	CH_4	N_2O
Manufacturing Industries and Construction	**1788.8**	**2.6**	**5.2**	**1075.6**	**1.7**	**3.3**	**1349.7**	**2.2**	**4.2**	**1127.4**	**1.8**	**3.6**	**1062.0**	**1.8**	**3.4**	**1031.9**	**1.9**	**3.6**
Iron and Steel	641.9	1.0	1.9	333.2	0.6	1.2	723.1	1.5	2.7	666.9	1.2	2.3	583.2	1.0	2.0	531.5	0.9	1.7
Non-Ferrous Metals	336.4	0.8	1.4	276.0	0.6	1.0	1.7	0.0	0.0	2.4	0.0	0.0	2.8	0.0	0.0	3.4	0.0	0.0
Chemicals	77.5	0.1	0.2	0.0	0.0	0.0	21.4	0.0	0.0	7.1	0.0	0.0	8.8	0.0	0.0	7.9	0.0	0.0
Pulp, Paper and Print	0.0	0.0	0.0	0.0	0.0	0.0	8.4	0.0	0.0	2.3	0.0	0.0	2.9	0.0	0.0	2.2	0.0	0.0
Food Processing, Beverages and Tobacco	54.5	0.1	0.1	122.6	0.1	0.3	99.5	0.1	0.2	61.5	0.2	0.3	64.8	0.2	0.3	65.0	0.2	0.3
Non-Metallic Minerals	133.0	0.1	0.2	330.9	0.3	0.7	380.8	0.3	0.7	269.0	0.2	0.5	276.2	0.3	0.7	293.1	0.6	1.1
Machinery	9.6	0.0	0.0	2.9	0.0	0.0	16.4	0.0	0.0	10.6	0.0	0.0	12.5	0.0	0.0	15.9	0.0	0.0
Mining (excluding fuels) and Quarrying	43.8	0.0	0.1	5.3	0.0	0.0	11.3	0.0	0.0	40.6	0.0	0.1	42.5	0.0	0.1	40.9	0.0	0.1
Textile and Leather	20.7	0.0	0.1	0.7	0.0	0.0	52.8	0.1	0.3	24.8	0.1	0.1	23.5	0.0	0.1	21.2	0.0	0.1
Non-Specified Industry	471.3	0.5	1.1	3.9	0.0	0.1	34.3	0.1	0.2	42.2	0.1	0.1	44.9	0.1	0.1	50.7	0.1	0.2

3.2.3 Transport

Participating with 28.1% in 2016, the transport category is the second biggest contributor in the overall Energy sector emissions. Regarding the fuels, gas/diesel oil (road diesel), motor gasoline, liquefied petroleum gases (LPG), aviation gasoline and natural gas are used.

Three subcategories actively contributing to the emissions: Road Transportation, Railways and Domestic Aviation. Road Transportation releases almost all of the emissions 99.7% in 2016, while emissions from Railways are 0.3% and from the Domestic Aviation are close to zero (Figure 18). Unlike the other categories and Energy sector as a whole, the emissions from the Transport show an increasing trend, 165% and 26.6% more emissions in 2016 compare to 1990 and 2014, respectively (Figure 18). An insight in Transport GHG emissions by categories and by gasses are given in Table 8.

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

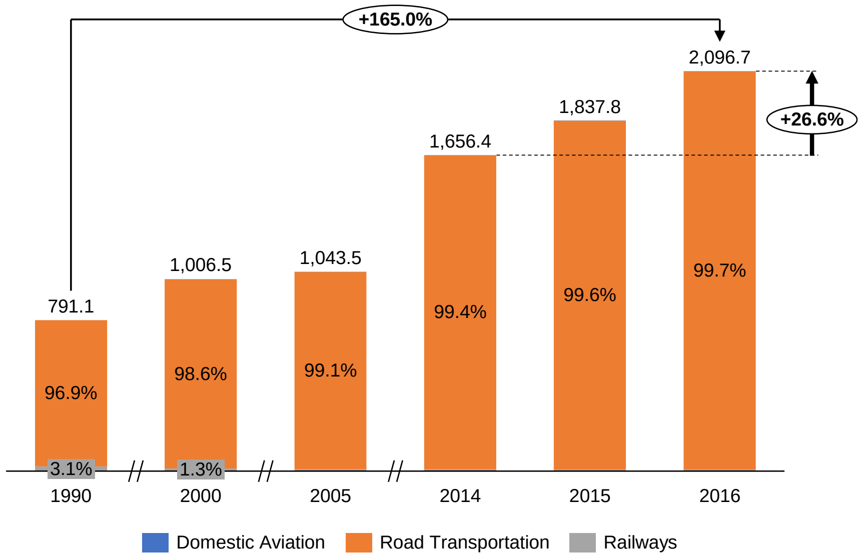


Table 8. GHG emissions in Transport, by category and by gas (in Gg CO_2-eq)

Categories	1990			2000			2005			2014			2015			2016		
	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	CO_2	CH_4	N_2O
Transport	**771.5**	**6.3**	**14.4**	**987.1**	**6.1**	**14.3**	**1021.6**	**7.0**	**15.0**	**1624.4**	**8.3**	**23.8**	**1802.8**	**9.0**	**26.2**	**2057.1**	**9.7**	**30.0**
Civil Aviation (Domestic)	**NA**	**NA**	**NA**	**1.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**
Road Transportation	749.2	6.2	11.2	971.7	6.1	14.3	1013.1	6.9	14.0	1615.7	8.3	22.9	1796.5	9.0	25.5	2050.4	9.7	29.2
Railways	22.3	0.0	3.2	13.3	0.0	0.0	8.3	0.01	1.0	8.3	0.0	1.0	6.0	0.0	0.7	6.4	0.0	0.7

Note: NA – Not Applicable

3.2.4 Other sectors

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. Two subcategories, Residential and Agriculture/Forestry/Fishing/Fish Farms contribute in the emissions in the Other sector category, which emitted only 2.0% in the overall Energy sector emissions in 2016. For the second subcategory, only emissions from stationary combustion of fuels are estimated. In 2016, 69.2% of the emissions in this category came from the Residential subcategory and the rest (30.8%) from the Agriculture/Forestry/Fishing/Fish Farms. The GHG emissions in 2016 were 76.5% and 5.5% lower than the emissions reported in 1990 and 2014, respectively. The GHG emissions from Other Sectors in absolute terms are listed in Table 9.

In the previous reports (FBUR and SBUR), for the period 1990 – 2005 the category Other Sector also included the emissions under the subcategory Commercial/Institutional, while after 2005 these emissions were reported under the Non-specified subcategory (in accordance with the SSO energy balances). In this report, based on the IEA and SSO energy balances, the activity data for the period 1990 to 2005 are included within the Non-Specified instead of Commercial/Institutional subcategory. This was done in order to be compatible with the subcategories reported in the Energy Balances from the SSO, thus reporting a consistent time series of emissions for the period 1990 – 2016 under this category.

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

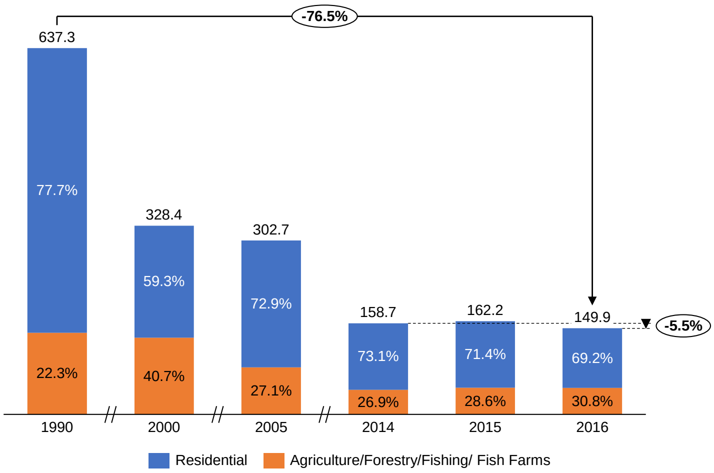


Table 9. GHG emissions in Other Sectors, by category and by gas (in Gg CO_2-eq)

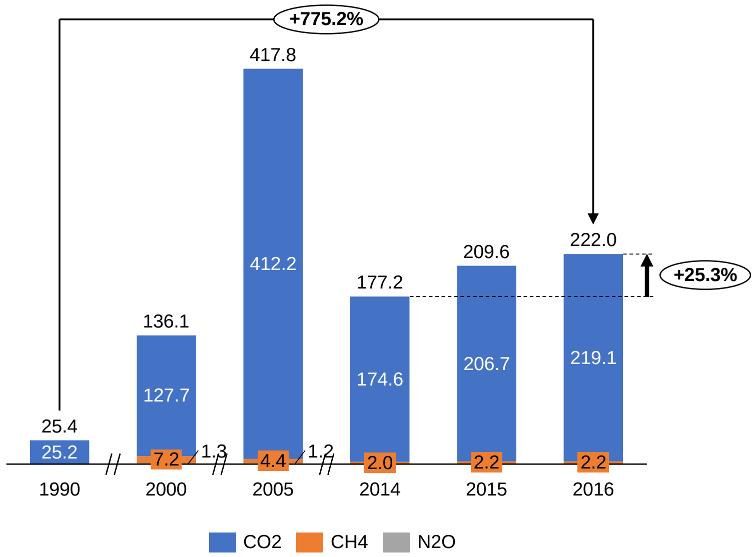
Categories	1990			2000			2005			2014			2015			2016		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Other Sectors	**568.6**	**58.5**	**10.2**	**258.9**	**59.7**	**9.7**	**228.2**	**64.2**	**10.3**	**75.6**	**71.7**	**11.4**	**81.7**	**69.5**	**11.1**	**81.7**	**58.8**	**9.4**
Residential	427.3	58.1	9.8	126.2	59.2	9.4	147.0	63.6	10.1	33.8	70.8	11.3	36.3	68.6	10.9	36.5	58.0	9.2
Agriculture/Forestry /Fishing/ Fish Farms	141.3	0.5	0.3	132.7	0.5	0.3	81.2	0.6	0.2	41.7	0.8	0.2	45.3	0.9	0.2	45.2	0.8	0.2
Stationary	141.3	0.5	0.3	132.7	0.5	0.3	81.2	0.6	0.2	41.7	0.8	0.2	45.3	0.9	0.2	45.2	0.8	0.2

3.2.5 Non-specified

The last category from the Fuel Combustion Activities is Non-Specified, having a share of 3.0% of the Energy sector GHG emissions in 2016. 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 increasing trend. In 2016 there is an increasing of 25.3% compared to 2014. The pick year is 2005 achieving 417.8 Gg CO_2-eq (two times higher compared to 2016. The reason for such huge difference is higher consumption of Lignite, Residual Fuel Oil and Gas/Diesel Oil in 2005, while in 2016 there is more Electricity consumption.

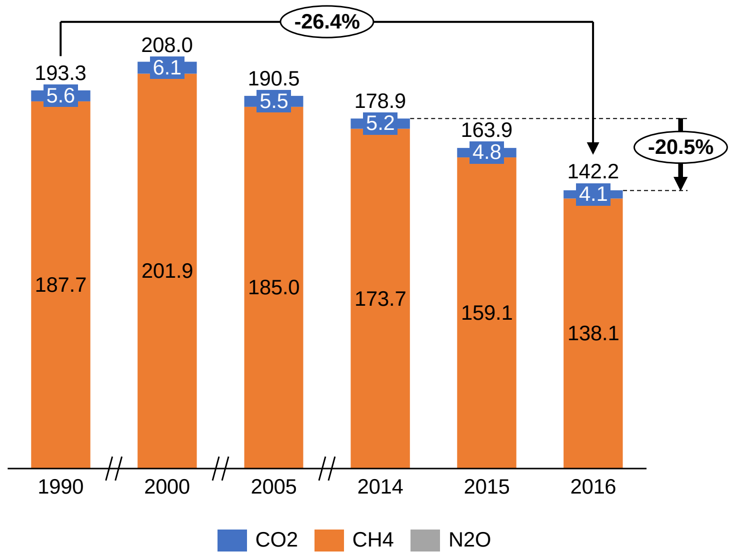
Figure 20. GHG emissions in Non-Specified category (in Gg CO_2-eq)



3.2.6 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 dominantly CH_4 emissions, with lower share of CO_2 emissions that were included in this BUR. The fugitive emissions contributed with 1.9% in the overall Energy sector emissions in 2016. Almost all of them came from solid fuels (coal mining) or 142.2 Gg CO_2-eq in 2016, i.e. the fugitive emissions from oil and natural gas are below 0.1 Gg CO_2-eq (Figure 21). Over the reported period, the fugitive emissions have decreased by 26.4%, while compare to 2014, in 2016 the emission are lower by 20.5%.

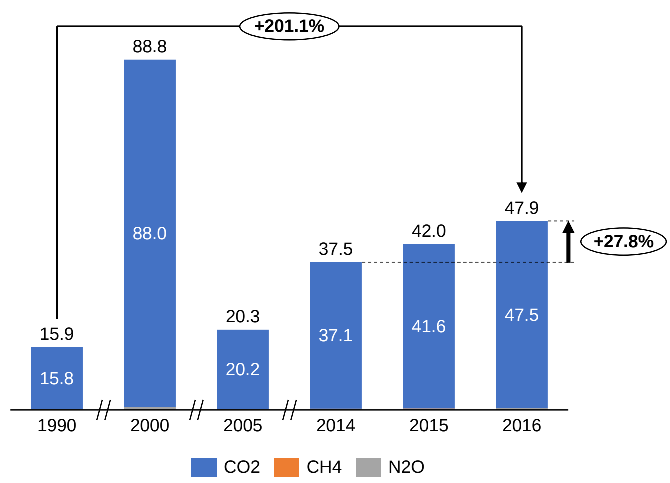
Figure 21. Fugitive emissions from fuels by gasses (in Gg CO_2-eq)

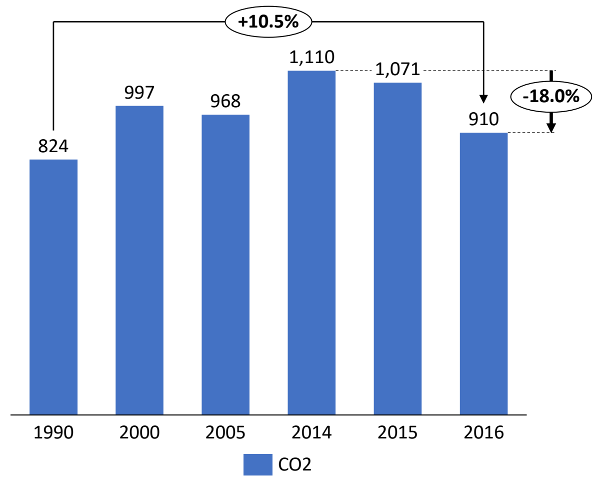


3.2.7 Memo and Infomation Items: International aviation and Biomass combustion for energy production

The contributions from the International Aviation are almost insignificant. Jet kerosine is used as fuel. The emissions have increased throughout the period 2014-2016 (27.8% more emission in 2016 compare to 2014) (**Error! Reference source not found.**). According to the IPCC Guidelines, the CO_2 emissions that occur as a result of biomass combustion for energy production are reported as information items. These emissions have increased over the period 1990 – 2016 for 10.5%, but starting from 2014 a decreasing trend can be noticed, resulting in 18% lower emissions in 2016 relative to 2014, (Figure 23)

Figure 22. GHG emissions from International aviation (in Gg CO_2-eq) – Memo Items	***Figure 23. CO_2 emissions from biomass burning for energy production (Gg) – Information Item***





3.3 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 10 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 2% for all reported years. Furthermore, the differences from 2014 up to 2016 are smaller than 0.02%.

Table 10. Comparison of Sectoral and Reference Approach – total consumption and CO2 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 (%)**
1990	97609.8	9187.0	97641.2	9333.6	-0.032	-1.570
2000	98242.2	9347.6	98065.5	9417.5	0.180	-0.742
2005	100191.8	9041.8	98218.3	8924.9	2.009	1.309
2014	85021.4	7728.3	85027.6	7729.1	-0.007	-0.010
2015	82734.6	7396.2	82722.7	7395.8	0.014	0.005
2016	83019.2	7175.6	83009.6	7175.4	0.011	0.003

3.4 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. Due to lack of data on the carbon content of lignite since 2013 the country-specific emission factor of lignite calculated for 2012 was used to estimate the CO_2 emissions in this BUR as well for the years 2014, 2015 and 2016. Because the quality of natural gas is the same during the reported period, the national emission factor calculated in the FBUR is also applied in this report. The country specific emission factor has also been calculated for residual fuel oil, using the same data on carbon content and the NCV as in the previous BURs.

The State Statistical Office issues annual Energy balances with information on fuel consumption both in natural units and kilotons 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 fuels' NCV from one sector to another were taken into account in this inventory.

When compared to the FBUR, the Energy balances used for the SBUR and 3rd BUR 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.

The concept of disaggregated data set applies also to the biomass and in the Energy balances issued since 2005, it has been reported in the following three categories:

- Biomass
- Wood wastes, Wood briquettes and Pellets
- Wood of fruit trees and other plant residues

In order to take advantage of the disaggregation in this National Inventory Report, the category Biomass is reported in 1000 m^3 under Wood/Wood Wastes in the IPCC Inventory Software. Additionally, Wood wastes, Wood briquettes and Pellets are reported in Gg. Wood of fruit trees and other plant residues are also reported as Wood/Wood Wastes (in 1000 m^3), with different conversion factor (NCV) from the biomass.

In this BUR the activity data for Energy sector are updated in compliance with the revised Energy Balances for period 2005 – 2016 from the SSO (published in October 2016). In continual collaboration with SSO and as a result of the inconsistencies noted by the GHG Energy Inventory team, latest data was obtained and accordingly corrected. The revised Energy Balances have new NCV for biomass used as fuelwood which is implemented in this report.

Regarding the fugitive emissions from fuels, specifically surface mines, the average CO_2 emission factor (0.44m^3 $tonne^{-1}$) from the 2019 Refinements to the 2006 IPCC Guidelines was taken in account, while for the CH_4 the factor remains the same as in the previous BURs.

The emission factors used to estimate the GHG emissions are given in Table 11.

Table 11. Emission factors used for Energy sector

Emission factor	FBUR	SBUR	3rd BUR	Comment
Energy Industries **Manufacturing Industries and Construction** **Other Sectors** **Non-Specified**	CS, DF	CS, DF	CS, DF	CS same as NIR-FBUR[2], NIR-SBUR[3] DF from 2006 IPCC Guidelines
Transport	DF	DF	DF	DF from 2006 IPCC Guidelines
Fugitive emissions from fuels	DF	DF	DF	DF from 2019 Refinements to the 2006 IPCC Guidelines

Note: DF=Default Factor, CS= Country Specific

3.5 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 and the Energy Balances and Statistics from the International Energy Agency (IEA) as a secondary data source. (Table 12)

Table 12. Data sources for Energy sector

	Documents	Data provider
Energy sector	• MAKSTAT database 2005-2016 • Energy balances, Revised data 2005-2016 • Energy Balances, Final data 1998 • Energy Balances, Final data 1999 • Energy Balances, Final data 2000 • Energy Balances, Final data 2001 • Energy Balances, Final data 2002	SSO
	• IEA Energy Balances and Statistics (1990-1997;2003,2004)	IEA

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

[3]Available at: http://unfccc.org.mk/content/Documents/SBUR/3%20Macedonian%20SBUR%20National%20Inventory%20Report.pdf

4 Industrial processes and product use

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, several industries that continued their production have become the largest contributors of GHG emissions in the Industrial processes and product use (IPPU) sector. Most of the GHG emissions come from the metal industry (from steel and ferroalloys production) and the mineral industry (from production of cement production).

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.

4.1 Emission trends

Over the reported period, the emissions from this sector had slightly changed, with generally decreasing trend, however the participation of different categories had significantly changed. In the 2016, the overall emissions from IPPU sector achieved 858 Gg CO_2-eq, which represent a decrease of 8% relative to 1990, or a decrease of 3.2% compared to 2014 (Figure 24).

Until 2000, the metal industry was prevailing source of the emissions, mostly from the ferroalloy production. After 2000, when ODS substitutes usage in the country have started to increase, the share of the GHG emissions from the Metal industry have decreased considerably (from 64% in 1990 to 19% in 2016), while the emissions from the Mineral industry have been fluctuating over the inventory period. In the last three reporting years the product uses as substitutes for ODS had grown for around 50%, resulting with share of almost 37% of the IPPU emissions in 2016. However, the dominant share in 2016 had the Mineral industry with 44%, while the share of the Metal industry was reduced to 19%. Emissions from the other categories, like Chemical industry, Non-Energy Products from Fuels and Solvent Use, Electronics Industry and Other Product Manufacture and Use do not occur in the country (Table 13). In the previous BURs, emissions were reported in the Chemical industry, from Soda Ash production, but during the preparation of this report, all publications from the State Statistical office for the Industry sector were carefully scrutinized and it was concluded that there is only consumption of soda ash in the country (in the industry for production of basic chemical products and in the industry for processing of chemical products). Therefore, the data previously reported under Soda ash production, were now reported as Other Uses of Soda Ash, under subcategory Other Process Uses of Carbonates category in Mineral Industry.

Figure 24. GHG emissions from the IPPU sector, (in Gg CO_2-eq)

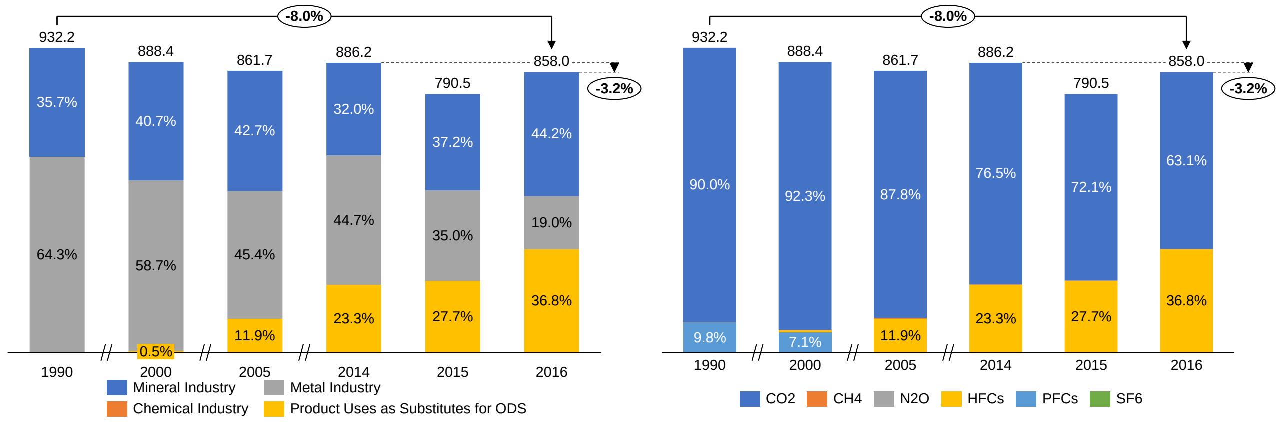


Table 13. GHG emissions from the IPPU sector, by category (in Gg CO2-eq)

Categories	1990	2000	2005	2014	2015	2016
Industrial Processes and Product Use	**932.2**	**888.4**	**758.5**	**886.2**	**790.5**	**858.0**
Mineral Industry	**333.1**	**361.8**	**368.1**	**283.2**	**294.4**	**379.4**
Cement production	293.8	348.8	355.3	275.7	288.6	372.9
Lime production	33.7	11.2	11.1	6.4	4.7	5.4
Glass Production	0.3	0.0	0.0	0.0	0.0	0.0
Other Process Uses of Carbonates	5.3	1.9	1.6	1.1	1.1	1.0
Ceramics	2.6	0.4	0.3	0.0	0.0	0.0
Other Uses of Soda Ash	2.7	1.4	1.3	1.1	1.0	1.0
Other	0.0	0.0	0.0	0.0	0.0	0.0
Chemical Industry	**NO**					
Metal Industry	**599.1**	**521.8**	**390.8**	**396.4**	**277.0**	**162.9**
Iron and Steel Production	24.7	15.2	58.2	17.0	11.0	15.3
Ferroalloys Production	265.6	196.4	332.2	379.4	264.6	145.3
Aluminium production	100.4	68.9	0.4	NO	NO	NO
Lead Production	22.1	23.0	NO	NO	1.4	2.3
Zinc Production	186.2	218.4	NO	NO	NO	NO
Non-Energy Products from Fuels and Solvent Use	**NA, NO**					
Electronics Industry	**NA, NO**					
Product Uses as Substitutes for ODS	**0.0**	**4.8**	**102.8**	**206.6**	**219.1**	**315.7**
Refrigeration and Air Conditioning	0.0	4.8	102.8	206.6	219.1	315.7
Refrigeration and Stationary Air Conditioning	0.0	4.8	102.8	206.6	219.1	315.7
Mobile Air Conditioning*	IE					
Foam Blowing Agents	**NA, NE**					
Fire Protection						
Aerosols						
Solvents						
Other Applications						
Other Product Manufacture and Use						
Other						

Note: *Emissions from Refrigeration and Air Conditioning are calculated based on imported substitute of ODS and all are reported under Stationary Air Conditioning

NO - Not occurring, NA – Not Applicable, NE – Not Estimated, IE – Included Elsewhere

In 2016, the CO_2 emissions accounted for 63.1% of the overall greenhouse emissions from IPPU. The HFCs were second highest contributor and accounted for 36.8% of the total emissions. CH_4 emissions were negligible and accounted only for 0.1% of the greenhouse emissions from this sector. The emission of SF6 were not estimated due to unavailability of activity data. The emissions segregated by gas are presented in Table 15 and Table 16.

Table 14. CO_2, CH_4 and NO_x emissions from the IPPU sector, by category (in Gg CO_2-eq)

Categories	1990			2000			2005			2014			2015			2016		
	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	CO_2	CH_4	N_2O
Industrial Processes and Product Use	**839.3**	**1.3**	**0.0**	**819.8**	**1.0**	**0.0**	**756.7**	**1.8**	**0.0**	**677.8**	**1.8**	**0.0**	**570.3**	**1.2**	**0.0**	**541.7**	**0.6**	**0.0**
Mineral Industry	333.1	NO	NO	361.8	NO	NO	368.1	NO	NO	283.2	NO	NO	294.4	NO	NO	379.4	NO	NO
Chemical Industry	NO, NA																	
Metal Industry	506.2	1.3	NO	457.9	1.0	NO	388.7	1.8	NO	394.6	1.8	NO	275.9	1.2	NO	162.3	0.6	NO
Non-Energy Products from Fuels and Solvent Use	NO, NA	NA		NO, NA	NA		NO, NA	NA		NO, NA	NA		NO, NA	NA		NO, NA	NA	
Electronics Industry	NA																	
Product Uses as Substitutes for ODS	NA																	
Other Product Manufacture and Use	NA																	
Other	NA																	

NO - Not occurring, NA – Not Applicable, NE – Not Estimated

Table 15. HFCs, PFCs and SF_6 emissions from the IPPU sector, by category (in Gg CO_2-eq)

Categories	1990			2000			2005			2014			2015			2016		
	HFCs	PFCs	SF_6	HFCs	PFCs	SF_6	HFCs	PFCs	SF_6	HFCs	PFCs	SF_6	HFCs	PFCs	SF_6	HFCs	PFCs	SF_6
Industrial Processes and Product Use	**NO**	**91.7**	**NO**	**4.8**	**62.9**	**NO**	**102.8**	**0.3**	**NO**	**206.6**	**NO**	**NO**	**219.1**	**NO**	**NO**	**315.7**	**NO**	**NO**
Mineral Industry	NA																	
Chemical Industry	NA																	
Metal Industry	NO	91.7	NO	4.8	62.9	NO	102.8	0.3	NO	206.6	NO	NO	219.1	NO	NO	315.7	NO	NO
Non-Energy Products from Fuels and Solvent Use	NA																	
Electronics Industry	NA, NO		NE, NA	NA, NO		NE, NA	NA, NO		NE, NA	NA, NO		NE, NA	NA, NO		NE, NA	NA, NO		NE, NA
Product Uses as Substitutes for ODS	NO	NO	NO	4.8	NO	NO	102.8	NO	NO	206.6	NO	NO	219.1	NO	NO	315.7	NO	NO
Other Product Manufacture and Use	NA	NO, NA		NA	NO, NA		NA	NO, NA		NA	NO, NA		NA	NO, NA		NA	NO, NA	
Other	NA																	

NO - Not occurring, NA – Not Applicable, NE – Not Estimated

4.2 Mineral industry

4.2.1 Cement production

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. The emissions from the cement production were influenced by the volume of industrial activity and their fluctuation were observed over the inventory period. However, an increasing trend can be seen in the last three years, resulting with 35% higher emissions in 2016 relative to 2014.

In this BUR, some improvements have been made of the activity data for the cement production. Specifically, by taking into account the clinker production and the specific emission of CO_2 (per ton clinker) reported in annual reports from the factory "Titan-Usje", the clinker fraction in cement was calculated for each year in the period 2007 – 2016, and for the previous years (1990 – 2006) the average value of these fractions was used., Also, the annual report for Industry from the SSO were used as a data source for the cement production.

4.2.2 Lime production

According to the SSO's reports for Industry sector, the lime production in the country include production of quicklime, hydraulic lime and slacked lime, with variation in their production between the years (not all of them are produced in all years). In 2010, 2011 and 2012, there is no evident lime production in the country, and from 2012 until 2016 only production of hydraulic lime is reported.

The emissions from lime production are influenced by the volume of industrial activity and are following generally decreasing trend over the inventory period. Thus, in 2016 the emission are 84% lower compared to 1990, and 14% lower compared to 2014.

4.2.3 Glass production

The glass production in the country is noticeable before 2000, but after that there is no substantial production, although in 2016 a slight increase can be seen. As a result, the overall emissions from this category from 0.33 Gg CO_2-eq in 1990 were reduced to 0.05 CO_2-eq in 2016.

4.2.4 Other process uses of carbonates

The other process uses of carbonates in the mineral industry in the country include ceramics production and soda ash use in the chemical industry. The data for different types of clay used in the industry for processing of other non-metallic minerals from the SSO reports, available only until 1998, is used as activity data for ceramic production. To calculate the mass of carbon consumed, a default carbonate content of 10% was used. Since there was evident production of ceramic products (such as bricks and roof tiles, refractory products, expanded clay products, wall and floor tiles, table and ornamental ware, sanitary ware etc.) in the country after 1998, the data for ceramic products were multiplied by a factor of 1.2 in order to continue the trend line for the clay. The factor was calculated as an average of the ratio between the data for clay used in processing industries and the ceramics products produced in the period 1990 – 1998. According to the SSO reports, soda ash is used in the industry for production of basic chemical products and in the industry for processing of chemical products, but data are only available until 1998. The trend of these data was used to extrapolate the series for until 2016.

Therefore, the estimated emissions from other process uses of carbonates followed the decreasing trend of both, ceramic product and soda ash uses.

4.3 Metal industry

4.3.1 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). To calculate the emissions form this category, the data for production of steel middling, steel fragments and slabs were taken into consideration from the SSO reports for Industry, which represent only the steel making process. The MOEPP has started to use Tier 2 approach for calculation of air pollutants from Iron and Steel Industry (for the separate processes) and during the preparation of this report only the data for 2016 and 2017 were available. Once MOEPP will have a consistent series of calculation for each of the Iron and steel processes from 1990 onward, the same activity data should be taken into consideration in the development of the future GHG inventories.

The trend of the CO_2 emissions from steel production had significant variations. The fluctuations can be partially described as consequences of financial crises that have occurred in the country and in the region, and for some years even globally. In 2012, the industrial installations in the country were obliged to buy electricity at the open market, therefore their production become highly dependent on the market price of the electricity, which had also reflection on the emissions from this industry. As a result, the emissions in 2016 from this industry were 38% lower compared to 1990, and 10% lower relative to 2014.

4.3.2 Ferroalloys production

In Macedonia, electricity is mainly used for the production of ferro-alloy. In the electric furnaces, heating is realized 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, mainly as a result of the financial crises (locally and globally). In 2016, the GHG emissions amount have decreased for 45% from 1990 level, and for 62% compared to 2014.

4.3.3 Aluminum production

In Macedonia, there was the largest industrial plant that had a complete process for the production of aluminium alloys, profiles, pipes and structures that was closed. As a result the aluminium production in the country was drastically reduced, and realized by several small production facilities. From 2014 there is no evident production of aluminium. The GHG emissions from this category have significantly reduced after 2003, at level below 1 Gg CO_2-eq.

4.3.4 Lead production

Lead production in Macedonia was realized until 2003 in a lead and zinc smelter that used to produce under IST (Imperial Smelt Technology). In 2015 and 2016, the SSO had reported production of crude lead in the country. As the industrial plant has started with operations in 2015, GHG emissions from this category have occurred again in the country, even though at low level, or 1.4 Gg CO_2-eq in 2015 and 2.3 Gg CO_2-eq in 2016.

4.3.5 Zinc production

The zinc production in Macedonia was performed until 2003 with pyrometallurgical process using Imperial Smelt Technology (IST), 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 GHG emissions from this category occurred until 2003.

4.4 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 data for 2015 and 2016 were provided by the Ozone Unit of the MOEPP.

In this BUR a correction was made in the F-gases data used as input in the IPCC Software. Namely, for the Assumed lifetime of the equipment, the recommended value of 15 years was entered (according to the IPCC Guidelines), and for the Emission Factor from installed base the value of 15 % was used.

The HFC emissions from this sector followed an increasing trend in the reported years, reaching 317 CO_2-eq in 2016, or 53% more compared to 2014.

4.5 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. The emission factors were compared to those used in the previous biennial report and national communications and are presented in the Table 16. 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'*[4].

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

Table 16. Emission factors used for IPPU sector

Emission factor	FBUR, SBUR, 3rd BUR	Comment
Industrial Processes and Product Use	**CS, DF**	
Mineral Industry	**CS, DF**	
Cement production	CS	National CO2 and non-CO2 emission factors for key sectors under IPCC and CORINAIR methodologies
Lime production	DF	DF from 2006 IPCC guidelines
Glass Production	DF	DF from 2006 IPCC guidelines
Other Process Uses of Carbonates	DF	DF from 2006 IPCC guidelines
Ceramics	DF	DF from 2006 IPCC guidelines
Other Uses of Soda Ash	DF	DF from 2006 IPCC guidelines
Metal Industry	CS, DF	
Iron and Steel Production	CS	National CO2 and non-CO2 emission factors for key sectors under IPCC and CORINAIR methodologies
Ferroalloys Production	CS	National CO2 and non-CO2 emission factors for key sectors under IPCC and CORINAIR methodologies
Aluminium production	DF	DF from 2006 IPCC guidelines
Lead Production	DF	DF from 2006 IPCC guidelines
Zinc Production	DF	DF from 2006 IPCC guidelines
Product Uses as Substitutes for Ozone Depleting Substances	DF	
Refrigeration and Air Conditioning	DF	DF from 2006 IPCC guidelines
Refrigeration and Stationary Air Conditioning	DF	DF from 2006 IPCC guidelines

DF=Default, CS= Country Specific

4.6 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 17).

Table 17. Data sources for IPPU sector

	Documents	Data provider
Mineral Industry		
Cement production	SSO, Industrial production 1989 – 1992, 1993 – 1998, 1996 – 2000 SSO, Industry 2002 SSO, Industry 1999 – 2003 SSO, Industry 2000 – 2005 SSO, Industry 2002 – 2007 SSO, Makstat database 2007 - 2015	Usje-Titan – Annual reports; SSO
Lime production		SSO
Glass Production		SSO
Other Process Uses of Carbonates		SSO
Ceramics		SSO
Other Uses of Soda Ash		SSO
Other		SSO
Metal Industry		
Iron and Steel Production	SSO, Industrial production 1989 – 1992, 1993 – 1998, 1996 – 2000 SSO, Industry 2002 SSO, Industry 1999 – 2003 SSO, Industry 2000 – 2005 SSO, Industry 2002 – 2007 SSO, Makstat database 2007 - 2015	SSO
Ferroalloys Production		
Aluminium production		
Lead Production		
Zinc Production		
Product Uses as Substitutes for Ozone Depleting Substances		
Refrigeration and Air Conditioning	HCFC Management Phase out Plan- Report Ozone Unit – MOEPP (data for 2015 ad 2016)	MOEPP
Refrigeration and Stationary Air Conditioning		

5 Agriculture, forestry and other land use

Agriculture, Forestry, and Other Land Use (AFOLU) is unique among the sectors considering the numerous processes leading to emissions and removals of greenhouse gases, which can be widely dispersed in space and highly variable in time. The AFOLU Sector has some unique characteristics with respect to developing inventory methods. The factors governing emissions and removals can be both natural and anthropogenic (direct and indirect) and it can be difficult to clearly distinguish between causal factors. For the AFOLU Sector, anthropogenic greenhouse gas emissions and removals by sinks are defined as all those occurring on 'managed land'. Managed land is land where human interventions and practices have been applied to perform production, ecological or social functions.

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

Forests and forestland in Macedonia cover around 1.1 mil. ha and 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 m3, and total annual growth is around 1,7 mil m3. Very large part of the land considered as forest, are Mediterranean type of forest, characterized with small trees and bushes.

5.1 Emission trends

Livestock sector as a one of the main sources of GHG with a total emission of CO_2-eq varying in a range of 1,108.11 Gg in 1990, to only 792.68 Gg in 2014 (Figure 25 and Table 18). Cattle are the main source of GHG among the ruminants. The majority of methane emission arouses from enteric fermentation while manure management contribute with only 18% of the total CH_4 emissions.

Forestry sector is the major contributor of GHG sinks in Macedonia within the Land subsector of AFOLU, with exception of several years when the amount of forest fires (burned areas) were significantly above the annual average. The area of forestland, the species composition (conifers, broadleaved, mixed), as well as the annual increment and removals from the forests are relatively stable. The estimated GHG sinks in this sector for 2015 is estimated on 1,608.31 and in 2016 2,120.65 Gg CO_2 eq.

The other land use like Cropland, Grassland, Settlements and Other land, participate in the emission of CO_2, and in some years can be considered as a significant source of emissions of this GHG. This emission is mainly result to the conversion of one to another category of land use, when significant amounts of above and below ground biomass is rapidly removed and is considered as a direct loss. For the other areas, which remains under same category of land use, gains and losses, are in balance (Tier 1) and are considered as carbon neutral.

For the non-CO_2 sources of GHG, it can be concluded that there are a numerous management practices and inputs resulting in significant amount of GHG emissions, which total emission when summed up, differ in a small ranges of 313.11 Gg CO_2-eq in year 2000 up to 382.27 Gg CO_2-eq, in 1990. As a major source of non-CO_2 emissions are managed soils, which contribute with 55.4% in 1990, out of the total emissions in this subsector, up to the 62.4 % in 2016.

Figure 25. GHG emissions (and removals) from AFOLU sector (in Gg CO_2-eq)

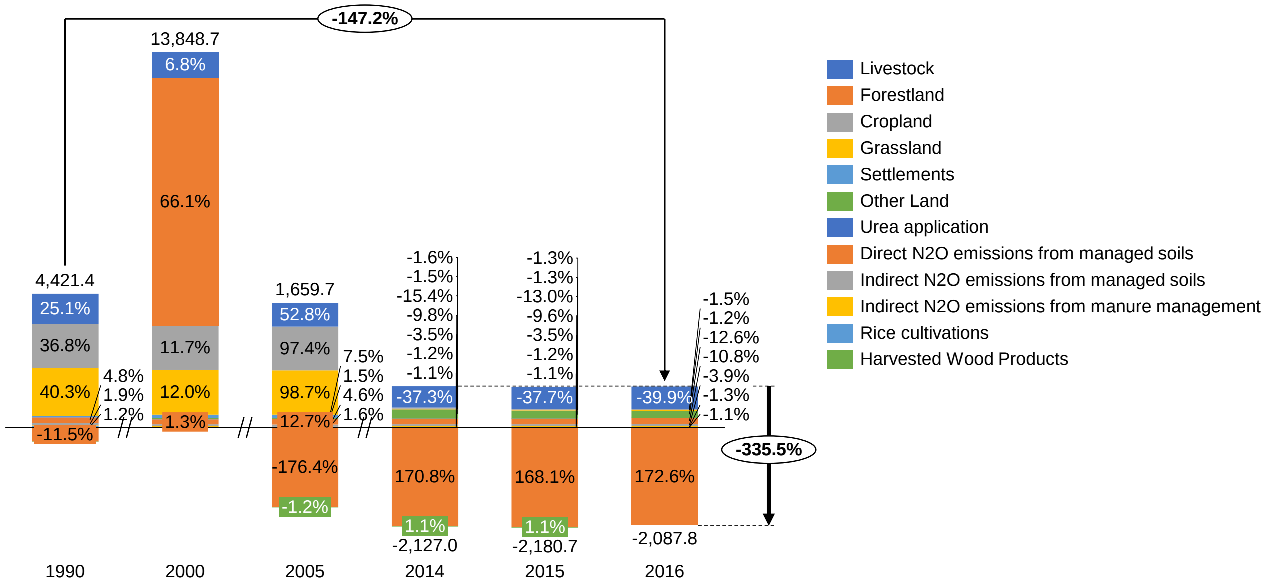


Table 18. GHG emissions and removals from AFOLU sector, by category (in Gg CO_2-eq)

	1990	2000	2005	2014	2015	2016
AFOLU	**4421,35**	**13848,73**	**1659,67**	**-2126,96**	**-2180,67**	**-2087,8**
Livestock	**1108.11**	**936.53**	**876.40**	**792.68**	**821.53**	**833.53**
Land	**2944,71**	**12613,02**	**476,22**	**-3234,23**	**-3316,34**	**-3281,12**
Forestland	-509,78	9160,32	-2927,68	-3632,75	-3666,64	-3603,62
Cropland	1627,44	1624,87	1616,19	34,76	28,84	31,22
Grassland	1780,39	1662,27	1638,68	32,25	27,94	25,80
Settlements	26,77	130,20	124,28	3,64	9,36	2,92
Other Land	19,88	35,35	24,76	327,87	284,16	262,57
Aggregate sources and non-CO_2 emissions sources on land	**382,27**	**313,11**	**327,73**	**338,78**	**337,41**	**359,78**
Urea application	3,74	9,09	1,28	3,67	3,51	3,19
Direct N_2O emissions from managed soils	211,96	183,67	210,79	209,33	208,37	224,45
Indirect N_2O emissions from managed soils	82,25	68,45	77,08	75,46	75,26	80,71
Indirect N_2O emissions from manure management	32,05	29,25	26,47	26,27	27,10	28,01
Rice cultivations	52,27	22,65	12,11	24,05	23,17	23,42
Other	**-13,73**	**-13,92**	**-20,69**	**-24,19**	**-23,27**	**/**
Harvested Wood Products	-13,73	-13,92	-20,69	-24,19	-23,27	/

5.2 Livestock

GHG emissions from livestock activities are consequence of their biological activity and manure management on the farms. However, there are differences in emissions in different species but also type of production, production system, level of productivity, farm specific management, and so on. National livestock production of cattle, sheep, goat and horses, mostly is characterized with production systems with low to moderate intensity. However, some part of dairy cows, and the most of swine and poultry production systems are very intensive where emissions from manure management can be closely monitored. Although steps towards Tier2 were done in SBUR, for 3rd BUR there are still lacks of sufficient data to describe various farms' profiles. Hence, for this report the same emission factors form SBUR were used.

5.2.1 Emissions from livestock activities

Ruminants are the main source of GHG emissions form livestock. In particular, dairy cows and other cattle are emitting the majority of GHGs. Sheep and goats (ruminants), horses, swine and poultry contribute significantly less to the sector's emissions. In 2015 and 2016, CH_4 emissions were around 31 Gg CO_2-eq

(Figure 26). Mainly CH_4 emissions are from enteric formation (82%), while manure management is contributing with 18%. The most CH_4 is produced by enteric fermentation and manure management in cattle (21 Gg CO_2-eq - enteric and 4 Gg CO_2-eq manure) accounting for 80% of total methane emission form livestock. Enteric fermentation from all other species (sheep, goat, horses and swine) contributed about 15% in total CH_4 emission in the sector. The manure management in all those species contributes for only 5% to CH_4 emission from manure management.

N_2O emissions were solely due to manure management. The emissions in 2015-16 were 0.14 Gg CO_2-eq (Figure 27). The main emitters were again cattle manure with 78%, followed by sheep and swine manure contributing each with 7%. Similarly, to CH_4 emissions, dairy cows were the largest contributor with 57% of annual N_2O emissions generated in livestock sector.

In the assessment, emissions of CH_4 and N_2O were transferred into CO_2 equivalents (Table 19).The CH_4 emissions were 781.03 CO_2-eq and 792.17 Gg CO_2-eq in 2015 and 2016. The emissions of N_2O over the years are rather stable around 41 Gg CO_2-eq. The total emissions due to livestock activity in 2015 were 821.53 Gg CO_2-eq, while in 2016, 833.53 Gg CO_2-eq. This increase of about 4-5% compared to 2014 (792.68 Gg CO_2-eq) is due to increase in number of heads in cattle (for about 5%) and swine (for 34%) but decrease in sheep, horses and poultry.

Figure 26. Emissions of CH_4 (in Gg CO_2-eq) from Enteric Fermentation and Manure Management

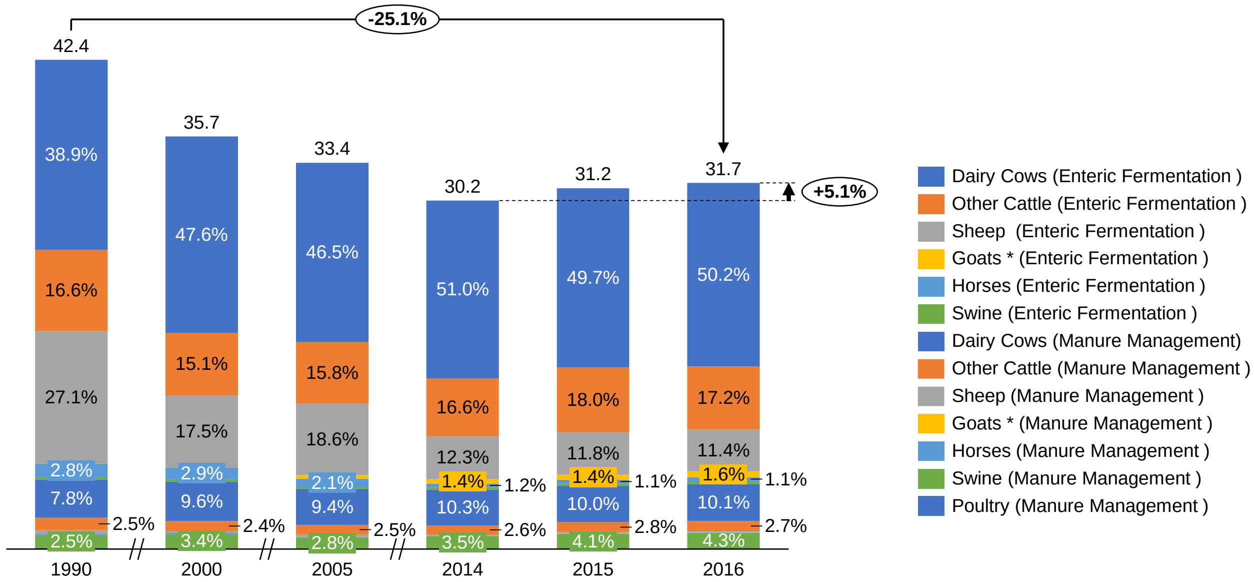


Figure 27. Emissions of N_2O (in Gg CO_2-eq) from Enteric Fermentation and Manure Management

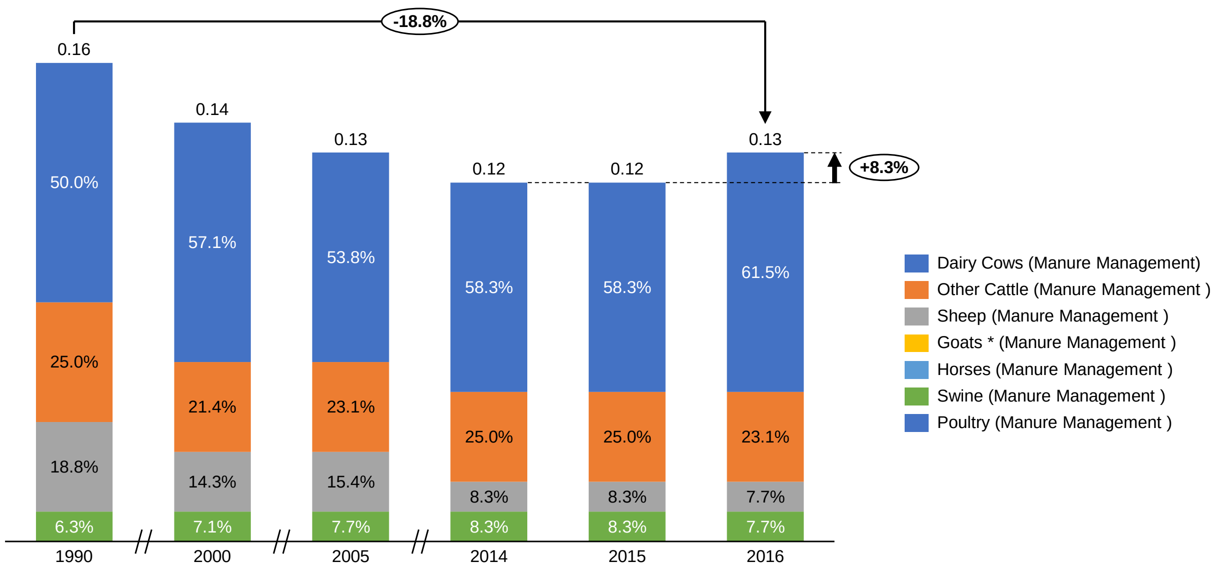


Table 19 Emissions of CH_4 and N_2O (in Gg) due to activities in livestock production

Categories	CH_4						N_2O					
	1990	2000	2005	2014	2015	2016	1990	2000	2005	2014	2015	2016
Enteric Fermentation	**36.33**	**29.88**	**28.23**	**25.01**	**25.77**	**26.06**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Cattle	23.47	22.41	20.83	20.39	21.12	21.36	NA					
Dairy Cows	16.46	17.00	15.54	15.39	15.51	15.90						
Other Cattle	7.01	5.41	5.29	5.00	5.61	5.46						
Sheep	11.49	6.25	6.22	3.70	3.67	3.62						
Goats *	IE	IE	0.31	0.41	0.44	0.51						
Horses	1.19	1.02	0.71	0.35	0.34	0.35						
Swine	0.18	0.20	0.16	0.17	0.20	0.23						
Manure Management	**6.03**	**5.85**	**5.21**	**5.14**	**5.48**	**5.62**	**0.16**	**0.14**	**0.14**	**0.13**	**0.14**	**0.14**
Cattle	4.39	4.27	3.96	3.88	4.00	4.06	0.12	0.11	0.10	0.10	0.11	0.11
Dairy Cows	3.32	3.43	3.14	3.11	3.13	3.21	0.08	0.08	0.07	0.07	0.07	0.08
Other Cattle	1.07	0.84	0.82	0.78	0.87	0.85	0.04	0.03	0.03	0.03	0.03	0.03
Sheep	0.34	0.19	0.19	0.11	0.11	0.11	0.03	0.02	0.02	0.01	0.01	0.01
Goats *	IE0	IE	0.01	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Horses	0.11	0.09	0.07	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Swine	1.07	1.22	0.93	1.06	1.28	1.37	0.01	0.01	0.01	0.01	0.01	0.01
Poultry	0.11	0.07	0.05	0.04	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Total emissions	**42.36**	**35.74**	**33.44**	**30.15**	**31.24**	**31.69**	**0.16**	**0.14**	**0.14**	**0.13**	**0.14**	**0.14**
Total emissions (Gg CO_2-eq.)	**1059.06**	**893.43**	**835.98**	**753.74**	**781.03**	**792.17**	**49.05**	**43.09**	**40.42**	**38.95**	**40.50**	**41.36**

*Note: * Until 2006 the goats are included in the sheep category, IE-Included Elsewhere, NA- Not Applicable*

5.3 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.

5.3.1 Forest land

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

5.3.1.1 Total Forest Area

Data for the total forest area were found in the Statistical Yearbooks, from the State Statistical office, Forestry management plans (PE “Makedonski sumi”, other subjects that manage forests, Ministry of Agriculture, forestry and water economy) and Faculty of Forestry (different experts). All those different data were compared between themselves, and they all differ due to their different update year. It is not possible to find difference in this sector on annual level because there is no legal obligation to evident them. Most of the data are collected on 10 year cycle, there is no forest inventory done, and there are really rear data that can be used with modern technology (satellite images) and prompt evidence of the changes. Analyzing the previous series (1990 – 2014) it was found that the forestry area differs in the data of different subject. This is due to the different needs of different subject. For 2010-2016, extended data for forestry land in the State statistical office reports were found. These data were compared with the data from Forestry sector (MAFWE, PE “Makedonski sumi” and other subjects managing other forests) and found out that it slightly differs from satellite images from CORINE land cover (CLC). For the period 2000-2016, State statistical office has not collected data the same way, so there is a lack of such data.

5.3.1.2 Areas by different tree species

The data for tree species composition in the forests was used from State Statistical office, compared with the data from the Forestry management plans from MAFWE, PE “Makedonski sumi” and other subjects that manage the forests. There were significant differences in data, so they were changed from the previous report, from 2000 to 2016.

In the previous reports, the data for those categories of forestland were not taken into consideration. In this report we established new categories in the IPCC software, established their area, growing stock, and used different emission and sink factors from other forest categories. Since data for those categories before 2010 could not be found, the series is only for the last 6 years.

5.3.1.3 Growing stock

Revising the previous reports, it was noticed that used growing stock factors are not compatible with the national ones i.e. they are too high to implement for the country. The growing stock factors were therefore changed for conifer, broadleaved and mixed categories of forests, as well as for the two new categories established in this report, using data from actual Forestry management plans, provided by the experts from UKIM Faculty of Forestry, Department of Forest growth and yield.

5.3.1.4 Land use changes from and to forestry

Since there are no data on annual level for changes in land use, CLC images were used for 2000, 2006, 2012 and 2018. The changes that were acknowledged for 6-year period were interpolated on annual bases and evidenced in the actual land use changes reports. This was continuation of the first try to actually use modern technologies in this sector, initially introduced in the SBUR.

5.3.1.5 Forest for commercial use and firewood

Analyzing previous report, it was noticed that in the worksheet, extraction of firewood was twice counted in tables Loss of carbon from wood removals and Loss of carbon from fuelwood removals. This was revised, and the series has been updated.

5.3.1.6 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. It was found that there are big alterations in some years between the different sources, therefore expert judgment has been used to select the most appropriate ones.

5.3.1.7 Emission trends

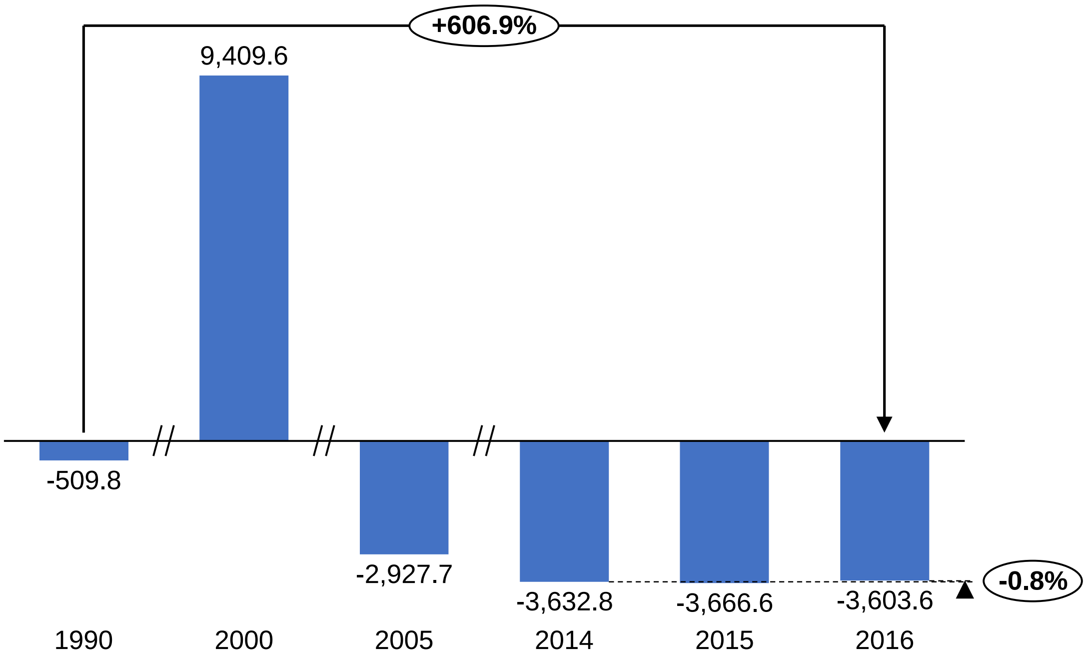
Emissions in Macedonia from forestry sector are product of firewood consumption as well as the forest fires. The most constant producer of CO_2 emission are households that use firewood for heating. Forest fires are the second emitter of CO_2, but they are not constant, and their contribution varies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

Methodology used for estimation of the emission is Tier1, since there are no accurate data on annual level, improved using CLC maps to establish annual land use changes. In addition, the annual increment of different types of forests, were changed and national averages were used for different categories of forests, provided by the experts from UKIM Faculty of Forestry, Department of Forest growth and yield. Default emission factors were used from the software. Land use changes from forestry are shown in Table 20. Trend of the emissions from this sector is shown in the time series in Figure 28.

Table 20. Forestland area, ha

	1990	2000	2005	2014	2015	2016
Forest remaining forest	**970978**	**957550**	**955228**	**1084048**	**1101265**	**1102352**
Land converted to forest land	21554	15969	14030	233	202	187
Total	992532	973519	969258	1084428	1101467	1102539

Figure 28. GHG emissions and removals from Forest land (in Gg CO2-eq)



5.3.2 Cropland

The land use class Cropland covers the area used for cultivation of: field crops, and perennial crops, which mainly includes vineyards, orchards and grasses (meadows and loans). According the methodology of the State Statistical Office (SSO), cropland refers to cultivated land, used for performing agricultural activities for producing of annual yields. 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. This category includes fallow and uncultivated arable land.

According the IPCC methodology, GHG emissions and removals are result to the human activities related to land use change, change of management practices and inputs. If no changes occur, the cropland remaining cropland, under annual crops, is considered as system where emissions and removals are in equilibrium (carbon neutral). Significant alteration in carbon pools on cropland, occurs during the conversions of perennial to annual crops (uprooting), since the whole biomass according Tier 1 is considered as immediate emission, and establishing of new plantation where annual sinks occurs due to the bioaccumulation in the growing plants. Significant change of carbon stocks, because of human activates (change of F_{LU}, F_{MG} and F_I), occurs in SOC pool.

5.3.2.1 Cropland area

In this report, estimation of cropland areas was done on the base of data available within several sources, like national data published in State Statistical Office (SSO) Year Books for the period 1990-2016, and the special publications of the SSO, *"Field crops, orchards and vineyards*" and *"Macedonia in numbers"* (2004-2016) and the digital data base, MakStat (http://makstat.stat.gov.mk/PXWeb/ pxweb/en/MakStat) for the period 2014-2016.

In order to improve the quality and consistency of data for areas under cropland, in this report additional data sources, like CORINE Land Cover (CLC), were used. In previous report, the digital data from CLC was used for calculation of areas under Cropland and were checked against the official state data; while for the period before 2000 (when CLC did not existed); SSO data were used for areas under Cropland. Statistical data from the period of the '90 does not correspond to the IPCC land use categories and in addition to the forestland and cropland contains data only for grassland and other land. Most probably, for these reasons, the total area under Cropland is reported for more than 620,000 ha, which is much higher than the areas of Cropland after year 2000. In this NIR, additional effort for improvement of the activity data used for land use has been made, i.e. data extrapolation for the years before 2000, based on the period of 18 years (2000-2008) with CLC database.

As a result, the area under Cropland is estimated on 542668 ha, which is in line with the other five years which are reported in this period, where the area under cropland fluctuate in a range of several hundred hectares from year to year.

The analyze of the CLC graphical data set, also enables us to calculate the spatial conversions from other land use category to Cropland, which is of crucial importance for calculation and estimation of the GHG emissions, and implementing of the Approach 3 and higher Tiers in selection of activity data. In addition, the conversions in Cropland were extrapolated until 1990, which enable us to estimate the emissions of CO_2, since the post part of emissions is result to the conversions.

In terms of emission factors, in an absence of national emission factors, the global one is used. This is a serious obstacle in accurate estimation of the emissions of GHG, since the emissions factors are the second crucial component in addition to the activity data, for estimation of emissions/removals, hence the use of global data, excludes any possibility for moving towards higher Tier,

Therefore, if the national priority is to implement higher Tier methodology in assessment of the GHG emissions in the crop production subsector, the intensive investing in research related to determination of national emission factors is required.

5.3.2.2 Perennial crops area

Perennial area as a part of Cropland is of significant importance for estimation of the emissions and removals in this category of land use. As previously, mentioned, perennial crops participate in removals o CO_2 on yearly base, through its accumulation in the above and below ground biomass. Despite this, when uprooted (clearance) a huge emission of CO_2 occurs. For these reasons, accurate estimation of perennial crops is very important. In our country, 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 from several sources, the special publication Field crops, orchards and vineyards, published by State statistical office of the Republic of Macedonia (period 2007-2016) and the Statistical Yearbook of Republic of Macedonia, for the period 1990 – 2006, of total areas. For this report in order to have a better overview of the dynamics of the new established and uprooted perennial plantations, additional data were collected from the regional offices of the Ministry of Agriculture, Forestry and Water Economy and the Agency for Financial Support of Agricultural and Rural Development (Paying agency.)

5.3.2.3 Cropland Area remaining cropland

The cropland area that remain as a cropland in each year was calculated based on the total cropland area and the total land use changes was subtracted from other land use types to the results obtained from the conversion analyses conducted by CLC temporal analyses.

5.3.2.4 Conversion from one to other land use type

The area of converted area is estimated exclusively on the base of CLC data set. For the period 2000-2018, 4 data sets were used covering 3 periods 2000-2006-2012-2018.

Conversions were permed with subtraction of the territory designated as Cropland, from each consecutive data set. New areas are considered as gains while the missing parts are considered as loss. With the special analysis performed in GIS environment, it was possible to determine the origin of the gains and conversion path of losses. On this way, an estimation of areas Cropland remaining Cropland and conversions of each land use category to Cropland and, was enabled.

Out of the data presented in Table 21 it can be noticed that the area of land converted to cropland is significantly variable. This variability is due to the inconsistency of the CLC data set or the country. The total area of converted land in the period 2000-2016 is much higher than for the other 2 periods. It is assumed that the data set from the year 2000, which was the first data set for the country, suffered massive corrections in 2006, when most probably huge areas were converted from one to another category of land use. For the periods 2006-2012 and 2012-2018 datasets, converted area for all land use types is significantly reduced, indicating that the CLC database has been improved.

5.3.2.5 Emission trends

Emission from cropland are manly result to the conversions and changes in perennial plantations. Giving though that the converted areas, as previously explained, significantly differ among the reported years, in a range of over 12 thousand ha in year 2000, to only 155.1 ha in 2016, the quantities of emitted CO_2 differ as well from more than 1620 Gg CO_2-eq in 2000, to just 31.22 Gg, which is more reliable quantity than the former one.

As for the Cropland Remaining Cropland the areas are stable and vary in the range of 542,667.9 in 1990 (extrapolated value), down to 508,399.11 in 2000. In all other years the area is very similar, around 512 to 516 thousand ha. The quantities of emitted CO_2 are very low and are mainly due to the changes in perennial crops. In the period 2014-2016 there is a negative trend (removals) of CO_2 which is result to the more intensive establishing of perennial plantations (especially orchards), as a result of the policy of subsidizing the establishment of perennial plantations (Table 22 and Figure 29).

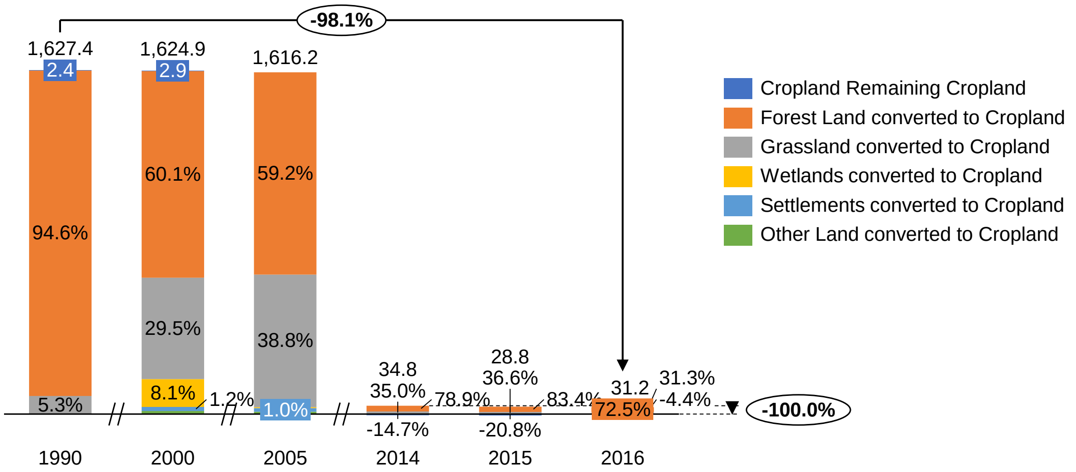
Table 21. Cropland, ha

	1990	2000	2005	2014	2015	2016
Cropland, area, ha	**542,668**	**508,399**	**516,312**	**513,271**	**512,882**	**512,303**
Cropland Remaining Cropland	525,559	496,170	505,176	513,078	512,714	512,148
Land Converted to Cropland	17,109	12,229	11,136	193	168	155

Table 22. Emissions from cropland (CO_2-eq)

	1990	2000	2005	2014	2015	2016
Cropland, Gg CO_2,	**1627.44**	**1624.87**	**1616.19**	**34.76**	**28.84**	**31.22**
Cropland Remaining Cropland	2.41	2.93	0.00	-5.12	-6.00	-1.38
Land Converted to Cropland	1625.03	1621.95	1616.19	39.88	34.84	32.60
Forest Land converted to Cropland	1538.77	977.08	956.50	27.44	24.06	22.64
Grassland converted to Cropland	86.26	479.09	626.49	12.18	10.56	9.76
Wetlands converted to Cropland	0.00	131.80	4.74	0.00	0.00	0.00
Settlements converted to Cropland	0.00	18.84	16.94	0.03	0.02	0.02
Other Land converted to Cropland	0.00	15.14	11.53	0.23	0.20	0.18

Figure 29. GHG emissions from Cropland (in Gg CO_2-eq)



5.3.3 Grassland

Grassland together with the cultivated land represent the total agriculture land. This land use category (according to the CLC that has been used for this analysis) encompasses the following categories: Pastures, Complex cultivation patterns and Natural land with significant areas of natural vegetation. Pastures covers areas on higher altitudes above the forests, called high mountainous pastures, and areas in the lower parts used for grazing of animals during the winter period. The majority of grassland is state owned and managed by the Public Enterprise or Pasture Management, while only small part of grassland is private owned. Grassland is used for grazing of animals on open field predominantly sheep's, and on small areas a special breed of domestic cattle. Grassland in the past decades has been undermanaged and therefore in many cases grassland degraded and unsuitable for sheep breeding.

Unlike cropland, which is under heavy pressure of the human activities, like unsuitable management practices and inputs, grassland can be threatened just from over grazing, especially in the summer period when grazing of the animals on an open field is particularly intensive. During wither period this pressure is much lower.

In terms of GHG emissions, according to the IPCC methodology, due to the low inputs and management practices for the areas designated as Grassland Remaining Grassland, in Tier 1 approach, grassland is considered as a system in equilibrium in terms of emissions/removals, due to what emissions are not reported. The only inputs on these areas is the urine and excrement deposition from grazing animals.

Main sources of GHG emission arouses during the conversion of other land to grassland, especially forest and cropland.

5.3.3.1 Total Grassland

For this report in order to have better overview of the spatial distribution of Grassland and its temporal dynamics, CLC graphical data set was used as a main source of information. In addition several auxiliary national data sources were used as well, like: State Statistic Office Year Books for the period 1990-2016, and the special publications of the SSO, Field crops, orchards and vineyards and Macedonia in numbers (2004-2016) and the digital data base, MakStat (http://makstat.stat.gov.mk/PXWeb/ pxweb/en/MakStat) for the period 2014-2016.

Similarly, like with the Cropland, data obtained with the analysis of CLC, were further interpolated in order to file gap years between two reporting period, while for the period before year 2000, extrapolation has been made based on the four existing data sets, with satisfactory results.

According the results from the analysis, it can be noted that the total area of grassland fluctuates in a very narrow range from slightly above 667 thousand ha in 2000 to around 615 thousand ha for the period 2014-2016 (Table 23).

In an absence of national emission factors, the global one is used, which is a serious obstacle in accurate estimation of the emissions of GHG, and excludes any possibility for moving towards higher Tier. The development of national emission factor as a prerequisite or implementing of higher Tier needs long-term and exact research activities.

5.3.3.2 Grassland remaining grassland

Grassland remaining Grassland, are areas designated as Grassland in at least two consecutive CLC data sets, all other changes are considered as gains and losses and are reported as conversions.

5.3.3.3 Conversion from other land use types to grassland

As in the case of Cropland conversion were calculated through spatial and temporal analysis of CLC data set, by the means of GIS methods. As previously explained, because of the inconsistency o the CLC, the areas under Grassland or the first period 2000-2006 seriously differ from the other 2 periods (2006-2012 and 2012-2018). Still, there are certain trend that should be noted, despite this discrepancy, especially the fact that the majority of conversion to this land use category for all periods arouses from Forest and Croplands to Grassland. As mentioned before, the converted areas to Grassland from other categories, for the period 1990-2000, were calculated with interpolation of CLC data.

5.3.3.4 Emission trends

Emissions from the areas of Grassland Remaining Grassland are not reported since removals and emissions, according Tier 1 approach, are in equilibrium (carbon neutral) in all CO_2 pools, like above and below ground biomass, dead wood and SOC. There are certain sources of non-CO_2 emissions from burning of Grassland, but due to the absence of exact data of the burned areas, these emissions are not reported. The emission from the grassland is mainly caused by land use changes. Emissions trends from Grassland similarly like the area under this category significantly differ from 1,662.27 Gg CO_2-eq in year 2000, to only 25.8 Gg CO_2-eq. The values of CO_2 emissions, within the period 2014-2016 are very similar, with slight decreasing over time (Table 24 and Figure 30).

In order to bridge this serious obstacle with the CLC database, in the next reports additional efforts will be made in order to increase the estimation accuracy of land use. As planned, other sources of data will be used, like satellite imagery photointerpretation and other existing auxiliary graphical data on a national level.

Still in this moment, our opinion is that the emissions reported for the period 2014-2016 are closer to the real situation in the country.

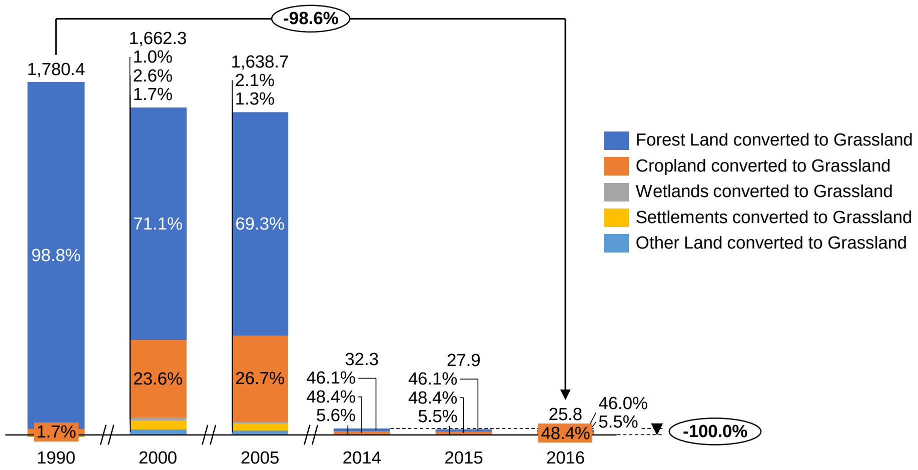
Table 23. Grassland area, ha

	1990	2000	2005	2014	2015	2016
Grassland	**637,103**	**667,146**	**645,420**	**616,297**	**615,980**	**615,700**
Grassland Remaining Grassland	616,821	653,847	632,219	616,082	615,794	615,529
Land Converted to Grassland	20,282	13,299	13,201	214	186	171

Table 24. Emissions from grassland (CO_2-eq)

	1990	2000	2005	2014	2015	2016
Grassland	**1,780.39**	**1,662.27**	**1,638.68**	**32.25**	**27.94**	**25.80**
Grassland Remaining Grassland	0.00	0.00	0.00	0.00	0.00	0.00
Land Converted to Grassland	1780.39	1662.27	1638.68	32.25	27.94	25.80
Forest Land converted to Grassland	1759.48	1181.31	1135.38	14.86	12.87	11.87
Cropland converted to Grassland	30.76	393.01	437.08	15.60	13.52	12.49
Wetlands converted to Grassland	-1.89	16.76	9.35	1.79	1.55	1.43
Settlements converted to Grassland	-5.60	43.61	35.19	0.00	0.00	0.00
Other Land converted to Grassland	-2.36	27.57	21.67	0.00	0.00	0.00

Figure 30. GHG emissions from Grassland (in Gg CO_2-eq)



5.3.4 Wetland

Wetlands as a land use category in this report, encompasses several categories of CLC data set, like peat bogs and inland marches. The national Statistic does not report wetlands as a particular type of land use; due to what CLC is the only source of information.

It should be noted that these two land use classes of wetlands according CLC, covers area in the ranges of 15.3 to 15.9 thousand of hectares. According IPCC methodology, wetlands are defined as lands where the water table is artificially changed.

Following this definition, as wetlands in the country can be considered the small areas, which a left as remains of the reclaimed wetlands during the period of 50's and 60`is 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.

In addition to this, there are two small localities o peatland, which does not cover more than 20 ha and are not used for commercial purposes.

5.3.4.1 Total Wetland

As mentioned above, the total area of Wetland according CLC is estimated of 15.3-15.9 thousand ha. Most of them are protected by law and serve as natural habitats for various plant and animal species. As most referent are Katlanovo wetland, Ezerani and Monospitovo. Like in the previous cases, in order to fill the gap between reporting years of the CLC, linear regression was used to estimate the areas under Wetlands for years where CLC data are not available.

5.3.4.2 Wetland remaining wetland

For the identification of the areas under Wetland Remaining Wetland category, the exact procedure was followed like in the formerly described cases of Cropland and Grassland.

5.3.4.3 Conversion from other land use types to wetland

Conversion of other land categories to Wetlands were determined with spatial and temporal analysis of CLC data sets the year 2000, year 2006, year 2012 and 2018.

For the period 1990-2000 similarly like explained before linear regression model was used or extrapolation of CLC data.

5.3.4.4 Emission trends

Unfortunately, due to problems we faced with the database or software we did not get any emission or sink from the wetlands.

5.3.5 Settlements

Settlement is another category of land use that is not reported within the official national statistics of land use. For this reason, CLC data source was used to estimate the spatial distribution of the area of this category as well as its temporal dynamics. For this NIR, several land use classes relevant to Settlements were used (out of in total 31 class of land use reported in CLC data set): Continuous and Discontinuous urban fabric, Green urban areas and Sport and leisure facilities.

5.3.5.1 Total Settlements

Total area under this category of land use is estimated of approx. over 30 thousand ha, which slightly increase over time from 29,975 ha in 1990 up to 34,638.3 as a result of the intensive urbanization and conversion of other categories of land use into urban areas. This process of conversion is becoming very intensive and is serious problem since very often a fertile agricultural land is lost with soil sealing (Table 25).

Due to the big mapping units of the CLC data set and the large width of the linear objects, numerous villages from desegregated type are probably not considered as urban area. It is evident that the applied methodology is not fitting well to the area covered by infrastructure, but this was the best available data source. This fact increases the need of land use classification 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. In addition, this will solve problem of obtaining annual data for land use changes, real data instead of 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. Therefore, putting high priority on this issue in future is recommended.

5.3.5.2 Settlements Area remaining Settlements

Settlement Remaining Settlements category of land use are areas designated as Grassland in at least two consecutive CLC data sets. All other changes are considered as gains and losses and are reported as conversions.

5.3.5.3 Conversion from one to other land use type

Like in the cases of the other land use categories, conversion was calculated through spatial and temporal analysis of CLC data set, by the means of GIS methods. As previously explained, because of the inconsistency o the CLC, the areas under Grassland or the first period 2000-2006 seriously differ from the other 2 periods (2006-2012 and 2012-2018). In this case, the majority of area converted to settlements arouses from the categories of Cropland and Grassland, which is another prove of an intensive urbanization and soil sealing of fertile agricultural land and pastures. Similarly, like in the other categories of land use, the areas of converted areas to Settlement from other categories, for the period 1990-2000, were calculated with interpolation of CLC data.

5.3.5.4 Emission trends

The emission from the settlements is mainly caused by land use changes. The category of Settlements Remaining 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 and emission trends are calculated for the converted land or the reporting period. For the estimation of the gap years, between the years to which CLC refers to, interpolation of the data was performed, while for the period before year 2000, extrapolation has been made. Like in the previous cases, there is a huge discrepancy between the first and the other two period of CLC data. From the beginning of the period in 1990 up to year 2005 there high emissions of CO_2-eg which rate up to 130.2 Gg (year 200), while in the period beyond 2005, as a result to the small conversion rates, the emission is significantly reduced, to only 2.92 Gg CO_2-eq in 2016 (

Table 26 and Figure 31).

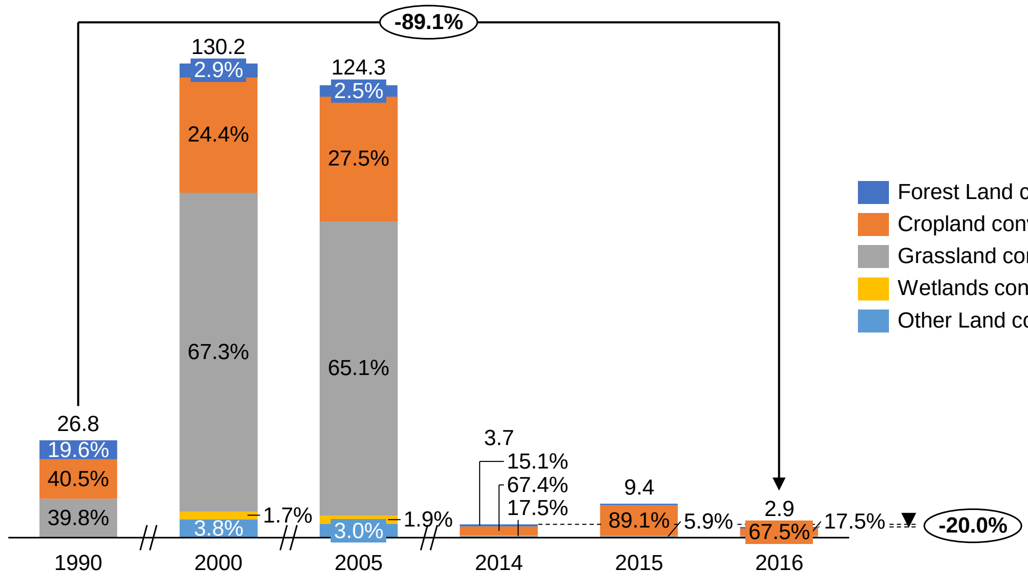
Table 25. Settlements area, ha

	1990	2000	2005	2014	2015	2016
Settlements	**29,975**	**31,785**	**34275**	**34,597**	**34,618**	**34,638**
Settlements Remaining Settlements	28,259	30,610	33158	34,569	34,593	34,615
Land Converted to Settlements	1,716	1,175	1117	28	25	23

Table 26. Emissions from settlements (CO_2-eq)

	1990	2000	2005	2014	2015	2016
Settlements	**26.77**	**130.20**	**124.28**	**3.64**	**9.36**	**2.92**
Settlements Remaining Settlements	0.00	0.00	0.00	0.00	0.00	0.00
Land Converted to Settlements	26.77	130.20	124.28	3.64	9.36	2.92
Forest Land converted to Settlements	5.26	3.72	3.16	0.55	0.47	0.44
Cropland converted to Settlements	10.85	31.76	34.19	2.46	8.33	1.97
Grassland converted to Settlements	10.66	87.57	80.87	0.64	0.55	0.51
Wetlands converted to Settlements	0.00	2.16	2.34	0.00	0.00	0.00
Other Land converted to Settlements	0.00	5.00	3.71	0.00	0.00	0.00

Figure 31. GHG emissions from Settlements (in Gg CO_2-eq)



5.3.6 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.

5.3.6.1 Total Other land

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

5.3.6.2 Conversion from one to other land use type

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

5.3.6.3 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. Land use changes for Other land are shown in Table 27.

Table 27. Other land area, ha

	1990	2000	2005	2014	2015	2016
Other land	**323,056**	**335,061**	**349,940**	**222,338**	**205,774**	**217,211**
Other land Remaining Other land	321,306	333,342	348,801	220,254	203,968	215,542
Land Converted to Other land	1,750	1,718	1,139	2,084	1,806	1,669

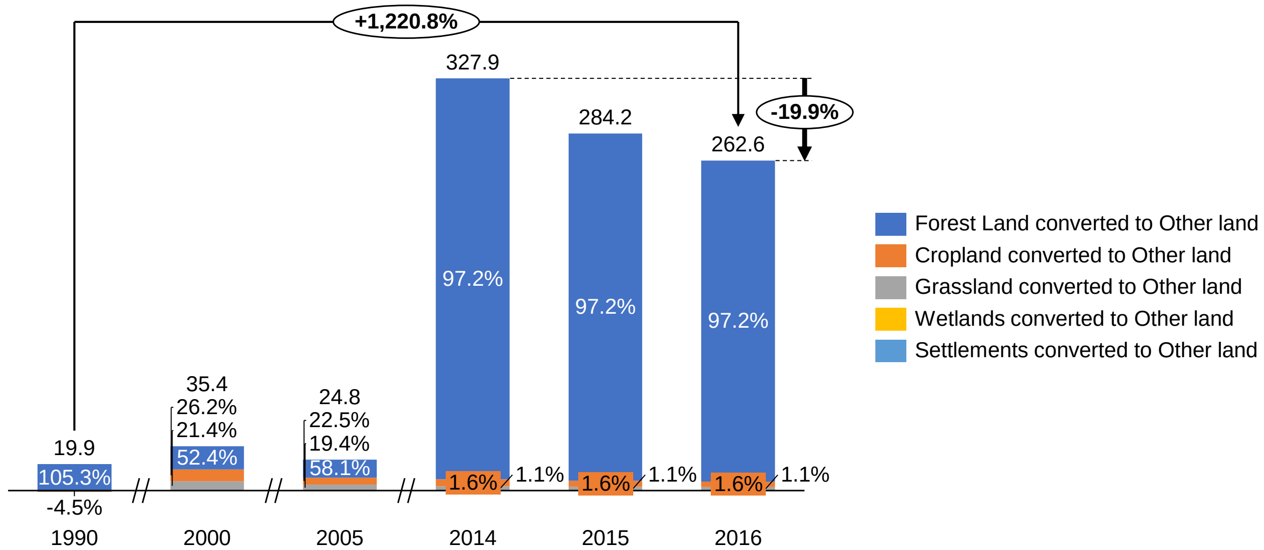
5.3.6.4 Emission trends

The emission 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 analysed. From the beginning of the period up to year 2006 there is reduction of the emissions, while after 2006 the trend is increasing, but with much lower rate that rate of the decreasing in previous period (Table 28 and Figure 32).

Table 28. Emissions from other land (CO_2-eq)

	1990	2000	2005	2014	2015	2016
Other Land	**19.88**	**35.35**	**24.76**	**327.87**	**284.16**	**262.57**
Other Land Remaining Other Land						
Land Converted to Other Land	19.88	35.35	24.76	327.87	284.16	262.57
Forest Land converted to Other Land	20.93	18.54	14.37	318.82	276.32	255.33
Cropland converted to Other Land	-0.90	9.26	5.57	5.38	4.66	4.31
Grassland converted to Other Land	-0.15	7.55	4.81	3.66	3.17	2.93
Wetlands converted to Other Land	0.00	0.00	0.00	0.00	0.00	0.00
Settlements converted to Other Land	0.00		0.00	0.00	0.00	0.00

Figure 32. GHG emissions from Other land (in Gg CO_2-eq



5.4 Aggregate sources and non-CO_2 emissions sources on land

Non-CO_2 emission refers to the practices in the AFOLU sector, which result in an emission of so-called non-CO_2 GHG, like: NOx, CO, CH_4. There are many management practices and inputs which a considered as important source of non-CO_2 emissions. The emissions considered here are from different sources as biomass burning, liming, urea application, and direct N_2O emissions from managed soils, indirect N_2O

emissions from managed soils, indirect NOx emission from manure management and methane emission from rice cultivation.

- Emission from biomass burning on Land, especially burning of Forest and Pastures, as well as burning of agricultural by-products,
- N_2O direct and indirect emission from managed soils, including indirect N_2O emissions arousing from the inputs of N containing urea and mineral fertilizers, and liming which is a practice used for changing of soil reaction. In this case significant quantities of lime are used which provokes emission of non-CO_2 gases. Liming is not a common practice in the country. As a result of this and inexistence of data, liming is not reported.
- NOx emission manure management is another significant source of NOx.

The emissions from of these particular sources, are not very high, except direct N_2O emissions from managed soils, but when aggregated they are much higher than direct CO_2 emissions from any of the land use classes.

The highest values of non-CO_2 emissions has its highest values in 1990, while its lowest values are in the year 2000, when gradually starts to increase up to 2016 with total annual emission of 359,78 Gg of CO_2 –eq (Figure 33 and Table 29).

Figure 33. GHG emissions from Aggregate sources and non-CO_2 emissions sources on land (in Gg CO_2-eq)

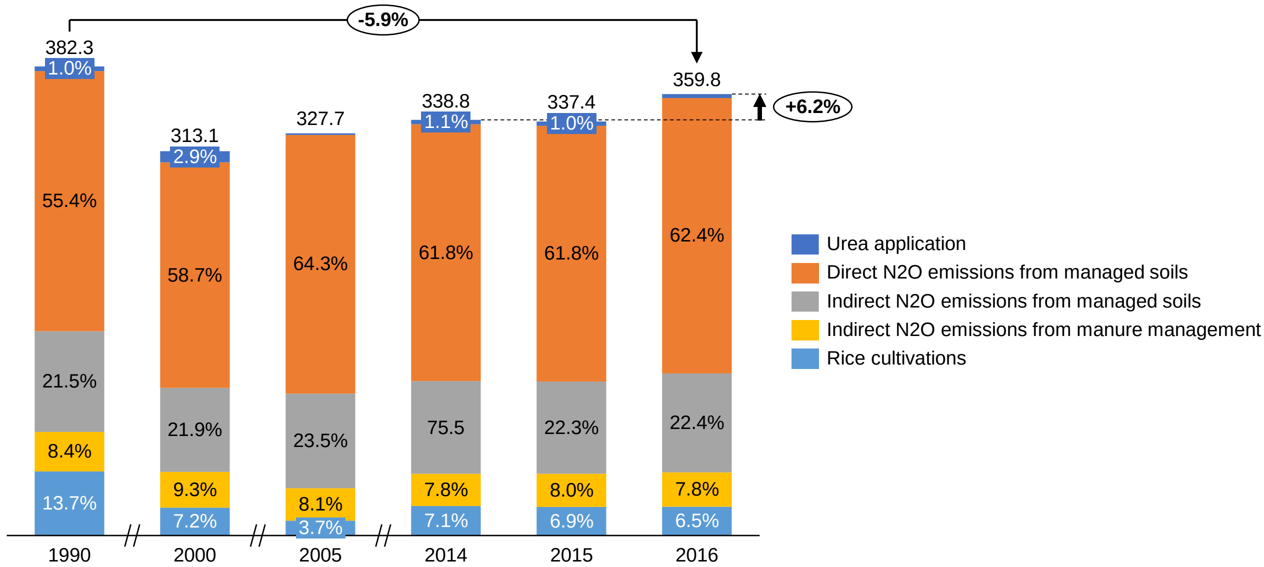


Table 29. GHG emissions from Aggregate sources and non-CO_2 emissions sources on land (in Gg CO_2-eq)

Categories	1990	2000	2005	2014	2015	2016
Aggregate sources and non-CO_2 emissions sources on land	**382.27**	**313.11**	**327.73**	**338.78**	**337.41**	**359.78**
Urea application	3.74	9.09	1.28	3.67	3.51	3.19
Direct N_2O emissions from managed soils	211.96	183.67	210.79	209.33	208.37	224.45
Indirect N_2O emissions from managed soils	82.25	68.45	77.08	75.46	75.26	80.71
Indirect N_2O emissions from manure management	32.05	29.25	26.47	26.27	27.10	28.01
Rice cultivations	52.27	22.65	12.11	24.05	23.17	23.42

5.4.1 Urea application

Urea is an important amendment in common agricultural practices. 46% of Urea is used as fast supplement of N to a growing plant in spring when plants enter intensive growing stages. The N in the urea is in amide form ($CO(NH_2)_2$), mining that the release of nitrogen is in close relation to the microbial activities of soil microflora. During this process the 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.

Emission of non-CO_2 GHG is very low and significantly variable in the period 1990-2005 while in the last 3 year of the reported period is stable in a range of 3.67 Gg-CO_2-eq in 2014, to 3.19 Gg-CO_2-eq in 2016(Figure 33). The low emission is mostly result to the limited use of urea in agricultural production, mainly on cereals and vegetables, in early spring, in the other phases of vegetation phases a slow release N fertilizer are needed, so the application of urea is quite limited.

5.4.2 Direct N_2O emissions from managed soils

Soil is very complex and dynamic media, where a vast number of processes occurs within very narrow time frame, which mostly result to the microbial activates as well to the other parts of the soil biodiversity. To this end, so called nitrogen turnover is a very complex process encompassing several phases that are directly related to the soil properties in certain moment (temperature, aeration, wetness, soil reaction etc.) and its influence on microbial activity. Main processes of nitrogen turnover are nitrification, denitrification, ammonification, immobilization, and mineralization.

Nitrous oxide is produced naturally in soils through the processes of nitrification and de-nitrification. One of the main controlling factors in this reaction is the availability of inorganic N in the soil. An increase in available N through human-induced N additions, or change of land-use and/or management practices that mineralize soil organic N, enhances nitrification and de-nitrification rates which then increase the production of N_2O.

For this reason, in estimation of N_2O emissions, human-induced net N additions to soils like: synthetic or organic fertilizers, deposited manure, crop residues, or mineralization of N in soil organic matter following cultivation/land-use change on mineral soils are of crucial importance.

Direct N_2O emissions from managed sols are mainly caused by the intensive inputs of mineral nitrogen fertilizers, manure and other organic amendments as well as the urine and dung deposits on pastures during grazing of animals on open field. The participation of these three sources of N is variable in the reporting years, hence in 1990 the majority of N_2O emissions arouse from organic fertilizers and urine and dung deposits, while in year 2000 the participation of these three sources is almost equal. Starting from year 2005 up to 2016 the emissions arousing rom mineral nitrogen fertilizers is increasing and prevails over the other two sources, reaching more than 105.5 Gg CO_2-eq.

As for the trends of the total emission of N_2O from managed soils, it can be noticed that except in the year 2000 when emissions has lowest values of only 183.67 Gg CO_2-eq, in all other reporting year the quantities of the emitted GHG are varying in very narrow range of 209.33 in 2014 up to 224.45 Gg CO_2-eq in 2016 (Figure 33).

5.4.3 Indirect N_2O emissions from managed soils

Managed soil can be a serious source of the so-called indirect N_2O emissions. In general, there are two main processes related to the indirect emission of N_2O: volatisation of N in the atmosphere and leaching/runoff of nitrogen.

In the both cases, the volatilization and leaching of N as NH_3 and oxides of N (NO_x), is result to the:

- inputs of synthetic N fertilizers; organic N applied as fertilizer; urine and dung N deposited on pasture by grazing animals,
- N in crop residues and
- mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils.

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.

From data presented in Figure 33 can be concluded that indirect emissions from managed soil are stable in all reporting years and vary in the ranges of 68.45 Gg CO_2-eq in 2000 up to the 80.71 Gg CO_2-eq in 2016.

5.4.4 Indirect N_2O emissions from manure management

Manure management can be a serious source of N_2O emissions, especially when is not properly managed. The emissions are in form of volatiosation of nitrogen in a form of ammonia NOx.

This portion of N_2O emissions is result to the mineralization of the organic nitrogen in animal excretions, and is most intensive in the process of the collection and storage. In case of a improper collection and storage, emissions of nitrogen through volatisation can be significant. For this purpose, appropriate and timely management of these two processes on farm is of crucial importance for reduction of N_2O emissions. 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 in the phase of storage of the manure at outdoor areas, in feedlots and in pastures where animals are grazing.

The final step of manure management is application and incorporation in soils. If the process of application and incorporation is not organized in a timely manner, significant losses of N trough volatiosation and leaching might occur on the field.

As previously mentioned, the N_2O emissions from manure management are mainly caused with improper management in the processes of collection, storage, application and incorporation in soil. The total estimated emissions of manure management are in the ranges of 26.27 Gg CO_2-eq in 2014 up to the 32.05 Gg CO_2 in 1990 equivalents. In general, we can say that the indirect N_2O emissions from manure management are stabile by time.

5.4.5 Rice cultivation

Area of rice growing land in this reported is sourced from the special publication Field crops, orchards and vineyards, published by State statistical office of the Republic of Macedonia (period 2007-2014) and the Statistical Yearbook of Republic of Macedonia, for the period 1990 – 2006.

Most part of the rice fields are situated in the vicinity of Kocani on both banks of Bregalnica river. Small portions of rice field are situated in some other parts of the country, in the vicinity of Veles. The sown area of rice fields significantly fluctuates over time, and strongly depends to the weather conditions, especially water supply from Kalimanci dam. The rice growing land fluctuated with strong drop in the middle of nighties from almost 9 thousand hectares in year 1990 to 1296 ha in year 1995. This was result of severe dry period in the nineties 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 finished with the significant drop in year 2001. After that rice was planted on about 2-3000 ha. In last 5-years period, there is evident trend of increase of the land planted with rice and again reached more than 5000 ha in 2014. The rice is important source of the GHG, particularly methane and increase of the area planted with rice is risk for increasing of the GHG emission from crop production within next period.

The trend of the emissions of CH_4 from the rice fields follows the trend of the rice planted land change, as described above. Out of the data presented in Table 29, it can be noticed that the emissions of CH_4 significantly drops in the period of 1990 to the beginning of 2000, and continue to decrease up to 2005 with only 12,11 Gg of CO_2-eq. In the past three reporting years, the emission is dabbled (24-24 Gg-CO_2-eq) and stable. This increase is related to the increase of the areas of rice fields in the past three years (Table 29).

5.5 Methodology and emission factors

5.5.1 Livestock

Emission 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. Official sources of livestock data publicly available (State Statistical Office, Ministry of Agriculture Forestry and Water Economy) are still not providing sufficient data for higher Tier application than Tier 1. Hence, for this inventory Tier 1 methodology was used, where qualitative improvements were done base done expert judgment. However, in order to meet Tier2 methodology, filed survey was done where small dairy and pig farms were involved. Results of the survey were not able to be implemented in preparation of current report but will be used in 4th NC. Detailed emission factors used for GHG emissions inventory in livestock activities in 3rd BUR, are given in Appendix I, part Emission factors (A I.3.3).

5.5.2 Land

5.5.2.1 Forestland

Emissions in Macedonia from forestry sector are product of firewood consumption as well as the forest fires. The most constant producer of CO_2 emission are households that use firewood 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 burned areas. There are several years (2000, 2007, and 2012) where due to the large burned area, forestry sector instead of removing, contributed into increase of the GHG emissions in the country.

5.5.2.2 Cropland

GHG inventory in AFOLU sector relay on two major segments, ***activity data*** that encompasses all activities resulting from human activities, like land use change, management practices and inputs and ***emission factors*** which refers to the effect of the human activities on the intensity of the GHG emissions and removals.

Tier1 methodology is used for estimation of the emission from cropland. In the past two NIRs some very valuable and important efforts have been done in order to move forward to the Tier 2 methodology. To this end, Land use/Land change data were calculated from a spatial graphical data source (European Space Agency, CORINE Land Cover), enabling implementation of Approach 3 (Chapter 3) and Tier 2 level in the segment of land use (land use category remain and land use category converted to other land use category). CORINE Land Cover is a graphical data set, with mapping scale of 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. In our report, the CORINE LC classes were grouped into six categories of land use according the IPCC methodology. In this Reports certain inconsistencies of the CLC data were detected which lead to a significant difference between periods covered with this data source. Irregularities were detected for lad from one category to another, especially in Cropland, Grassland and Forestland. For this reason, and in order to improve the temporal and spatial accuracy of land use data, it was decided in the next period to put some effort in developing of national graphical data source. Particular attention will be paid to build up the capacities of the institutions responsible for GHG inventory, to be able to perform photointerpretation and classification of satellite images, for regular updating of the land use/land database with accurate data.

In an absence of national emission factors, the global emission factors were used, recommended within the IPCC manuals or various category of land use. In Table 30 are indicated the emission factors used for estimation of: biomass carbon stock in perennial crops and conversions, soil organic carbon stock, emissions of methane from rice fields and urea application.

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.

Table 30. Emissions factors used for GHG emissions inventory in Land

Emission factor	3rd BUR	Comment
1. Cropland remaining cropland		
1a. Biomass carbon stock	• 2,1 t/ha biomass accumulation per year in perennial plantations (first 20 years) - ΔCG, • 63 t/ha biomass loss with clearance of perennial plantations - ΔCL	IPCC Guide – Chapter 5, Table 5.1 and 5.3
1.b Dead organic matter		In Tier 1 methodology Dead organic matter is not calculated
1.c Soil Organic Carbon	0.9 t/ha for stock exchange factor (land use) 1 t/ha for stock exchange factor F_{MG} (management) 1 t/ha for stock exchange factor F_I (input)	IPCC Guide Chapter 5, Table 5.5
1.1. Forest land converted to cropland	120 t/ha biomass loss with clearance during the conversion	IPCC Guide, Chapter 4 Tables 4.7 to 4.12
1.2. Grassland converted to cropland	6,5 t/ha biomass loss biomass loss with clearance during the conversion	IPCC Guide, Chapter 6, Table 6.4
2. Grassland Remaining Grassland		
2.a Biomass carbon stock		Grassland where there is no change in either type or intensity of management, biomass will be in an approximate steady-state
2.b Dead organic matter		The Tier 1 method assumes that the dead wood and litter stocks are at equilibrium,
2.c. Soil Organic Carbon	1,0 t/ha for stock exchange factor (land use)	IPCC Guide Chapter 6, Table 6.2

	0.95 t/ha for stock exchange factor F_{MG} (management) 1,0 t/ha for stock exchange factor F_I (input)	
2.1 Forest land converted to grassland	120 t/ha biomass loss with clearance during the conversion	IPCC Guide, Chapter 4 Tables 4.7 to 4.12
2.2 Cropland converted to grassland	10,0 t/ha biomass loss biomass loss with clearance during the conversion	IPCC Guide, Chapter 5, Table 5.1
3. Urea application	0.2 volatisation/leaching factor	IPCC Guide, Chapter 11 Table 11.3
3. Rice fields	1.3 Emission factor for CH_4 emission from continuously flooded fields	IPCC Guide, Chapter 11 Table 11.3

5.6 Data sources

5.6.1 Livestock

In the inventory of the GHG emission relevant to the livestock activities, the official data from State Statistical Office are used (MakStat database available online on:

http://makstat.stat.gov.mk/PXWeb/pxweb/en/MakStat/MakStat__Zemjodelstvo__DobitocnoProizvodstvo.

The data provided in online database is in fully agreement with FAO-stat and Eurostat. For the reported years in some livestock, species data for different categories was available and it was used in assessment. Data for GHG emissions inventory due to activities in Livestock production are given in Annex I, Table 24. 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).

5.6.2 Land

5.6.2.1 Forestland

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, Subjects that manage state and private owned forests, UKIM- Faculty of Forestry in Skopje, Centre for management of crises, Firefighting union of Macedonia, expert opinions and other domestic and international sources. The sources of data for different categories are presented in Table 31.

Table 31. Data sources for Forestland

Forestry sector	Documents	Data provider
Forest area	SSO Yearbooks; Forestry management plans;	SSO; Subjects that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE;
Forest types	SSO Yearbooks; Forestry management plans	SSO; Subjects that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE;
Growing stock	Forestry management plans; Department of Forest growth and yield;	Subjects that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE; Faculty of forestry;
Land use change	SSO Yearbooks CORINE land cover maps (2000, 2006, 2012)	SSO CORINE land cover;
Removal from forests	SSO Yearbooks; Monthly and Annual Reports	SSO; Subjects that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE
Burned forest area	SSO Yearbooks, Annual reports, internal documents	Subjects that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE, Crisis Management Center, Macedonian fire protection unit

5.6.2.2 Land, Non-CO_2, Aggregate sources and non-CO_2 emissions sources on land

Data from several sources were used for preparation of the subsectors Land and the aggregate sources of non-CO_2 emissions. National data sources used were the annual SSO publication, indicated in Table 32, and the digital database (http://makstat.stat.gov.mk/PXWeb/pxweb/en/MakStat). In addition to this or calculation of the agricultural areas under perennial crops, data from the MAFWE`s regional offices as well data from the Paying Agency were used as well.

For the calculation of the spatial and temporal land use/land use change in all IPSS categories of land use, the ESA product - CORINE LC data sets were used as indicated in Table 32. (https://www.esa.int/Applications /Observing_the_Earth/Copernicus)

Mineral fertilizers and urea quantities, in the absence of national data were provides from two data sources, FAO-stat and the International Fertilizer Association Data base - IFA-stat (www.ifastat.org/databases/plant-nutrition).

Table 32. Data sources for Cropland, Grassland, Wetland, Settlement and Other land use, fertilizers and rice

	Documents	Data provider
Cropland remain cropland area	Field crops, orchards and vineyards (1990-2016) Statistical Yearbook of Republic of Macedonia (1990-2016) CORINE Land Cover (2000, 2006, 2012, 2018)	State Statistical Office of Republic of Macedonia SENTINEL/ESA
Grassland remain grassland area		
Wetlands remain wetlands area		
Settlements remain settlements area		
Other land remain other land area		
Conversions in other category of land use	Processing of CORINE Land Cover (2000, 2006, 2012, 2018) graphical digital data sets	SENTINEL/ESA Expert work
Areas under permanent crops (vineyards and orchards)	Field crops, orchards and vineyards (1990-2016) Statistical Yearbook of Republic of Macedonia (1990-2016) Yearly evidence of Regional Agricultural Offices, Regional Offices Paying Agency	State Statistical Office of Republic of Macedonia Ministry of Agriculture, Forestry and Water Economy,
Rice growing Area	Field crops, orchards and vineyards (1990-2016) Statistical Yearbook of Republic of Macedonia (1990-2016)	State Statistical Office of Republic of Macedonia
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
Urea application	FAO Digital Data Base International Fertilizer Association Data base	FAO-stat IFA-stat

6 Waste

The categories reported under waste sector 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 non-compliant 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 non-compliant landfills, dumpsites or in rural areas, the wastes are simply dumped by the Communal Enterprises with almost none standard landfilling activities, no operational costs, except some overheads and occasional waste consumption costs for the extinguishing of emerging landfill fires. There are around 50 operational municipal non-compliant landfills. The need for improvement of their waste management practices has been recognized in the national, regional and local waste management strategic documents. Furthermore, there are around 1000 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 and for the first time in this inventory the emissions caused by this activity are reported. In the past, a few 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. Emissions from Biological Treatment of Solid Waste have been, for the first time, introduced for the period from 2014 to 2016 as a result of data availability.

6.1 Emission trends

The calculations show that the Waste sector is one of the sectors with an increasing trend of GHG emissions achieving 610 Gg CO_2-eq in 2016, which is doubled compared to 1990 or 6.3% more compared to 2014. Out of all the sectors, the emission from Solid Waste Disposal category are most significant participating with 77.5% in the total GHG emission in 2016 (Figure 34, Table 33). Second category with significant amount of GHG emissions is Wastewater Treatment and Discharge participating with around 19% in 2016. Incineration and open burning of waste category contribute with around 4% in the last three reported years. The CH_4 and N_2O emissions from the Biological Treatment of Solid Waste category do not contribute largely to the overall emissions due to the small amount of reported composted waste. Around 92% of the GHG emissions in the last three years of the reporting period are CH_4, while N_2O and CO_2 participates with 7.2%, 1% respectively (Figure 35). Detailed results by gases and categories are reported in Table 34.

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

	1990	2000	2005	2014	2015	2016
Waste	406.7	412.7	435.2	574.3	596.7	610.2
Solid Waste Disposal	265.6	299.4	316.0	441.4	457.4	473.2
Biological Treatment of Solid Waste	0.0	0.0	0.0	0.8	1.2	1.0
Incineration and Open Burning of Waste	8.8	9.6	14.1	22.2	23.0	22.7
Wastewater Treatment and Discharge	132.3	103.6	105.1	109.9	115.1	113.4

In this inventory the recommendations from the SBUR were incorporated. Based on it the emissions from Waste category in this inventory are more than 4 time lower compare to the results from the SBUR. There are several factors which contributed to such a big difference in the results. In the SBUR, for industrial waste the default waste generation rate IPCC factor was used. Based on the latest data from the SSO domestic waste generation rate is created. However, at this stage it was very hard to make a distinguish of the data on waste production by industry type, so it was decided to use the data for total waste generated by the manufacturing industries. Having this in mind and following the IPCC guideline, Degradable organic carbon factor was revised and 15 was replaced with 1 (Table 2.5 Chapter 2: Waste Generation, Composition and Management Data, IPCC guideline). At the same time, based on the latest national waste management plans, revision of waste composition of municipal solid waste was made. Furthermore, based on SSO data more industrial sectors are introduced in the Industrial wastewater treatment and discharge sub-category. In addition a revision of the overall time series was made.

Figure 34. GHG emissions from Waste sector, by category (in Gg CO_2-eq)

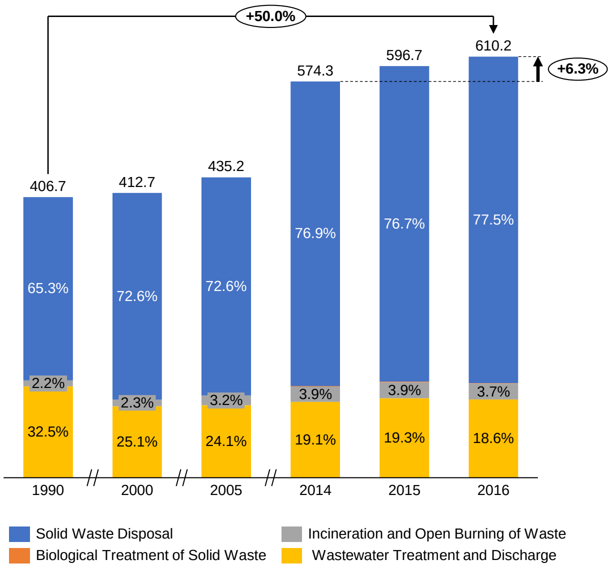


Figure 35. GHG emissions form Waste sector, by gas (in Gg CO2-eq)

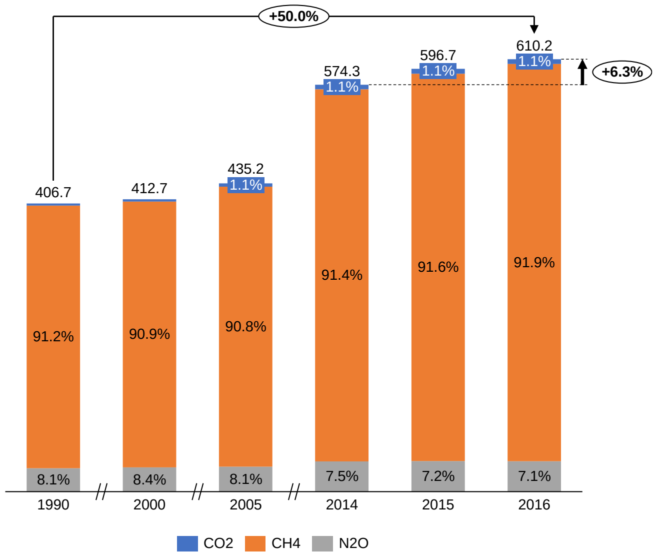


Table 34. GHG emissions from Waste sector, by category and by gas (in Gg CO_2-eq)

Categories	1990			2000			2005			2014			2015			2016		
	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	CO_2	CH_4	N_2O
Waste	**2.9**	**370.8**	**33.0**	**3.2**	**375.0**	**34.5**	**4.8**	**395.1**	**35.3**	**6.5**	**524.9**	**42.9**	**6.8**	**546.7**	**43.2**	**6.6**	**560.5**	**43.1**
Solid Waste Disposal	**0.0**	**265.6**	**0.0**	**0.0**	**299.4**	**0.0**	**0.0**	**316.0**	**0.0**	**0.0**	**441.4**	**0.0**	**0.0**	**457.4**	**0.0**	**0.0**	**473.2**	**0.0**
Managed	NE																	
Unmanaged	NE																	
Uncategorized	NE																	
Biological Treatment of Solid Waste	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**	**0.3**	**0.0**	**0.7**	**0.5**	**0.0**	**0.6**	**0.4**
Incineration and Open Burning of Waste	2.9	5.9	0.0	3.2	6.4	0.0	4.8	9.3	0.0	6.5	12.4	3.3	6.8	12.8	3.4	6.6	12.7	3.4
Waste Incineration	NE	NE	NE	0.1	NE	NE	0.3	NE	NE	0.5	NE	NE	0.7	NE	NE	0.5	NE	NE
Open Burning of Waste	2.9	5.9	0.0	3.1	6.4	0.0	4.5	9.3	0.0	6.0	12.4	3.3	6.2	12.8	3.4	6.1	12.7	3.4
Wastewater Treatment and Discharge	**0.0**	99.3	33.0	**0.0**	69.1	34.5	**0.0**	69.7	35.3	**0.0**	70.7	39.2	**0.0**	75.8	39.3	**0.0**	74.1	39.3
Domestic	0.0	19.7	33.0	0.0	19.8	34.5	0.0	20.1	35.3	0.0	20.4	39.2	0.0	20.4	39.3	0.0	20.4	39.3
Industrial	0.0	79.6	0.0	0.0	49.4	0.0	0.0	49.7	0.0	0.0	50.3	0.0	0.0	55.4	0.0	0.0	53.6	0.0
Other	**NO**																	

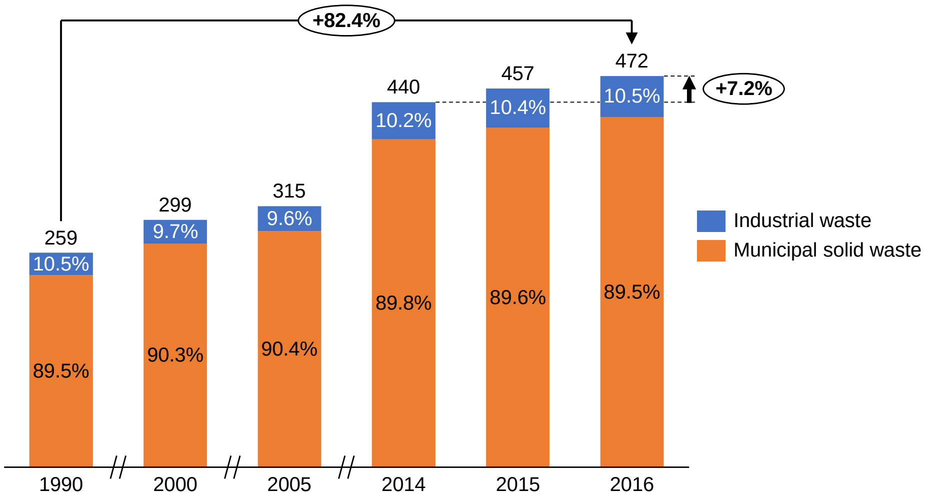
6.1.1 Solid waste disposal

Treatment and disposal of municipal and industrial solid waste produces significant amounts 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. As it was mentioned above, based on the latest national waste management plans domestic shares for composition of municipal solid waste are created.

In order to calculate the total municipal solid waste that was created in each year, the time series on population data has been updated for the years 2015 and 2016. The data sources used for the revision are elaborated in detail in the Chapter 6.3. The average municipal solid waste per capita for the period 2014 to 2016 is 375.3 kg/cap/yr. Moreover, the ratio of collected and generated municipal solid waste was 74.5% in 2014, 78.9% in 2015 and 76.7% in 2016. However, having in mind that in SWDS there is a category Uncategorized SWDS (in the IPCC software), which according to our national methodology are damp site, a recalculation of the overall time series was made and it was found that from the total MSW, 90% is going to SWDS, including the Uncategorized SWDS. The rest 10% of waste is reported in the category Open Burning of Waste. In addition, starting from 2006, annual share of different category of SWDS is made, based on the SSO data.

The results show that the amount of CO_2-eq emissions from solid waste disposal have been constantly rising achieving 473 CO_2-eq in 2016 Figure 36. Compared to 1990 CO_2-eq emissions in 2016 are 78% higher, while compare to 2014 around 7%. Municipal solid waste participates with around 90% over the reporting period.

Figure 36. Emissions of CH4 from Solid Waste Disposal (in Gg CO2-eq)

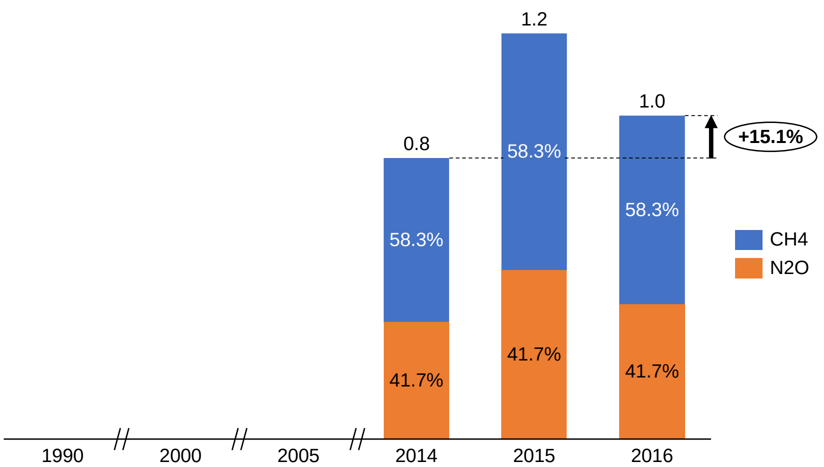


6.1.2 Biological treatment of solid waste

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 2014, 2015 and 2016. Observance shows that they are very low, i.e. around 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 2014 is equal to 1,945 t, while 2,807 t and 2,239 t had been composted in 2015 and 2016, respectively. 58% of the GHG emissions from Biological treatment of solid waste are CH_4, while the rest are N_2O (Figure 37)

Figure 37. GHG emissions from Biological Treatment of Solid Waste (in Gg CO_2-eq)



6.1.3 Incineration and open burning of waste

Waste incineration is defined as the incineration of solid and liquid waste in controlled incineration facilities. The Drisla landfill is the only big landfill that has waste incineration facility and only medical waste is incinerated at this site. The greenhouse gas emissions from incineration of medical waste (since 2000) are taken into account in this report.

Open burning of waste can be defined as the burning of unwanted combustible materials such as paper, wood, plastics, textiles, rubber, waste oils and other debris in nature (open-air) or at non-compliant landfills or dumpsites, where smoke and other emissions are released directly into the air without any emission control activities. 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 (including the Uncategorized SWDS). This approach was used for the values over the reporting period. 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. This emissions participated with around 56% in the last three years, while the share of CO_2 and CH_4 is 29% and 15%, respectively (Figure 38. Most of the emissions coming from Open Burning of Waste (98%) (Figure 39).

Figure 38. GHG emissions from Incineration and Open Burning of Waste by gasses (in Gg CO_2-eq)

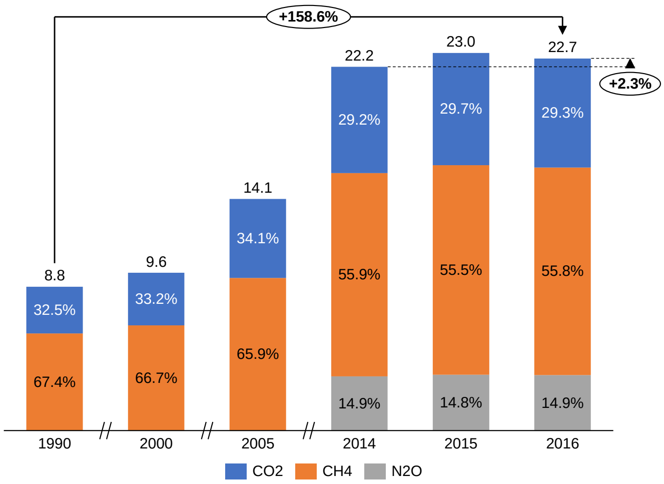
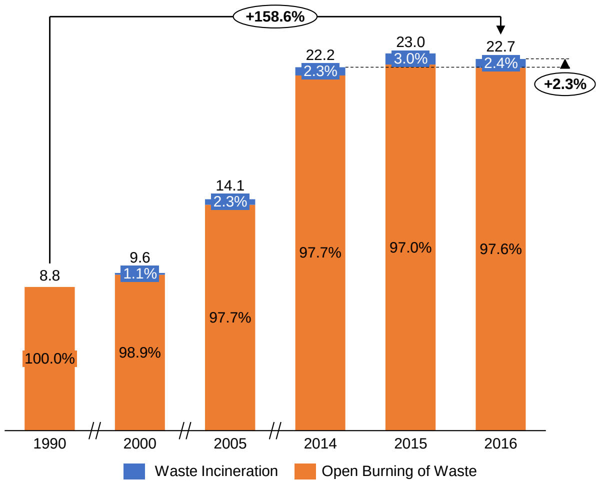


Figure 39. GHG emissions from Incineration and Open Burning of Waste by categories(in Gg CO_2-eq)



6.1.4 Wastewater treatment and discharge

Wastewater can be a source of CH_4 when treated or disposed anaerobically. It can also be a source of N_2O emissions. 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 participating with around 50% in the overall emissions from the Wastewater treatment and discharge sub-category (Figure 40). Industrial wastewater emissions are from industrial practices only.

Domestic wastewater treatment and discharge is not a key source of GHG emissions, so the default parameters and emissions factors have been used. The GHG emissions in this category depend on the population size so the emissions gradually increase achieving around 60 CO_2-eq in 2016 (Figure 41). 66% of the emissions are CH_4 while the rest are N_2O associated with the degradation of nitrogenic components in the wastewater, such as urea, nitrate and protein. It should be noted that the GHG emissions from this category account for just above 50% of the all the emissions in the category Wastewater Treatment and Discharge.

The GHG emissions from industrial wastewater treatment and discharge have been estimated using the industrial production data. The recommendations from the SBUR were incorporated, so based on SSO data more industrial sectors are introduced in the Industrial wastewater treatment and discharge sub-category. In addition, because of the inconsistence of the data for the reporting period, a revision of the overall time series was made.

The data have been classified in the following industrial sectors: Alcohol Refining, Beer & Malt, Coffee, Dairy Products, Meat & Poultry, Organic Chemicals, Petroleum Refineries, Plastics & Resins, Pulp & Paper (combined), Soap & Detergents, Starch Production, Sugar Refining, Vegetable Oils, Vegetables, Fruits & Juices, Wine & Vinegar. The correlation with the SSO data was made using the NACE codes. 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.

Methane emissions account for all of the emissions which are the result of industrial wastewater treatment and discharge. Compared to 2014, the emissions in 2016 are 6.7% higher, while compare to 1990 they are for almost 30% lower. The share of emissions from industrial wastewater treatment and discharge out of the total emissions in the category Wastewater Treatment and Discharge are 46% in 2014, 48% in 2015 and 47% in 2016.

Figure 40. GHG emissions from Wastewater Treatment and Discharge (Gg CO_2-eq)

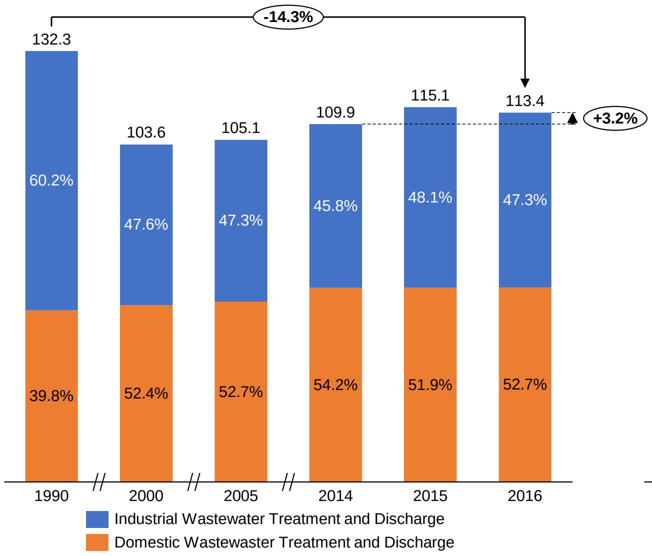
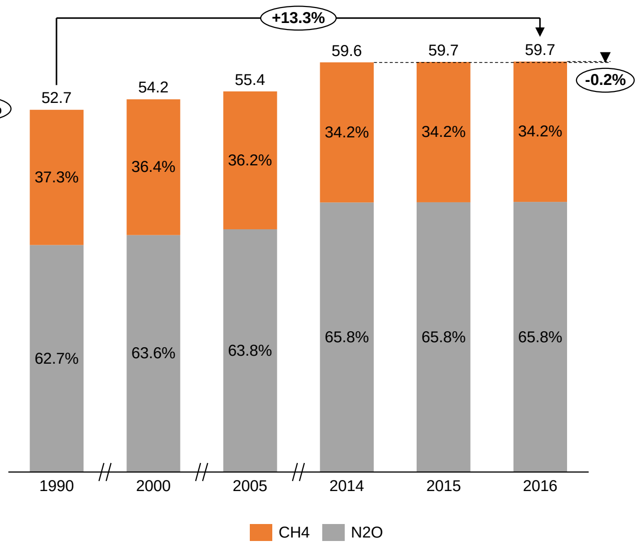


Figure 41. Emissions of CH_4 from Domestic Wastewater Treatment and Discharge (in Gg CO_2-eq)



6.2 Methodology and emission factors

In the inventory prepared in the 3rd BUR 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 2011-2016. 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 CH_4 and N_2O, which have been used to estimate the emissions from composting activities in the SBUR, are used in the 3rd BUR as well.

Table 35. Emission factors used for Waste sector

Emission factor	FBUR	SBUR, 3rd BUR	Comment
Municipal Solid Waste	DF	DF	IPCC 2006 Guidelines 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

6.3 Data sources

In the Solid Waste Disposal sector, the population and GDP data for the period 1990-2014 were revised as a part of SBUR inventory process. In this inventory the population and GDP for 2015 and 2016 were taken from the SSO annual reports.

The State Statistical Office has issued reports on Municipal Waste for the years 2014, 2015 and 2016. 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 2014, 2015, 201 6 Estimation of Population of R. Macedonia GDP at current prices	SSO MAKStat database
Biological Treatment of Solid Waste	Annual Report on Quality of Environment 2015-2016	MOEPP
Incineration and Open Burning of Waste		
Waste incineration	http://www.drisla.mk/page_detail.asp?IID=3&ID=25	Drisla web side
Open Burning of Waste	Municipal Waste for 2014, 2015, 201 6	SSO
Wastewater Treatment and Discharge		
Domestic Wastewater Treatment and Discharge	Estimation of Population of R. Macedonia World Population Prospects: The 2017 Revision	MAKStat database United Nations Population Division
Industrial Wastewater Treatment and Discharge	Online database SSO 2007-2016 Statistical review: Industry and Energy 2002-2007 Statistical review: Industry and Energy 1999-2003 The industry in the Republic of Macedonia 1996-2000 The industry in the Republic of Macedonia 1993-1998 The industry in the Republic of Macedonia 1987-1992	SSO

7 Precursors and indirect emissions

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

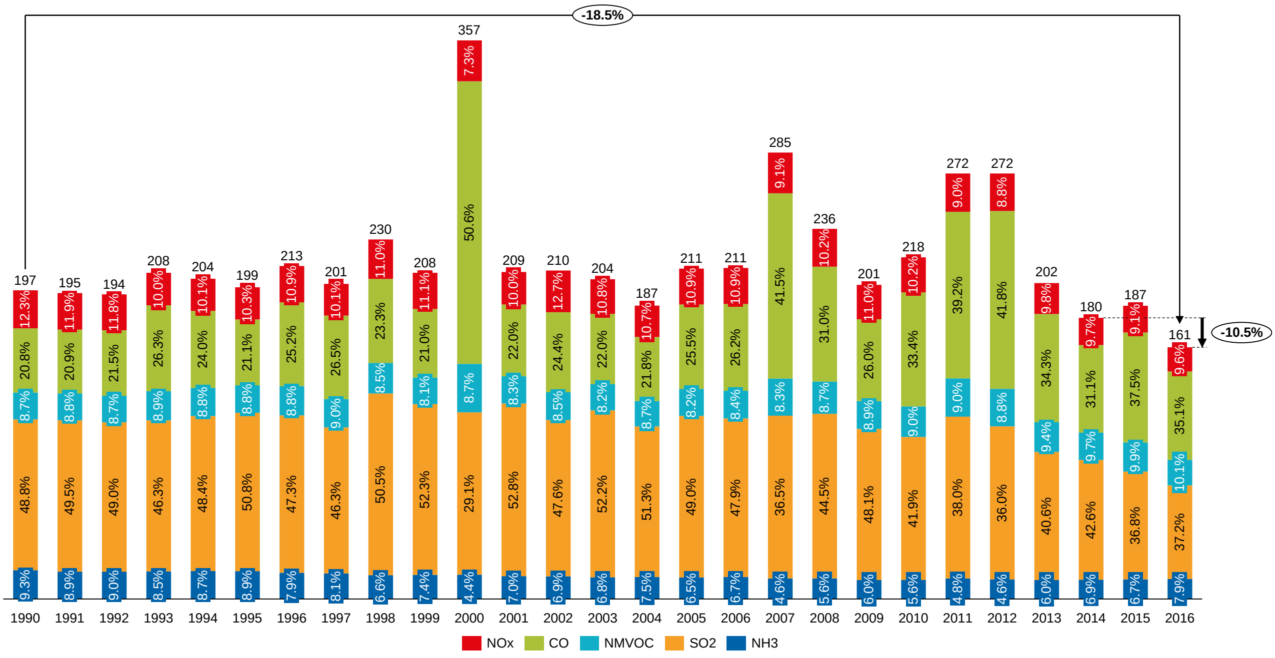
The most recent 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 7: Precursors and Indirect Emissions introduces ways to adopt methodologies to calculate the non-GHG emissions, provides a link to relevant methodology chapters in the EMEP/CORINAIR Emission Inventory Guidebook. Some 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.

In the SBUR, the emissions of NOx, CO, NMVOC and SO_2 were estimated for the period 1990 – 2014. In this BUR, the emission for 2015 and 2016 year have been estimated, in line with the methodology in the latest EMEP/EEA air pollutant emission inventory guidebook, 2019. In addition review and recalculation for come categories for the period 1990-2014 is done. Also, the NH_3 emissions have been included, where applicable.

7.1 Emission trends

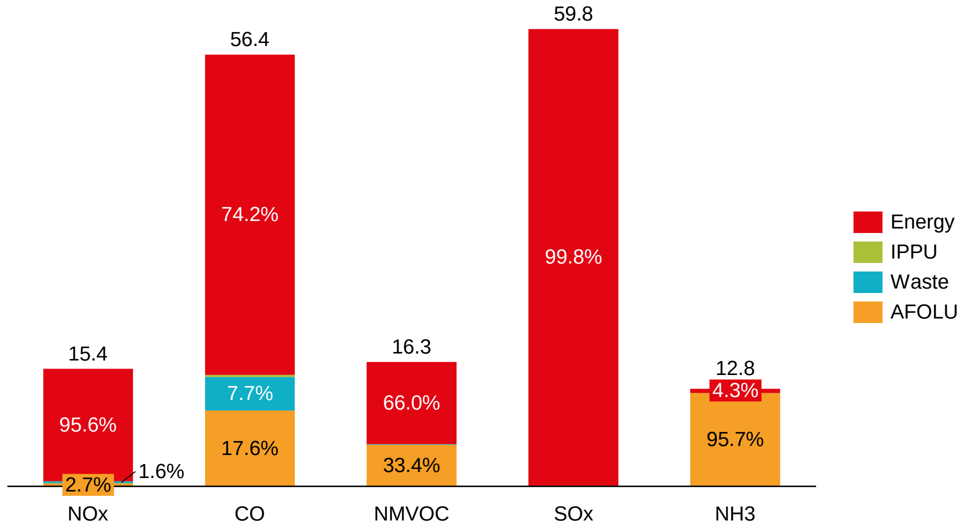
The results for precursors and indirect emissions show that they are reduced by 18.5% and 10.5% in 2016 compared to 1990 and 2014 respectively (Figure 42). At average the emissions are around 200 Gg/year, but there are peaks in 2000, 2007, 2008, 2011 and 2012 mainly as a results of forest fires. The highest numbers are estimated for 2000, 357 Gg. SO2 participates with around 50% over the entry reporting period, but in the last five years it shares is below 40%, as a result of reduction in electricity production from lignite, as well as fuel change (oil for heat production is replaced with natural gas). CO is the second contributor, participating with around 30%, with peak in the years with more forest fires. NH_3 as a new gas that is introduced in this inventory, participate with around 8% during the reporting period.

Figure 42. Emissions of NOx, CO, NMVOC, SO_2 and NH_3 in the period 1990 – 2014 (in Gg)



The assessment of the sectoral precursors and indirect emissions, shows that during the entire reporting period, Energy sector is the most significant contributor in all of them except in NH_3. In 2016, this sector is a source of almost all SO_2 and NO_x emissions, 99.8 and 95.6%, respectively (Figure 43). At the same time the energy sector participate with 74% in CO and 66% in NMVOC. AFOLU is the second contributor with around 96% share in NH_3, 33.4% in NMVOC and 17.6% in CO. Waste participate with 7.7% in CO most as a result of open burning of waste.

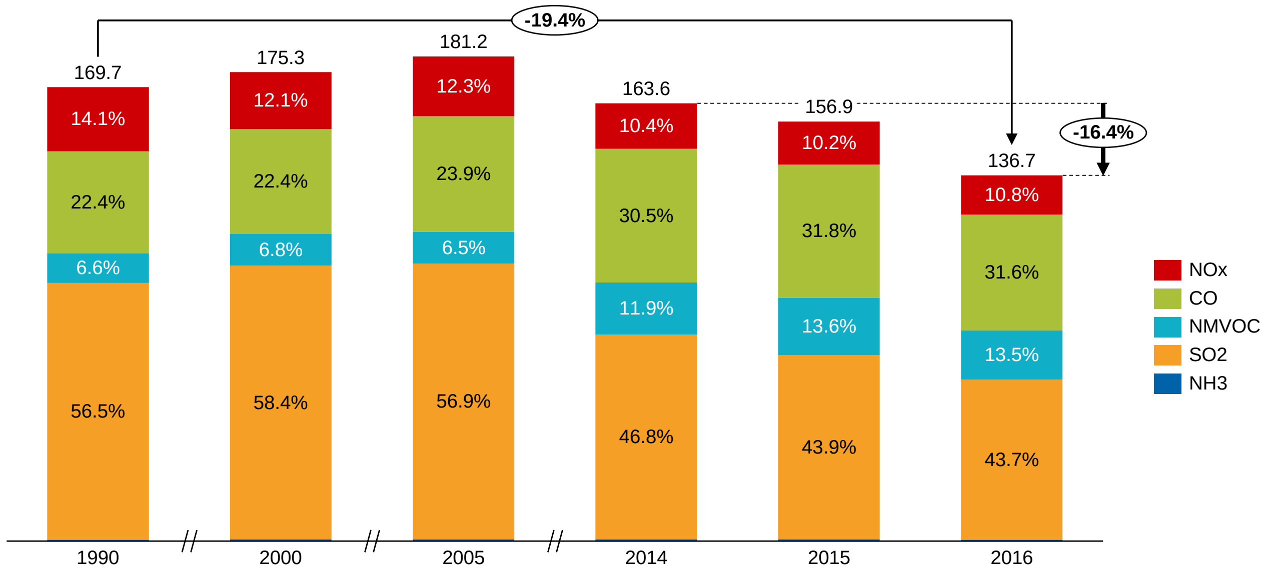
Figure 43. Emissions precursors and indirect GHG emissions (in Gg) and share of by sectors (in %) in the year 2016



7.2 Energy

The SO_2 emissions are the dominant form in the combustion emissions at around 50% or greater during the overall reporting period (Figure 44). These emissions are in direct correlation with the combustion of lignite used for electricity generation. On the other hand, as a result of the biomass consumption in the households, CO emissions are the second in dominance, above 30% in 2015 and 2016. Because of the declining trend in electricity generation from lignite, the overall number of precursors and indirect emissions is reduced for 16.4% in 2016 compared to 2014, while compared to 1990 the emissions are reduced by 19.4%.

Figure 44. Emissions of NOx, CO, NMVOC, SO_2 and NH_3 from the Energy sector (in Gg)



Electricity production from lignite is the main source of SO2 emissions participating with at least 89% in the reporting period (Figure 45). Furthermore, it is responsible for the majority of NOx emissions (57% in 2016) (Figure 46). With almost 24% in 2015 and 2016, Manufacturing Industries and Construction is the second biggest contributor to NOx, while it participates with 9% and 10% in the share of SO_x emissions in 2015 and 2016, respectively. Far behind these two categories are all other. In the share of NOx emissions, the Non-specified category participates with 10%, Transport with 5.2%, and Other Sectors with 4%. On the other hand, the contribution of these three categories in SO_x emissions is almost zero. Comparing to 1990, SO_2 and NOx emissions are reduced by almost 38% and 39% in 2016, respectively. This is mainly a result of reduced electricity production from lignite and an increase in electricity imports. The detailed emissions by categories and subcategories are presented in Table 37.

Figure 45. SO_2 emissions from the Energy sector, by category (in Gg)

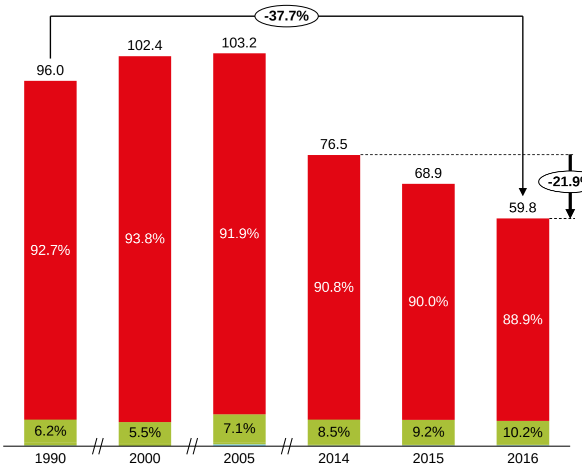
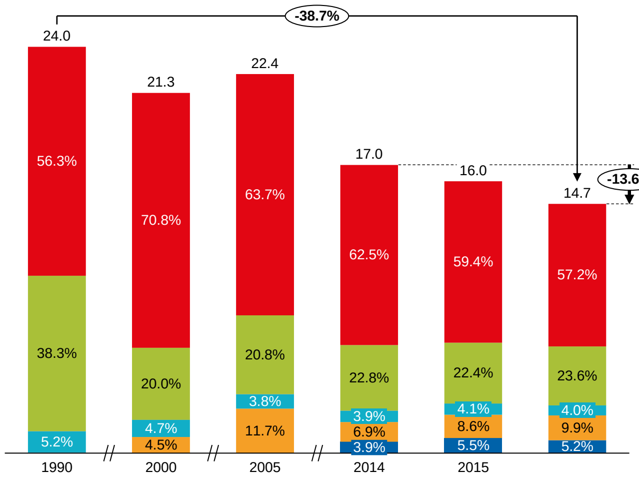


Figure 46. NOx emissions from the Energy sector, by category, (in Gg)



Note: Transport contains only the emissions of the Railways Transportation and Domestic Aviation

For the CO and NMVOC emissions, the situation is opposite to the previous one (SO_2 and NO_x). Most of the CO and NMVOC emissions are coming from the category Other Sectors. The share of this category in CO emissions is around 87% and 83%, in 2015 and 2016 respectively (Figure 47,

Table 38), while in NMVOC emissions the share is about 50% in the last two years (Figure 48,

Table 38). The contribution of the category Manufacturing Industries and Construction is the next one with shares for 2015 and 2016 of 11% and 14% for CO and 6% and 6% for NMVOC. Starting from 2000, NMVOC emissions from the category Fugitive emissions are decreasing due to the lowering of electricity production from lignite. The participation of the other categories is negligible, around 2%.

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

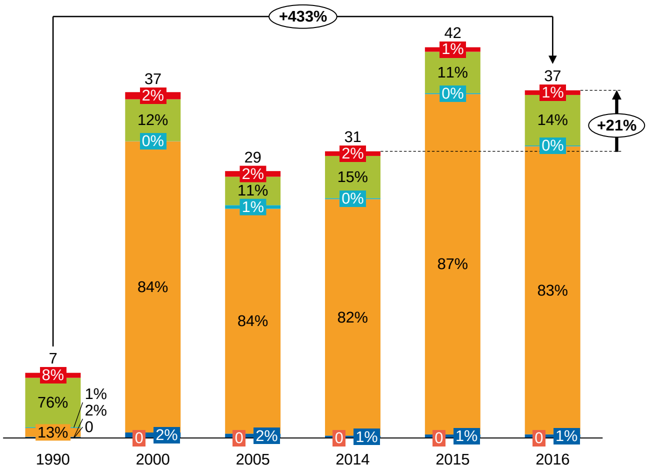
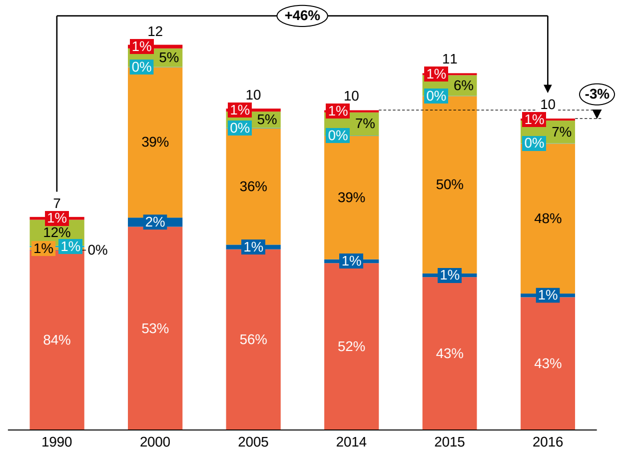


Figure 48. NMVOC emissions from the Energy sector, by category (in Gg)



Note: Transport contains only the emissions of the Railways Transportation and Domestic Aviation

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 EEA 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 Railways and Domestic Aviation and is not identified as a significant source of NO_x, CO, NMVOC, and SO_2 emissions. The emissions of the subcategory Petroleum Refining are included in the category Other Energy Industries.

Table 37. Emissions of NO_x, CO from the Fuel Combustion Activities (in Gg)

Categories	NO_x						CO					
	1990	2000	2005	2014	2015	2016	1990	2000	2005	2014	2015	2016
Fuel Combustion Activities	**24.0**	**20.4**	**22.4**	**16.3**	**15.2**	**13.9**	**38.1**	**39.2**	**43.2**	**45.7**	**44.3**	**38.4**
Energy Industries	**13.5**	**14.2**	**14.2**	**10.6**	**9.5**	**8.4**	**0.5**	**0.7**	**0.6**	**0.5**	**0.5**	**0.5**
Main Activity Electricity and Heat Production	13.5	14.2	14.2	10.6	9.5	8.4	0.5	0.7	0.6	0.5	0.5	0.5
Electricity Generation	12.4	13.7	13.6	10.3	9.2	7.9	0.4	0.5	0.5	0.4	0.3	0.3
Combined Heat and Power Generation	0.8	0.2	0.1	0.2	0.1	0.4	0.1	0.0	0.0	0.1	0.1	0.2
Heat Plants	0.3	0.2	0.5	0.1	0.2	0.1	0.0	0.2	0.1	0.1	0.1	0.0
Petroleum Refining	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Manufacture of Solid Fuels and Other Energy Industries	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other Energy Industries	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Manufacturing Industries and Construction	**9.2**	**4.2**	**4.7**	**3.9**	**3.6**	**3.5**	**6.5**	**6.0**	**7.9**	**7.0**	**6.8**	**6.6**
Transport	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Domestic Aviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Road Transportation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Railways	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Sectors	**1.2**	**1.0**	**0.8**	**0.7**	**0.7**	**0.6**	**30.9**	**31.8**	**34.1**	**37.9**	**36.7**	**31.1**
Residential	0.7	0.5	0.5	0.5	0.5	0.4	30.7	31.6	34.0	37.8	36.6	30.9
Agriculture/Forestry/Fishing/Fish Farms, Stationary	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Non-Specified	**0.0**	**1.0**	**2.6**	**1.2**	**1.4**	**1.5**	**0.2**	**0.6**	**0.7**	**0.3**	**0.3**	**0.3**

Note: NO – Not occurring; NE – Not estimated; IE – Included elsewhere

Table 38. Emissions of NMVOC, SO2 and NH_3 from the Fuel Combustion Activities (in Gg)

Categories	NMVOC						SO_2						NH3					
	1990	2000	2005	2014	2015	2016	1990	2000	2005	2014	2015	2016	1990	2000	2005	2014	2015	2016
Fuel Combustion Activities	**5.6**	**5.8**	**6.3**	**6.7**	**6.5**	**5.6**	**96.0**	**102.4**	**103.2**	**76.4**	**68.8**	**59.7**	**0.5**	**0.6**	**0.6**	**0.7**	**0.7**	**0.6**
Energy Industries	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**89.0**	**96.1**	**94.8**	**69.5**	**62.0**	**53.2**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Main Activity Electricity and Heat Production	0.1	0.1	0.1	0.1	0.1	0.1	89.0	96.1	94.6	69.5	62.0	53.2	NO	NO	NO	NO	NO	NO
Electricity Generation	0.1	0.1	0.1	0.1	0.1	0.0	84.6	91.5	92.5	69.3	62.0	53.2	NO	NO	NO	NO	NO	NO
Combined Heat and Power Generation	0.0	0.0	0.0	0.0	0.0	0.0	3.3	1.0	0.6	0.1	0.0	0.0	NO	NO	NO	NO	NO	NO
Heat Plants	0.0	0.0	0.0	0.0	0.0	0.0	1.1	3.5	1.5	0.0	0.0	0.0	NO	NO	NO	NO	NO	NO
Petroleum Refining	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO	NO	NO	NO	NO	NO
Manufacture of Solid Fuels and Other Energy Industries	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	NO	NO	NO	NO	NO	NO
Manufacture of Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other Energy Industries	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	NO	NO	NO	NO	NO	NO
Manufacturing Industries and Construction	**0.9**	**0.7**	**1.0**	**0.9**	**0.8**	**0.8**	**6.0**	**5.6**	**7.3**	**6.5**	**6.4**	**6.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Domestic Aviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	NO	NO	NO	NO	NO

Road Transportation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Railways	0.0	0.0	0.0	0.0	0.0	0.0	NO	NO	NO	NO	NO	NO	0.0	0.0	0.0	0.0	0.0	0.0
Other Sectors	**4.6**	**4.7**	**5.1**	**5.7**	**5.5**	**4.7**	**0.8**	**0.6**	**0.5**	**0.2**	**0.3**	**0.2**	**0.5**	**0.5**	**0.6**	**0.7**	**0.6**	**0.5**
Residential	4.5	4.7	5.0	5.7	5.5	4.6	0.6	0.4	0.4	0.2	0.2	0.2	0.5	0.5	0.6	0.7	0.6	0.5
Agriculture/Forestry/Fishing/Fish Farms, Stationary	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.1	0.1	0.1	NO	NO	NO	NO	NO	NO
Non-Specified	**0.0**	**0.3**	**0.2**	**0.1**	**0.1**	**0.1**	**0.2**	**0.1**	**0.5**	**0.1**	**0.2**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Note: NO – Not occurring; NE – Not estimated; IE – Included elsewhere

7.2.1 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. In this BUR, the latest EMEP/EEA air pollutant emission inventory guidebook from 2019 was used. The estimation of precursors and indirect emissions of the Energy sector is done using the Tier 1 methodology. 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 3rd BUR.

Table 39. Emission factors used for estimation of the emissions of Precursors and Indirect emissions of the Energy sector

Emission factor	3rd BUR	Comment
Energy sector	Tier 1 EF EMEP/EEA air pollutant emission inventory guidebook 2019	Tier 1 methodology applied. Not enough onsite measurement data and detailed parameters for application of higher Tier methodologies.

7.2.2 Data sources

All activity data for the period 1990-1997, as well as 2003 and 2004, are taken from the International Energy Agency database, while the remaining period is covered with data from the national energy balances published by the State Statistical Office (Table 40).

Table 40. Data sources for estimation of the emissions of Precursors and Indirect emissions of the Energy sector

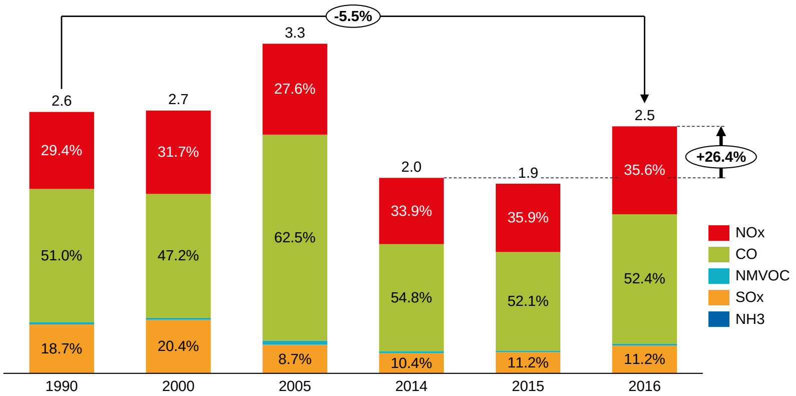
	Documents	Data provider
Energy sector	IEA Database, (annual databases from 1990-1997, 2003 and 2004) Energy balance, Final data, (1998-2002 publications, 2005-2016 MAKSTAT database)	International Energy Agency SSO

7.3 IPPU

During the preparation, of the IPPU non-GHG emissions part of the inventory it was found that there is a big gap in the emissions for the entire reporting period. Although activity data have been available in the software for the period 1990 – 2001, the non-GHG emissions from Iron and steel were not calculated. In addition, for several categories, different emission factors have been used. Having this in mind, the overall period before 2015 is revised.

The Non-GHG emissions from IPPU are very small compared to the emissions from the Energy industries sector. The peak of the emissions is in 2000 achieving 3.3 Gg, while in 2016 the emissions are 2.5 Gg or 26.4% more compared to 2014 (Figure 49). Most of the emissions are CO, which participates with 52% in 2016, follow by NOx with around 36% and SOx with 11%.

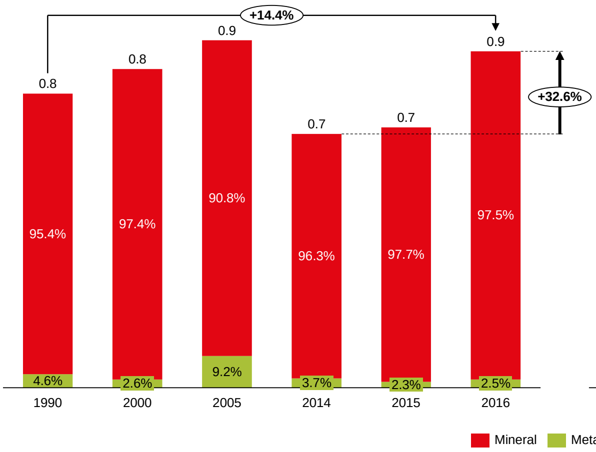
Figure 49. Emissions of NOx, CO, NMVOC and SO_2 from the IPPU sector (in Gg)



Mineral and metal industries are the only ones that have created the non-GHG emission in the IPPU category. Almost all NO_x and SO2 emissions are produced by the cement production in the Mineral industry, 97% and 93% in 20016 (Figure 50, Figure 51). The share of the Mineral industry is also dominant in the CO and NMVOC emissions participating with around 80%, 61%, respectively (Figure 52, Figure 53). As a result of the higher clinker production in 2016 compared to 2014 the NOx emissions are increased 32.6% during this period, while the SO_2 emissions are increased by 36.5%. The peak of the iron and steel production in 2005 led to the highest CO and NMVOC emissions from this sub-category. In that year the share of the Metal industry in CO was 52.8% while in NMVOC was around 72%.

Figure 50. NOx emissions from the IPPU sector, by category (in Gg)

Figure 51. SO_2 emissions from the IPPU sector, by category (in Gg)



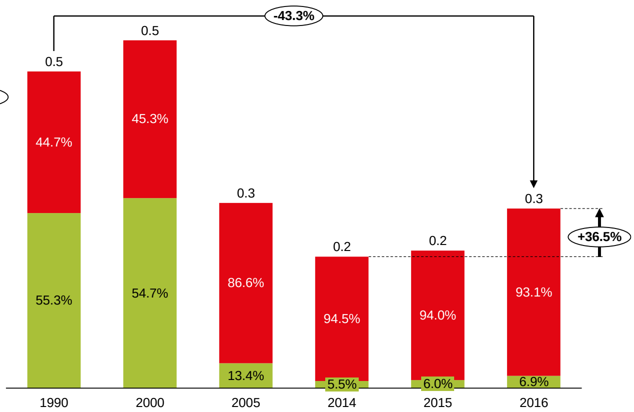
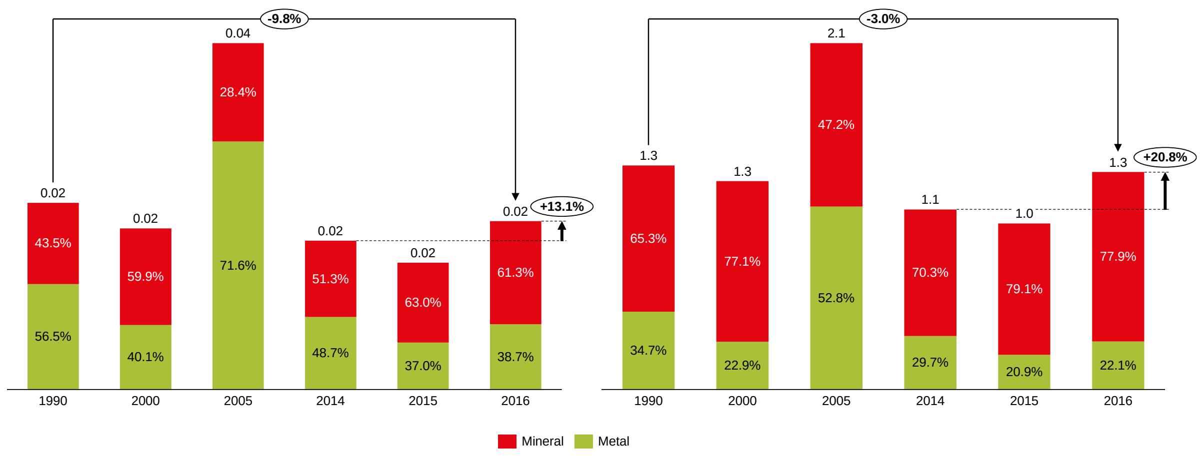


Figure 52. NMVOC emissions from the IPPU sector, by category (in Gg)

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



7.3.1 Methodology and emission factors

The Tier 1 approach was used to calculate the emissions of precursors and indirect emission from IPPU sector (Table 41).

Table 41. Emission factors used for estimation of the emissions of Precursors and Indirect emissions of the IPPU sector

Emission factor	3rd BUR	Comment
Mineral industry	EMEP/EEA air pollutant emission inventory guidebook 2019 Table 3.1 Tier 1 emission factors for source category 2.A.1 Cement production. Table 3-24 Tier 2 emission factors for source category 1.A.2.f.i, Cement production (1.A.2 Manufacturing industries and construction (combustion)) Table 3.1 Tier 1 emission factors for source category 2.A.2 Lime production. Table 3-23 Tier 2 emission factors for source category 1.A.2.f.i, Lime production (1.A.2 Manufacturing industries and construction (combustion)) Table 3.1 Tier 1 emission factors for source category 2.A.3 Glass production	
Metal industry	EMEP/EEA air pollutant emission inventory guidebook 2019 Table 3.15 Tier 2 emission factors for source category 2.C.1 Iron and steel production, steel making, electric arc furnace steel plant. Table 3.1 Tier 1 emission factors for source category 2.C.5 Lead production	

7.3.2 Data sources

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

Table 42. Data sources for estimation of the emissions of Precursors and Indirect emissions of the IPPU sector

	Documents	Data provider
Mineral industry	Cement Industry clinker production Industry (1990-1995, 1996-2001, 2002-2006, 2006-2010, 2011-2016), MAKSTAT 2007-2016	MOEPP SSO
Metal industry	Industry (1990-1995, 1996-2001, 2002-2006, 2006-2010, 2011-2016), MAKSTAT 2007-2016	SSO

7.4 AFOLU

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 Forest land (forest fires).

The non-GHG emissions from AFOLU vary during the reporting period, mostly depending on forest fires. The peak of the emissions of 178 Gg is achieved in 2000 (Figure 54), which is a result of the biggest forest fires in the overall reporting period. CO emissions participate with almost 80% in 2000. Compared to 2014 the non-GHG emissions in 2016 are higher for 48%. The second contributor in the overall non-GHG emissions is NH_3 from manure management, participating with almost 44% in 2016.

The results by categories shows that:

- During the analysed period emissions of NOx are typically in the range 0.1-0.7 Gg, with exception of the year 2000, where the emissions are 4.7 Gg, due to extensive forest fires and area burned in the country (Figure 55).
- The SO_2 emissions are around 0.1 Gg, while in 2000 they reached 0.9 Gg. All SO2 emissions are produced by forest fires (Figure 56).
- NMVOCs are in average 5 Gg/year, while in the year 2000 they are estimated on 19 Gg (Figure 57).
- CO emissions are in range 0.4-17 Gg, but in years 2000 they were 138 Gg, because of the fires (Figure 58).
- All NH3 are results of manure management activities. In 2016 they are lower for 32% compared to 1990, while for 5% higher from 2014 (Figure 59)

Figure 54. Emissions of NOx, CO, NMVOC, SO_2 and NH_3 from the AFOLU sector (in Gg)

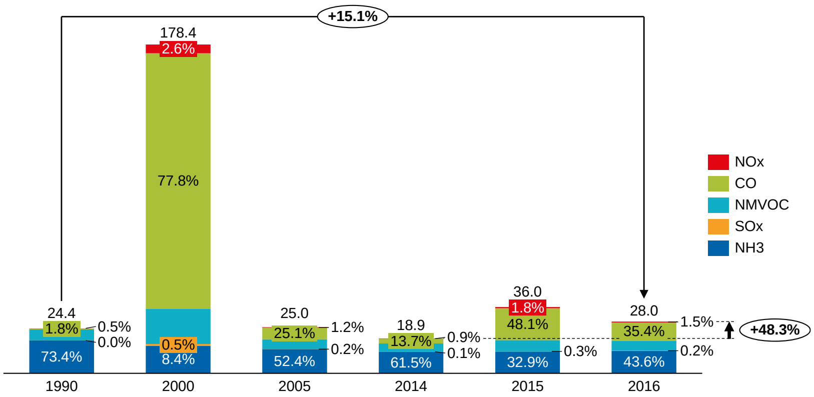


Figure 55. NOx emissions from the AFOLU sector, by category (in Gg)

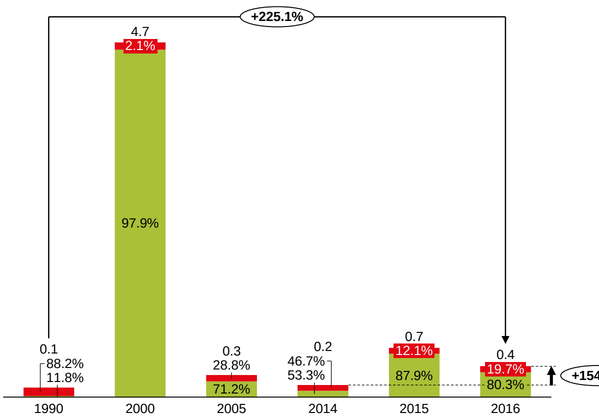


Figure 56. SO_2 emissions from the AFOLU sector, by category (in Gg)

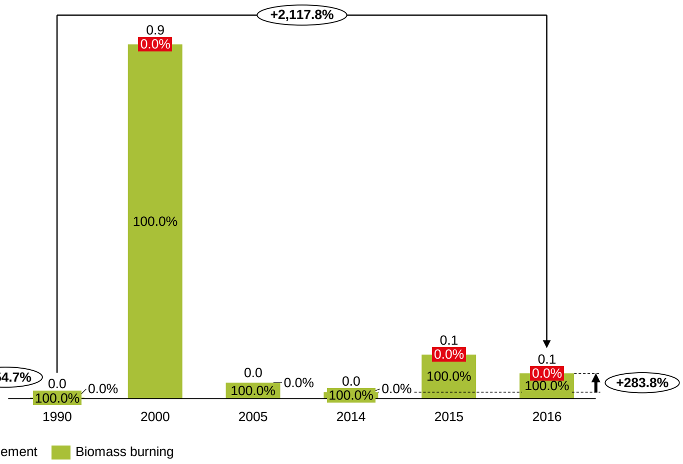


Figure 57. NMVOC emissions from the AFOLU sector, by category (in Gg)

Figure 58. CO emissions from the AFOLU sector, by category (in Gg)

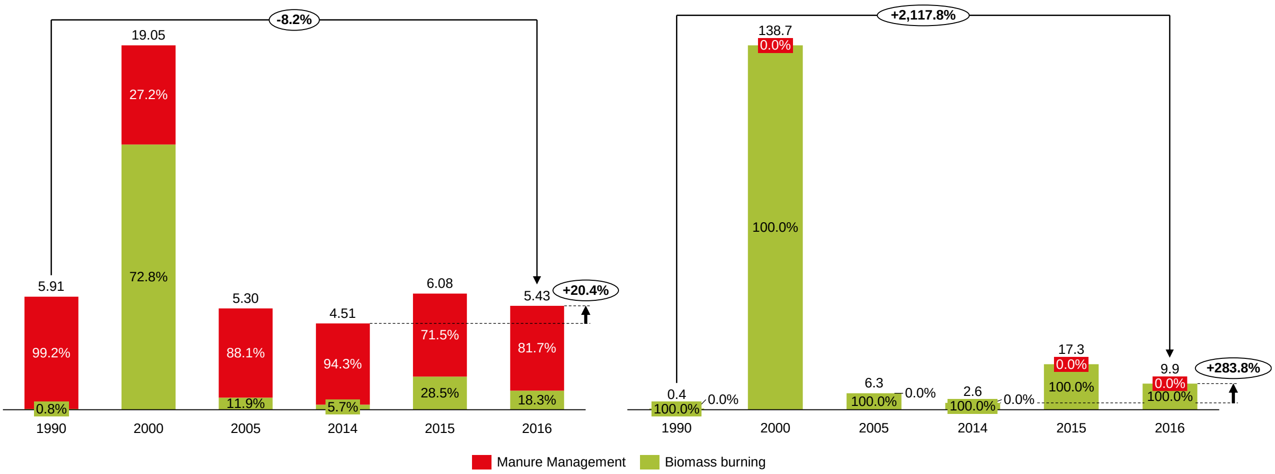
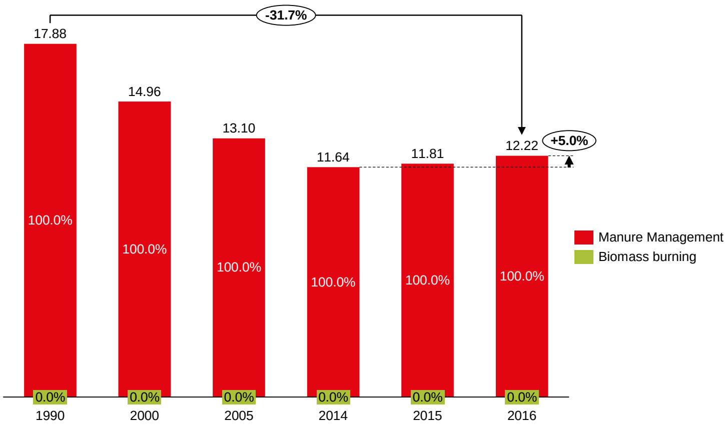


Figure 59. NH_3 emissions from the AFOLU sector, by category (in Gg)



7.4.1 Methodology and emission factors

Emissions of NMVOCs occur from silage, manure in livestock buildings, outside manure storages, field application of manure and from grazing animals. There is a 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.

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).

The Tier 1 approach was used to calculate the emissions of precursors and indirect emission from AFOLU sector (Table 43).

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

Emission factor	3rd BUR
Manure Management	EMEP/EEA pollutant emission inventory Guidebook 2019; 3.B Manure management

	Table 3.2. Default Tier 1 EF (EF_{NH3}) for calculation of NH3 emissions from manure management Table 3.3 Default Tier 1 EFs for NO (as NO_2) from stored manure Table 3.4 Default Tier 1 EFs for NMVOCs Table 3.5 Default Tier 1 estimates of EF for particle emissions from livestock husbandry (housing)
Emissions from biomass burning	EMEP/EEA pollutant emission inventory Guidebook 2019; 11.B Forest fires Table 3-1 Tier 1 emission factors for source category 11.B Forest fires

7.4.2 Data sources

The activity data used for manure management are livestock populations provided by SSO. For biomass burning the activity data are the areas burned (forests). Data on forest fires were obtained from MAFWE, State Inspectorate for Forestry and Hunting and the Crisis Management Centre (Table 44).

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

	Documents	Data provider
Livestock-Manure Management	Total number of livestock & poultry in Macedonia	SSO –MAKSTAT database
Biomass burning in forests	SSO Yearbooks, Annual reports, internal documents	Enterprises that manage forests (PE Makedonski sumi, National parks, Association of private forest owners), MAFWE, CMC (Center for Management of Crisis), FFU (Firefighting Union))

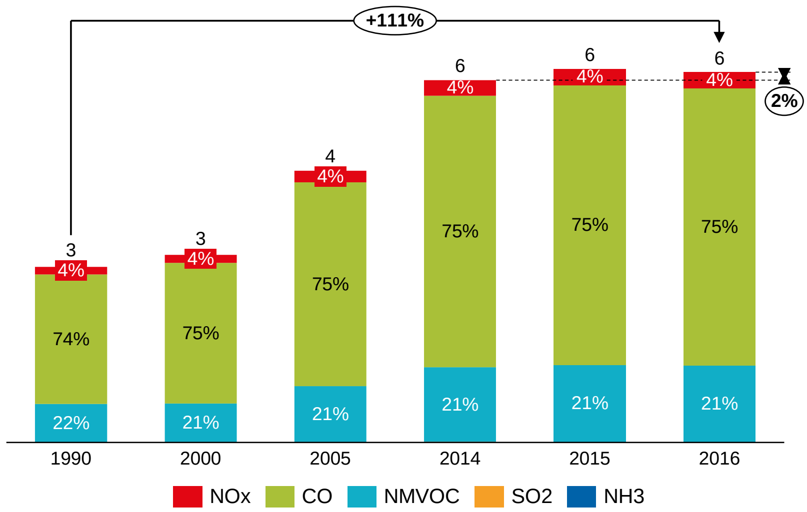
7.5 Waste

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.

During the preparation of the precursors and indirect emissions from waste, it was found that there are inconsistencies in the data and factors used in the period 1990-2014. Having in mind that better data are available, the revision of the times series was made. For example for Domestic wastewater treatment and discharge, lower factor for waste generation per capita was used. This factor is revised according to the data that SSO is publishing starting from 2016.

In 2016, the amount of precursors and indirect emissions is two times higher compared to 1990, or the average annual growth rate is 3% (Figure 60). The increase is coming from the Open burning of waste at the dump sites. CO is the dominant one with a participation of around 75% during the overall reporting period, while the second one is NMVOC with 21%.

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



Although there is an incinerator at Drisla landfill, the emissions are negligible and almost the overall amount of NOx, CO, and SO_2 emissions are generated by the subcategory Open burning of waste at the dumpsites (Table 45). On the other hand, the category Solid waste disposal is contributing with more than 87% in the NMVOC in 2015 and 2016.

Table 45. Emissions of NOx, CO emissions from the Waste sector (in Gg)

Categories	NOx						CO					
	1990	2000	2005	2014	2015	2016	1990	2000	2005	2014	2015	2016
Waste	**0.34**	**0.37**	**0.53**	**0.78**	**0.64**	**0.71**	**5.91**	**6.41**	**9.29**	**13.56**	**11.22**	**12.46**
Solid Waste Disposal	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
Biological Treatment of Solid Waste	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Incineration and Open Burning of Waste	**0.17**	**0.18**	**0.27**	**0.39**	**0.32**	**0.36**	**2.96**	**3.21**	**4.64**	**6.78**	**5.61**	**6.23**
Waste Incineration	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open Burning of Waste	0.17	0.18	0.26	0.39	0.32	0.35	2.96	3.21	4.64	6.78	5.61	6.23
Wastewater Treatment and Discharge	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
Domestic Wastewater	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Industrial Wastewater	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

NE – Not Estimated

Table 46. Emissions of NMVOC, SO_2 and NH_3 emissions from the Waste sector (in Gg)

Categories	NMVOC						SO_2						NH_3					
	1990	2000	2005	2014	2015	2016	1990	2000	2005	2014	2015	2016	1990	2000	2005	2014	2015	2016
Waste	**0.13**	**0.14**	**0.21**	**0.30**	**1.22**	**1.21**	**0.01**	**0.01**	**0.02**	**0.03**	**0.02**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Solid Waste Disposal	**0.00**	**0.00**	**0.00**	**0.00**	**0.97**	**0.93**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
Biological Treatment of Solid Waste	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Incineration and Open Burning of Waste	**0.07**	**0.07**	**0.10**	**0.15**	**0.12**	**0.14**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
Waste Incineration	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NE	NE	NE	NE	NE	NE
Open Burning of Waste	0.07	0.07	0.10	0.15	0.12	0.14	0.01	0.01	0.01	0.01	0.01	0.01	NE	NE	NE	NE	NE	NE
Wastewater Treatment and Discharge	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
Domestic Wastewater	0.00	0.00	0.00	0.00	0.00	0.00	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Industrial Wastewater	0.00	0.00	0.00	0.00	0.00	0.00	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

NE – Not Estimated

7.5.1 Methodology and emission factors

For all categories in the waste sector the default Tier 1 emission factors are used, except for the category Biological treatment of waste – composting for which Tier 2 emission factors are applied.

Regarding wastewater handling, emissions are calculated from both domestic wastewater treatment and industrial wastewater treatment. Starting from 2017, the State Statistical Office is issuing a report on Public water supply and Public sewage. This report contains information about the quantities of total discharged wastewater, non-purified wastewater and purified wastewater, which were used to calculate the share of wastewater treated. On the other hand, the quantities of discharged wastewater from households together with the number of populations, provide information about the domestic wastewater per capita. This information was used to calculate the total amount of domestic wastewater produced and treated in 2015 and 2016. The same methodology is applied for the period before 2015. In addition, for the industrial wastewater treatment, it was noted that in the activity data instead of wastewater generated in m^3, the industrial production in tones is used, so it was corrected.

Table 47. Emission factors used for estimation of the emissions of Precursors and Indirect emissions of the Waste sector

Emission factor	3rd BUR	Comment

Waste incineration of clinical waste	Table 3-1 from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019, Chapter 5.C.1.b.iii Clinical waste incineration	
Open burning of waste	Table 3-1 from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019, Chapter 5.C.2 Open burning of wastes	
Wastewater handling	Table 3-1 from EMEP/EEA Air Pollutant Emission Inventory Guidebook 2019, Chapter 5.D. Wastewater handling	

7.5.2 Data sources

The main data source is the State Statistical Office, as well as relevant reports from the institutions as MOEPP (Table 48).

Table 48. Data sources for estimation of the emissions of Precursors and Indirect emissions of the Waste sector

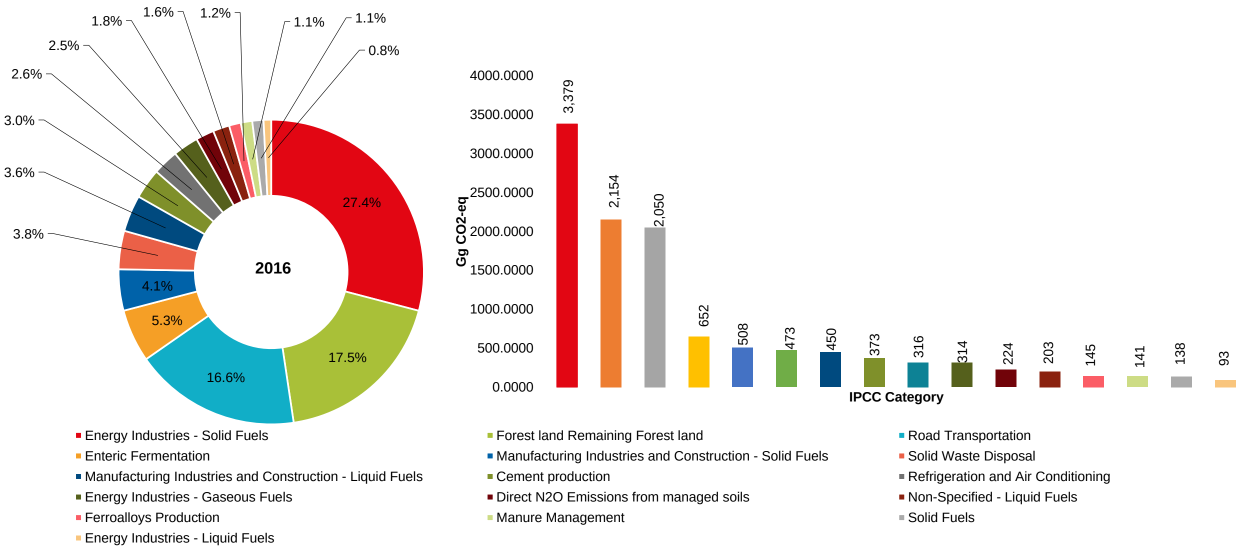
	Documents	Data provider
Waste incineration of clinical waste	Drisla landfill data on incineration of medical waste	Drisla web site, MOEPP reports on environment 2000-2016
Open burning of waste	Report on non-compliant landfilling in the R Macedonia, 2011 Municipal waste	MOEPP, SSO
Wastewater handling	Public water supply and Public sewage, Utilisation and protection of water against pollution in industry, Industrial production	SSO

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 2016, as the latest year. The results in Gg CO_2-eq and percentages (up to 95%) for 2016 are depicted in Figure 61. Consequently, the top five categories with the highest values of Gg CO_2-eq (both emissions and removals) include: Energy Industries – Solid Fuels (27.4%) (Energy sector), Forest Land Remaining Forest Land (17.5%) (AFOLU sector), Road Transportation (16.6%) (Energy sector), Enteric Fermentation (5.3%) (from Livestock in AFOLU sector) and Manufacturing Industries and Construction – Solid Fuels (4.1%) (Energy sector). The Forest land category is relevant for sinks, while the other categories for GHG emissions. The level assessment of key categories in 1990 and 2016 in details is given in Appendix III.

Figure 61. Level assessment of key categories and their contribution in 2016



The trend assessment of source categories is also executed, taking 1990 as base year and 2016 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%) presented on Figure 62 show that Forest Land Remaining Forest Land category participates with 27.4%, follow by Road Transportation with 22.8%, Energy Industries-solid fuels with 5%, Manufacturing Industries and Construction – Liquid Fuels with 4.8% and Refrigeration and Air Conditioning with 4.6%. An overview of the trend assessment relating to 1990 and 2014 is given in Appendix III.

The identified key categories, with both level and trend assessment, for 2016 are summarized in Table 49.

Figure 62. Contribution of key categories to the Trend (1990, 2016) in percentages

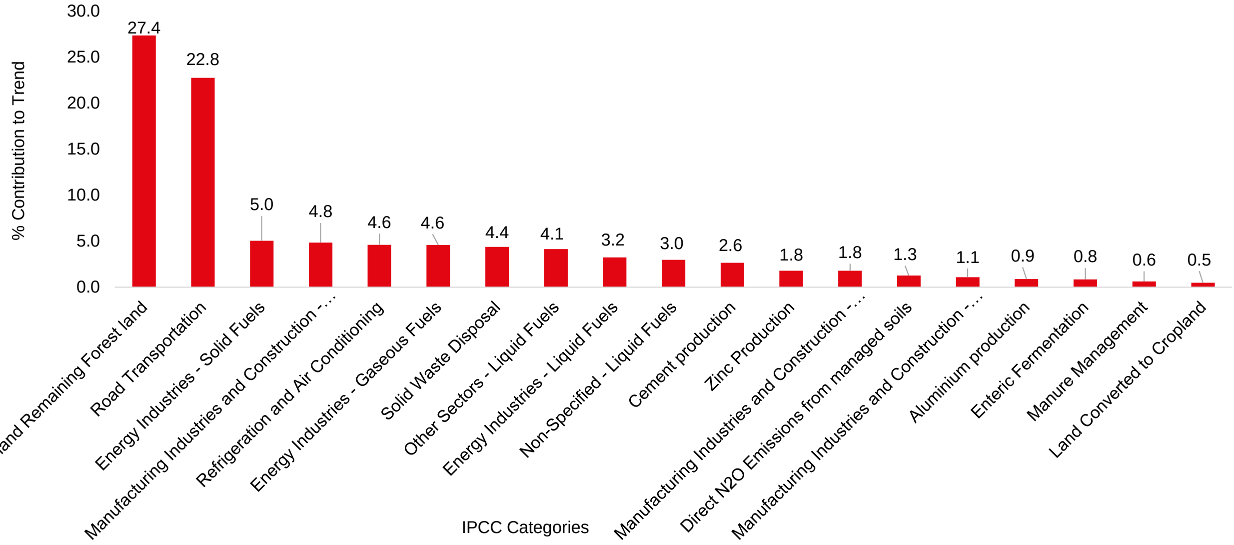


Table 49. Summary of key category analysis in 2016

	IPCC Category code	IPCC Category	Greenhouse gas	Identification Criteria	Comment
1	1.A.1	Energy Industries - Solid Fuels	CO_2	L1, T1	
2	3.B.1.a	Forest land Remaining Forest land	CO_2	L1, T1	
3	1.A.3.b	Road Transportation	CO_2	L1, T1	
4	3.A.1	Enteric Fermentation	CH_4	L1, T1	
5	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	L1, T1	
6	4.A	Solid Waste Disposal	CH_4	L1, T1	
7	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	L1, T1	
8	2.A.1	Cement production	CO_2	L1, T1	
9	2.F.1	Refrigeration and Air Conditioning	HFC	L1, T1	
10	1.A.1	Energy Industries - Gaseous Fuels	CO_2	L1, T1	
11	3.C.4	Direct N2O Emissions from managed soils	N_2O	L1, T1	
12	1.A.5	Non-Specified - Liquid Fuels	CO_2	L1, T1	
13	2.C.2	Ferroalloys Production	CO_2	L1	
14	3.A.2	Manure Management	CH_4	L1, T1	
15	1.B.1	Fugitive emissions - Solid Fuels	CH_4	L1	
16	1.A.1	Energy Industries - Liquid Fuels	CO_2	L1, T1	
17	1.A.4	Other Sectors - Liquid Fuels	CO_2	T1	
18	2.C.6	Zinc Production	CO_2	T1	
19	1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	T1	
20	2.C.3	Aluminium production	PFCs	T1	
21	3.B.2.b	Land Converted to Cropland	CO_2	T1	

Notation keys: : *L = key category according to level assessment; T = key category according to trend assessment; L1 – Level assessment, Approach 1; T1 – 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 inventory in SBUR 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 both, Approach 1 and Approach 2, are applied for each sector of the inventory for 2014, 2015 and 2016.

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 50). Additionally, in the IPPU sector the same input data for uncertainty are used in both methods (Table 50). 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 50. 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 51 and Table 52). 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 53.

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

Table 51. 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 52. 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 53. 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

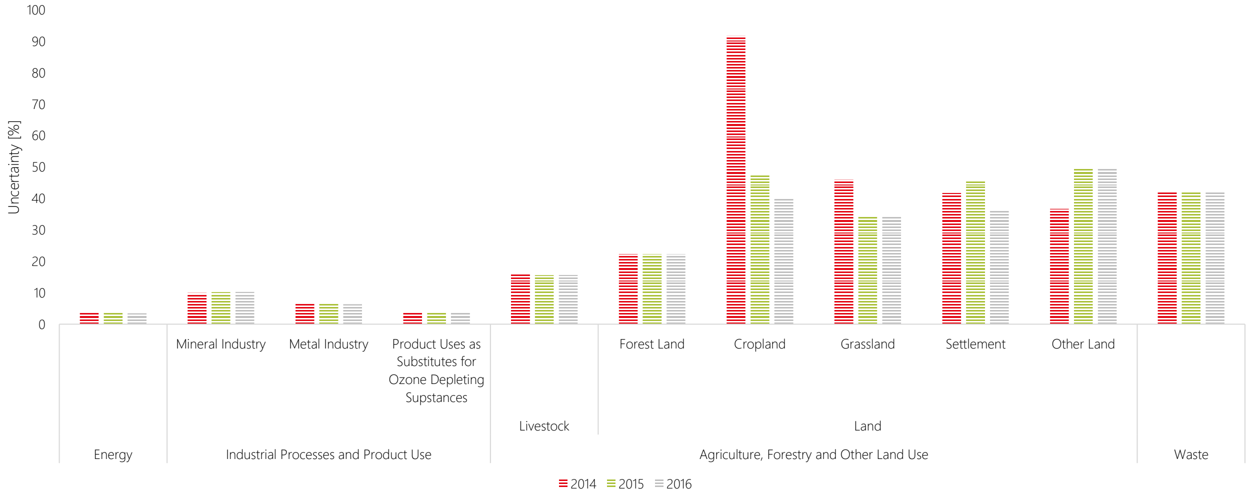
For the Monte Carlo method it is assumed that each input variable has normal distribution.

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% and in 2014 the uncertainty in the sub-category Land to cropland is more than 90%. 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 around 10%.

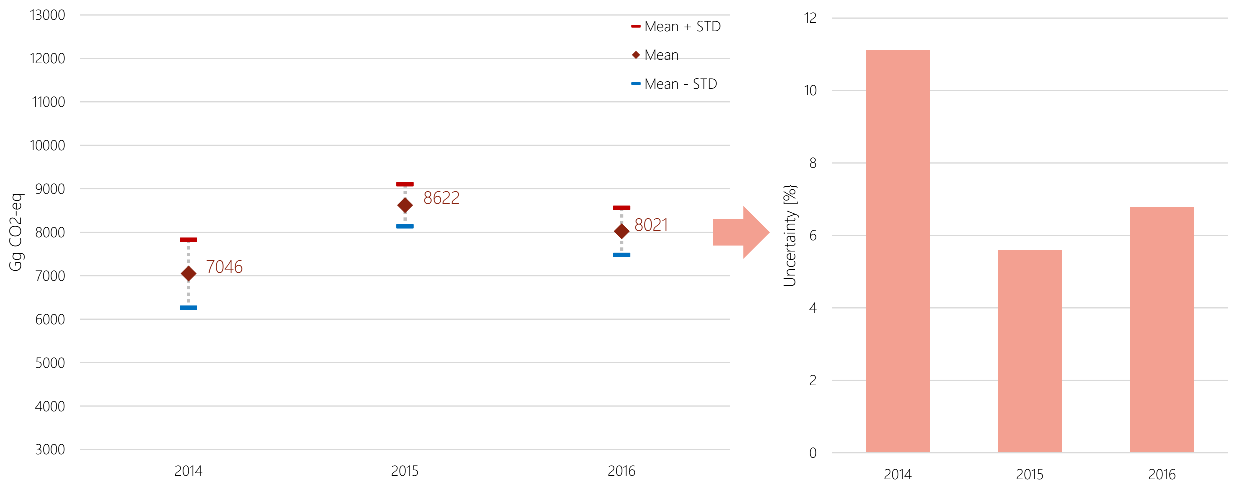
Figure 63. Uncertainty for 2014, 2015 and 2016 using Error Propagation method by subcategory



As a result of the different share of the individual subcategories in each analyzed year, the total annual uncertainty is different (Figure 64). The decrease of the share of the AFOLU sector (which have the highest uncertainty) in 2015 and 2016 compared to 2014, contributes to corresponding decrease of the total annual uncertainty in these two years.

The results show that the average deviation from the total annual emissions for 2014 is around ±782 Gg CO_2-eq, while for 2015 and 2016 it is around ±483 Gg CO_2-eq and ±544 Gg CO_2-eq, respectively (Figure 64).

Figure 64. Total yearly emissions (and standard deviation) and total uncertainty for 2014, 2015 and 2016 using Error Propagation method

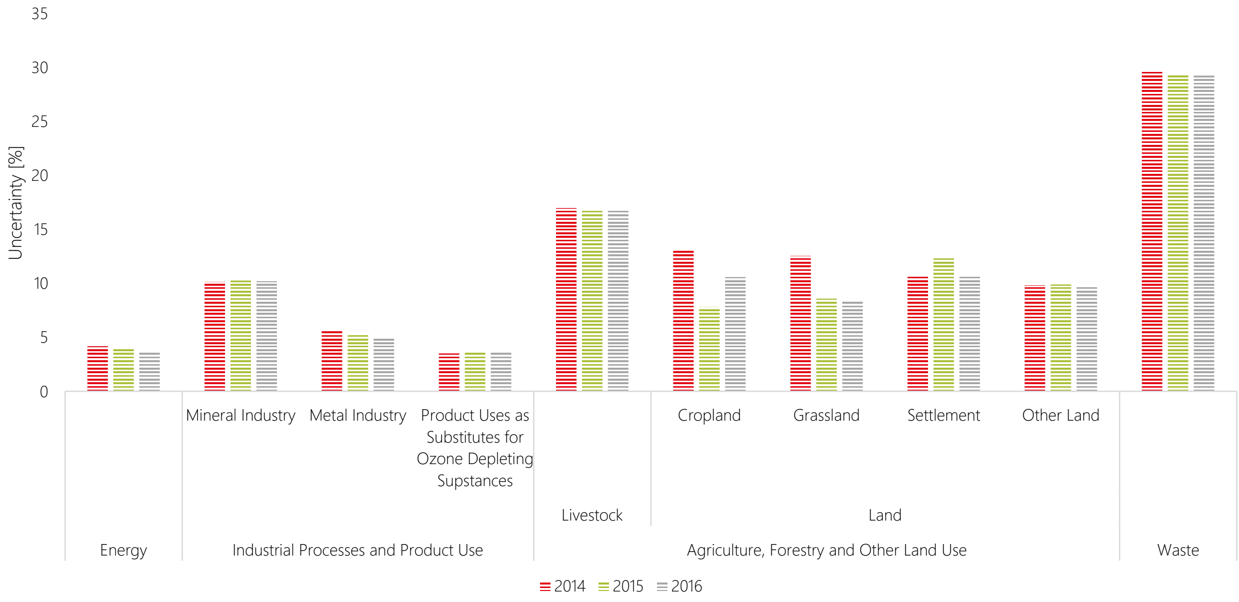


9.2.2 Monte Carlo method (Approach 2)

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 29% 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 2014, 2015 and 2016 using Monte Carlo method by subcategory

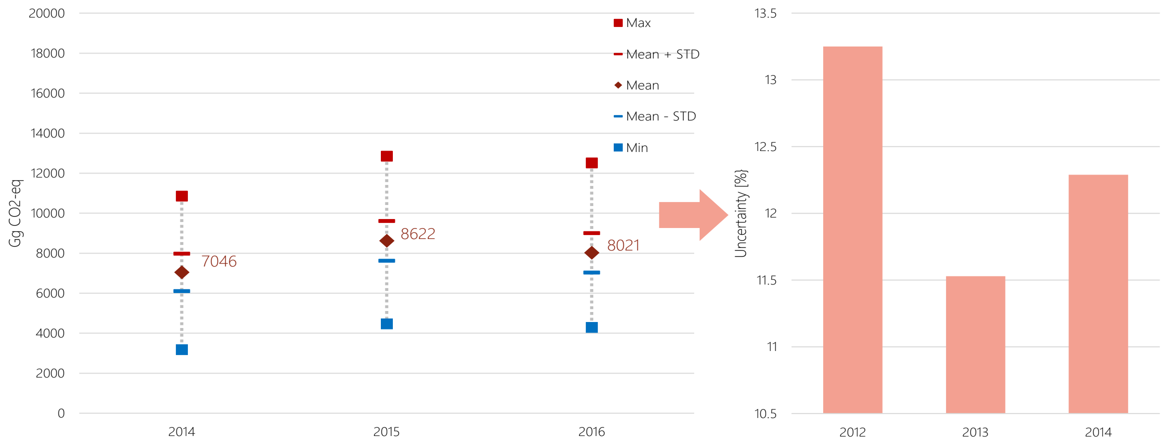


In order to obtain results from the Monte Carlo method 20,000 iterations were made. It is very important to note that the resulting annual average value is approximately the same as the calculated total emissions for each year and varies by less than 0.2% of the estimated annual emissions. This shows 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 2014 is approximately ± 934 Gg CO_2-eq, while for 2015 and 2016 it is approximately ± 994 Gg CO_2-eq and ± 986 Gg CO_2-eq, respectively.

As with the Error Propagation method, the decrease in the share of the sectors with greater uncertainty, also decreases the total annual uncertainty in 2015 and 2016 compared to 2014.

Figure 66. Total yearly emissions and total uncertainty for 2014, 2015 and 2016 using Monte Carlo method



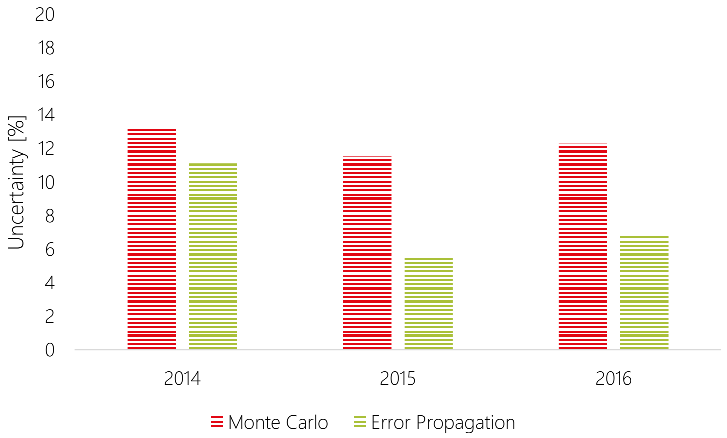
9.2.3 Comparison between Error Propagation method (Approach 1) and Monte Carlo method (Approach 2)

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 2014

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.

Furthermore, there is great uncertainty in the Livestock subcategory. Based on the survey conducted in the future, emissions for dairy cattle and pigs will be estimated by applying Tier2 methodology. The results were not available during the preparation of this report. Hence the uncertainty will be reduced in 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 QA/QC procedures presented in the SBUR are also applied in 3rd BUR. The QA/QC activities of the national GHG inventory process are based on the in-depth analyses of the inventory compilation practices in the country (used in the previous BURs) and the relevant international best practices..

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.

The IDT members that collect input data (i.e. identify/verify data sources and document the input data) and calculate the sectoral emissions are called “Enterer”, while the IDT members that conduct QC activities and procedures are called “Checker”.

10.1.3 QA team (QAT)

The 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 54. 3rd BUR 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 Approval of NIR and other reports QA/QC activities
Verica Taseska-Gjorgievska **verica@manu.edu.mk**	**IDT Member** **QAT Member** **Compilation of overall inventory and NIR**	Sectors: Energy, Waste, IPPU, Precursors and Indirect emissions (QC, development of the sectoral chapters) Key category analysis Sectors: AFOLU
Aleksandar Dedinec **dedinec@manu.edu.mk**	**IDT Member** **QAT Member**	Sectors: Energy, Waste, IPPU, Precursors and Indirect emissions (QC, development of the sectoral chapters) Key category and Uncertainty analysis Sectors: AFOLU
Aleksandra Dedinec **aleksandra.kanevche@finki.ukim.mk**	**IDT Member** **QAT Member**	Sectors: Waste (QC, development of the sectoral chapters) Uncertainty analysis Sectors: AFOLU
Emilija Mihajloska **emilija.mihajloska@sdewes.org**	**IDT Member**	Sectors: Energy, Waste, IPPU, Precursors and Indirect emissions (collecting and entering data, development of the sectoral chapters) Key category analysis
Vasil Bozhikaliev **bozhikaliev@gmail.com**	**IDT Member**	Sectors: Energy, IPPU (collecting and entering data, development of the sectoral chapters)

Lazar Aleksovski **laleksovski94@gmail.com**	**IDT Member**	Sector: Waste, IPPU (collecting and entering data)
Ljuleta Xhemaili **luljeta.xhemaili@unt.edu.mk**	**IDT Member**	Legal document on list of key data providers for GHG inventory
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 (QC for Forestry, development of the sectoral chapter)
Dusko Mukaetov **d.mukaetov@zeminst.edu.mk**	**IDT Member**	Sector: AFOLU (QC for Land Use, development of the sectoral chapter)
Ordan Cukaliev **cukaliev@gmail.com**	**IDT Member**	Sector: AFOLU (QC for Land Use, development of the sectoral chapter)
Hristina Poposka	**IDT Member**	Sector: AFOLU (collecting and entering data for Land Use, development of the sectoral chapter)
Dusko Nedelkovski	**IDT Member**	Sector: AFOLU (collecting and entering data for Land Use, development of the sectoral chapter)
Vjekoslav Tanskovic	**IDT Member**	Sector: AFOLU (collecting and entering data for Land Use, development of the sectoral chapter)
Elena Gavrilova **egavrilova.mk@gmail.com**	**QAT Member**	QA activities: Energy, Waste, IPPU and Precursors and Indirect emissions
Marjan Mihajlov **m.mihajlov@maneko.com.mk**	**QAT Member**	QA activities: Waste

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, processing, input, and handling,
- Data documentation and archiving,
- Emissions calculation.

Table 55. 3rd BUR 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 • Cross-check a sample of input data from each category (either measurements or parameters used in calculations) for transcription errors. • Utilize electronic data where possible to minimize transcription errors. • Use IPCC Inventory Software to minimize user/entry error.
Check that emissions/removals are calculated correctly.	• Reproduce a representative sample of emissions/removals calculations. • 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. • Check that units are correctly carried through from beginning to end of calculations. • Check that conversion factors are correct. • 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. • To extent possible, confirm that data relationships are correctly represented in the database. • Ensure that data fields are properly labeled and have the correct design specifications. • 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. • 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. • Check that every primary data element has a reference for the source of the data (via cell comments or another system of notation). • Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review. • Check that the archive is closed and retained in secure place following completion of the inventory • 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. • Check for consistency in the algorithm/method used for calculations throughout the time series. • 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. • Check for consistency in the algorithm/method used for calculations throughout the time series. • 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. • For subcategories, confirm that the entire category is being covered. • Proved clear definition of 'Other' type categories. • 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. • Check value of implied emission factors (aggregate emissions/removals divided by activity data) across time series. Are changes in emissions or removals being captured? • Check if there any unusual or unexplained trends noticed for activity data or other parameters across the time series.

Source: This list has been adapted from IPCC Good Practice Guidance and the 2006 IPCC Guidelines for National GHG Inventories.

10.3 Quality Assurance and Verification

The quality assurance (QA) activities are performed at the inventory evaluation stage i.e. after the implementation of QC procedures to the finalized inventory. 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, the 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.

An expert peer review was conducted for QA of the national GHG estimates of the sectors Energy, IPPU and Waste.

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

Table 56. 3rd BUR QA procedures implemented in the Energy, IPPU 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 ESM), the annual data on industrial production (published by SSO) and the national waste related data (the Waste related data published by the SSO and the Regional Waste studies 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 is 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
	Check if the activity data for estimating of the GHG emissions are equal for the activity data used to estimate the emissions of precursors and indirect emissions	Export the activity data from each worksheet in the IPCC 2006 database and compare with the AD provided in the tables for estimation of the emissions of precursors and indirect emissions
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

	Check if the EFs used for estimation of the emissions of precursors and indirect emissions are consistent, comparable and transparently documented	Check if the EFs used for estimation of the emissions of precursors and indirect emissions are in line with the EMEP/CORINAIR Emission Inventory Guidebook. In case CS EFs are used, check the background materials, the estimation methodology, the EF range and the comparability with other national reports
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
	Check if the excluded other non-energy use of fuels from activity data in energy sector is reported under the IPPU sector (in case emissions occurs from these non-energy uses)	Ensuring that the excluded from the Energy sector is accounted in the sector IPPU
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 a national UNFCCC certified reviewer – procedures described above)
- Two steps on international level (by the Global Support Programme (for the 3rd BUR NIR) and technical analysis as part of the UNFCCC international consultation and analysis process for non-Annex I countries (for the 3rd BUR)).

Recommendations provided by the Global Support Programme and the Technical Analysis of the UNFCCC ICA Process have been implemented in the GHG development process and in the NIR 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

The documentation on the data source, the choice of the emission factors and other information relevant for the GHG estimates are documented in the IPCC 2006 inventory database (as Worksheet remarks).

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 and constantly updated 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 newcomers in the process. Additionally, capacity building activities have been implemented and two new people within the MANU team were trained on development of GHG inventories.

11 Good practices, improvements and recommendations

In the Summary report of the Technical analyses of the Macedonian second BUR (TASR.2) it was concluded that the country has reported all the elements of information on greenhouse gases as required by the BUR guidelines (summarized in Table 1 of Annex I of the TASR.2) and commended Macedonia for the level and detail of the information provided in the NIR. Therefore, this NIR (under the 3rd BUR) was developed in the same manner, following and in same elements further improving the good practices from the previous BURs.

11.1 Energy

Good practices/improvements:

- The activity data are updated in compliance with the revised Energy Balances for the period 2005 – 2014 from the SSO (published in October 2016). In the process of updating the data, some errors and inconsistencies were noticed in the tables published by the SSO and with bilateral communication with the institution, the errors/inconsistencies were corrected. This kind of collaboration between the institutions (particularly in the Energy sector) is a good practice and relevant for improving the quality of the information reported in the BURs
- The activity data before 2005 for the Manufacturing industries and Construction category in the IPCC Inventory Software database were disaggregated in accordance with the SSO Energy balances (from 1998 till 2002). For the years for which the SSO did not publish Energy balances data from IEA databases were used.
- In the previous BURs, for the period 1990 – 2005 the category Other Sector also included the emissions under the subcategory Commercial/Institutional, while after 2005 these emissions were reported under the Non-specified subcategory (in accordance with the activity data from the SSO energy balances). In this report, based on the IEA and SSO energy balances, the activity data for the period 1990 to 2005 are included within the Non-Specified instead of Commercial/Institutional subcategory. This was done in order to be compatible with the subcategories reported in the Energy Balances from the SSO, thus reporting a consistent time series of emissions for the period 1990 – 2016 under this category
- The category *Diesel and Heating Oil* used in the Energy balances until 2011 has been separated into *Road Diesel* and *Heating & Other fueloil* in the updated Energy balances from 2005 onwards. Similarly, the *Biomass* category has been separated into *Biomass* and *Wood Wastes, Wood Briquettes and Pellets* and *Wood of fruit trees and other plant residues*. The advantage of the disaggregation has been reflected in this NIR and 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.
- The average CO_2 emission factor from the 2019 Refinements to the 2006 IPCC Guidelines was taken into account for the fugitive emissions from fuels, specifically surface mines.

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.
- Having in mind that there are several existing biogas power plants, their electricity production should be also taken into account in the next inventories, especially if more of this type of power plants will become available in the future. Since there are no data available on the amount of biogas used for electricity production, it is recommended to develop a separate study for the existing biogas power plants. This study would be also relevant for the AFOLU and Waste sectors since the biogas is produced from manure.

11.2 IPPU

Good practices/improvements:

- The activity data for all industrial processes subcategories have been revised, using the Reports for Industry from SSO, thus providing consistent time series of activity data for the whole reporting period, without using interpolation/extrapolation for the missing data. The data from the reports have been grouped using the relevant NACE codes, taking into account their revisions over the relevant period for the NIR.
- The factor for clinker production has been also corrected based on the annual reports from the cement factory.
- The F-gases input data used in the IPCC Software have been adjusted in accordance with the IPCC Guidelines.
- There is no soda ash production in the country and the emissions that have been reported in the previous BURs for this subcategory are now reported as not occurring. The emissions occur only from the use of soda ash and have been reported under subcategory Other uses of soda-ash.

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 3rd BUR was done with background data from State Statistical Office. In addition, data for manure used in biogas power plants were considered. Since 2015 two power plants of 3 MW each and 1 plant of 1 MW have been operational. The first two plans in biogas digesters use corn silage and manure form two dairy farms. Liquid manure of 440 m^3 have been collected on daily bases (50 t daily manure and the rest is technical water). The last one (1 MW power plant) use 9 t poultry manure (layers) and 5-10 t liquid swine manure. Total reduction of emissions from manure management due to biogas digesters in 2015 -16 was 0.016 Gg CO_2 – eq. However, due to lack of sufficient data for GHG emission from those biogas digesters in other related sectors (Energy and Waste) in 3rd BUR the reductions in emissions form manure management due to biogas digesters were neglected.
- Other aspect was commitment of field survey where detailed information were obtained for small dairy cows (less than 30 cows), and small swine farms (up to 50 sows). The outcomes of the survey were available later than 3rd BUR preparation, hence were not part of this report.

Recommendations for future inventories:

- In preparation of next BUR emission of GHG gases form manure management should be reduced for the use of manure in biogas digesters. In addition, Tier 2 methodology should be applied in dairy cows and swine.

▪ Land use

The inventory of the GHG emissions for the 3rd BUR or the sector-agriculture, was based to the available national data from the SSO and Ministry of Agriculture, Forestry and Water Economy (MAFWE) and international data sources, like CORINE Land Cover (CLC) and FAO-Stat.

Data from the SSO and CLC were used in order to estimate the area under certain land use category and its dynamics, which serve as activity data according IPCC methodology. Official data published by SSO refers to the area under certain Land Use type for a given year, 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 or a three periods, on the base of 3 data sets: 2000-2006, 2012 and 2018, and interpolated for the gap years between each monitoring campaign of CLC.

CLC data for all land use categories remaining in the same category, for each inventory year, were compared and adjusted to the SSO data, in addition, for this BUR, such comparison and calculation of dynamics among the newly established and uprooted, perennial plantations has been performed as well.

This is a significant improvement since the dynamics between the newly established and uprooted perennial plantations, is a serious sink/emission of CO2.

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.

For these reasons, in this BUR, a special attention has been payed to the design of detailed methodology and implementation of activities for enforcement of the capacities for RS and EO. Two GIS experts are engaged in this process, and as expected will develop digital data base with higher resolution and accuracy of the LU/LUC or the key categories according IPSS methodology, on a yearly level.

As planned, the following RS and EO activities is expected to be achieved:

- Analyze of the LU/LUC based on a high resolution open source Satellite Imagery photointerpretation
- Comparing the derived data sets with the exiting national graphical data sets , (e.g. aerial photographs available from State Cadastral Office)
- 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

This improvement in LU/LUC will allow moving forward in certain cases towards Tier 2, with regards to the activity data in Land subsector of AFOLU. In addition to the LU/LUC data, other activity data sets that needs to be improved, are:

a) Mineral fertilizers use – types and quantities used
b) Manure –quantity, quality and management
c) Plant organic residues and by-products-quantity and management

In order to move to higher Tier`s in the other sectors, an in addition to the proposed measures for development and improving of the existing LU/LUC data set and other activity data, 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: various land use types, land management practices and inputs,
b) SOC dynamics under certain lad use, management practices and Inputs
c) Annual biomass productivity of perennial crops measurements (orchards, vineyards, forage etc.)

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:

- Implemented satellite images for land use change from and to Forest land (CORINE Land Cover) for 2000, 2006, 2012 and 2018 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 "Nacionalni 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 evidence
- Collect data for other non-wood products

11.4 Waste

Good practices/improvements:

- Fractions for composition of the waste going to the SWDS have been updated using the data from the regional waste management plans.
- The emissions from waste composting activities introduced in SBUR for the period from 2012– 2014, are now extended for the period 2011 – 2016, based on the Annual reports on Quality of the Environment from the Ministry of Environment and Physical Planning.
- The percentage of waste deposited in disposal sites has been recalculated and 90% of the total generated MSW is going to SWDS, including the Uncategorized SWDS. The rest 10% of waste is reported in the category Open Burning of Waste.
- The emissions from incineration of clinical waste have been estimated for period 2000 -2016, based on the activity data available from the SWDS where the incineration is performed (SWDS Drisla).
- More industry sectors have been introduced in the subcategory Industrial wastewater treatment and discharge based on SSO data. The data have been classified in the following industrial sectors: Alcohol Refining, Beer & Malt, Coffee, Dairy Products, Meat & Poultry, Organic Chemicals, Petroleum Refineries, Plastics & Resins, Pulp & Paper (combined), Soap & Detergents, Starch Production, Sugar Refining, Vegetable Oils, Vegetables, Fruits & Juices, Wine & Vinegar. The correlation with the SSO data was made using the NACE codes. At the same time a revision of the overall time series has been made and the inconsistencies identified in the previous BUR were corrected.

Recommendations for future inventories:

- Currently, for the Solid waste disposal there are no data on waste production by industry type. It is recommended for the next inventories to disaggregate the data for waste generated from manufacturing industries by industry types, in order to be able to use the default values of DOC and fossil carbon contents in industrial waste for specific industry types (as per the IPCC 2006 Guidelines, Vol. 5, Ch. 2, Table 2.5). This should be done in close collaboration with the SSO.
- Having in mind that there are several existing biogas power plants, the biogas production in biodigestors should be further investigated and included in the inventory. This could be done as a separate study and in cooperation with biogas power plant installations.

11.5 Gender aspect

The national GHG inventory development process incorporated well balanced gender team: 43% women and 57% men. Additional efforts have been made to integrate gender responsive considerations into the GHG inventory to the extent possible, following the national Action plan on gender and climate change and the UNDP Gender Responsive National Communications Toolkit:

Making Greenhouse Gas Inventory Process More Gender Responsive		
	Y/N	More info
• Engage gender specialists from government, private sector and civil society to develop gender analysis framework for GHG data collection across sectors within the national context	Y	Link to the document. UNFCCC Gender and Climate Change Focal point appointed Gender consultant engaged to support integration of gender considerations within the 3rd BUR

• Establish criteria for technical working group (TWG) membership to ensure that social and gender analysis specialists participate in all aspects of GHG inventory process	Y	Network of climate change national practitioners established, comprising social and gender analysis specialists.
• Ensure work plan highlights categories where gendered divisions of labour indicate scope for in-depth gender analysis	N	There is absence of official statistical gender disaggregated data in the analyzed sectors. Additionally, the Inventory does not provide data on the labour force in each of the sectors, and therefore cannot include gender perspective in the social aspect as well.
• Where GHG inventories connect to social data, ensure collection of sex-disaggregated data, identify gaps in data and include consideration of gender issues in strategies to overcome data constraints	Y	To certain extend. Official data are not collected. However, innovative approach has been used to collect sex-disaggregated data for the household heating sector and used for various case-studies /analyses/policies.

The results of the assessments indicate that at this time the GHG Inventory cannot reflect the gender dimension, due to the absence of official statistical gender disaggregated data in the analyzed sectors: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU) and Waste, disaggregated by categories and subcategories on the percentage of female and male participation in the production of the GHG emissions.

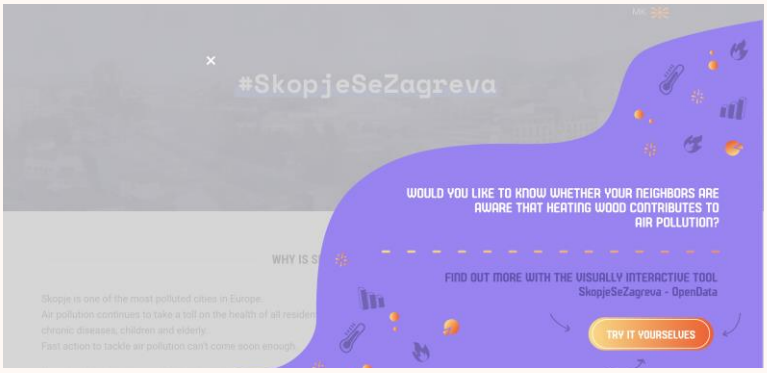
The official statistical agencies are recommended to start collecting gender disaggregated data in the listed sectors.

THE POWER OF CLIMATE DATA

According to the GHG inventory, energy is the main “sector to blame” for the national GHG emissions. On contrary, the relevant data statistics are far from gender sensitive and prevent gender responsive policies.

As a result of UNDP’s efforts to introduce innovation into climate change in the country, it was proved that big pool of data can be provided fast and with low-cost for one of the “main” reasons for the increase of greenhouse gases and local air pollution in Skopje – the Household Heating Practice.

Opening the data in a Microsoft PowerBi software tool enabled access and interactive specific analysis of the data in line with citizen and expert needs. The data served as baseline for many analyses, designing and testing actions for climate change mitigation, improving air quality and **identification of most vulnerable groups.**



Appendix I Activity data, methodology and emission factors

A I.1 Activity data

A I.1.1 Energy

Table 57. Activity data used in energy sector for 1990 (in TJ)

	Solid fuels						Liquid fuels					Gaseous fuels	Biomass
2006 IPCC Categories	Lignite	Coking coal	Sub-bituminous coal	Anthracite	Coke Oven Coke / Lignite Coke	Other bituminoous coal	Residual fuel oil	Motor gasoline	Gas/Diesel oil	LPG	Jet kerosene	Natural gas	Wood/Wood waste
1.A - Fuel Combustion Activities	53978.5	3079.1	0.0	0.0	0.0	318.5	20221.3	7132.3	11025.6	1886.0	0.0	0.0	7356.0
1.A.1 - Energy Industries	51118.7	0.0	0.0	0.0	0.0	0.0	6221.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a - Main Activity Electricity and Heat Production	51118.7	0.0	0.0	0.0	0.0	0.0	6221.6	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.a.i - Electricity Generation	50329.3						40.4						
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	789.4						3959.2						
1.A.1.a.iii - Heat Plants							2222.0						
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.1.c.ii - Other Energy Industries													
1.A.2 - Manufacturing Industries and Construction	2424.9	3079.1	0.0	0.0	0.0	318.5	11399.7	0.0	2641.2	1886.0	0.0	0.0	0.0
1.A.2.a - Iron and Steel	2202.9	212.4				318.5	3759.9			874.0			
1.A.2.b - Non-Ferrous Metals		2866.8					520.0		298.2	46.0			
1.A.2.c - Chemicals							920.0		85.2				
1.A.2.d - Pulp, Paper and Print													
1.A.2.e - Food Processing, Beverages and Tobacco	68.3						280.0		340.8				
1.A.2.f - Non-Metallic Minerals							880.0		170.4	828.0			
1.A.2.g - Transport Equipment													
1.A.2.h - Machinery	34.2									92.0			
1.A.2.i - Mining (excluding fuels) and Quarrying							280.0		298.2				

1.A.2.j - Wood and wood products													
1.A.2.k - Construction													
1.A.2.l - Textile and Leather	102.5						120.0						
1.A.2.m - Non-specified Industry	17.1						4639.9		1448.4	46.0			
1.A.3 - Transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7132.3	3741.0	0.0	0.0	0.0	0.0
1.A.3.a - Civil Aviation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.a.ii - Domestic Aviation													
1.A.3.b - Road Transportation								7132.3	3440.0				
1.A.3.c - Railways									301.0				
1.A.4 - Other Sectors	434.9	0.0	0.0	0.0	0.0	0.0	2599.9	0.0	4643.4	0.0	0.0	0.0	7356.0
1.A.4.a - Commercial/Institutional													
1.A.4.b - Residential	208.8						2079.9		3280.2				7356.0
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	0.0	0.0	0.0	0.0	0.0	0.0	520.0	0.0	1363.2	0.0	0.0	0.0	0.0
1.A.4.c.i - Stationary							520.0		1363.2				
1.A.5 - Non-Specified	226.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.5.a - Stationary	226.1												
Memo Items													
International Bunkers													
1.A.3.a.i - International Aviation (International Bunkers)											220.5		

Table 58. Activity data used in energy sector for 2000 (in TJ)

	Solid fuels			Liquid fuels						Gaseous fuels	Biomass
2006 IPCC Categories	Lignite	Coke Oven Coke / Lignite Coke	Other bituminous coal	Residual fuel oil	Motor gasoline	Gas/Diesel oil	LPG	Petroleum Coke	Jet kerosene	Natural gas	Wood/Wood waste
1.A - Fuel Combustion Activities	54587.4	2363.5	1869.0	14041.9	6387.0	13294.4	1539.4	2759.5	10.2	2277.3	8897.8
1.A.1 - Energy Industries	54264.9	0.0	12.6	9681.6	0.0	719.9	116.4	0.0	0.0	1983.6	352.0
1.A.1.a - Main Activity Electricity and Heat Production	54262.7	0.0	12.6	9681.6	0.0	552.2	115.4	0.0	0.0	1983.6	348.9
1.A.1.a.i - Electricity Generation	53212.9			4238.8		3.2					

1.A.1.a.ii - Combined Heat and Power Generation (CHP)	387.5			786.2						332.9	
1.A.1.a.iii - Heat Plants	662.2		12.6	4656.5		549.0	115.4			1650.7	348.9
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	2.3	0.0	0.0	0.0	0.0	167.7	0.9	0.0	0.0	0.0	3.1
1.A.1.c.ii - Other Energy Industries	2.3					167.7	0.9				3.1
1.A.2 - Manufacturing Industries and Construction	18.9	2363.5	1856.4	3188.1	0.2	2335.4	680.9	2759.5	10.2	293.7	80.3
1.A.2.a - Iron and Steel	14.2	289.3	1856.4	1140.8		1.8	556.5	1064.0		27.3	
1.A.2.b - Non-Ferrous Metals		2046.4		125.3		603.9	41.9				
1.A.2.c - Chemicals											
1.A.2.d - Pulp, Paper and Print						0.1	0.2				0.5
1.A.2.e - Food Processing, Beverages and Tobacco		27.8		15.4		1593.6	5.8				13.2
1.A.2.f - Non-Metallic Minerals	1.1			1891.8		28.4	60.2	1695.4	10.2	225.5	17.4
1.A.2.g - Transport Equipment											
1.A.2.h - Machinery					0.2	28.1	13.4				8.2
1.A.2.i - Mining (excluding fuels) and Quarrying				2.6		38.3				40.9	0.9
1.A.2.j - Wood and wood products											
1.A.2.k - Construction											
1.A.2.l - Textile and Leather	3.4					1.5	2.9				1.5
1.A.2.m - Non-specified Industry	0.3			12.3		39.6					38.6
1.A.3 - Transport	0.0	0.0	0.0	0.0	6340.3	7298.9	93.2	0.0	0.0	0.0	0.0
1.A.3.a - Civil Aviation	0.0	0.0	0.0	0.0	1.2	12.7	0.0	0.0	0.0	0.0	0.0
1.A.3.a.ii - Domestic Aviation					1.2	12.7					
1.A.3.b - Road Transportation					6339.1	7106.1	93.2				
1.A.3.c - Railways						180.1					
1.A.4 - Other Sectors	303.6	0.0	0.0	1172.2	46.6	2940.2	648.9	0.0	0.0	0.0	8465.5
1.A.4.a - Commercial/Institutional											
1.A.4.b - Residential	235.3					1093.3	300.9				7617.5
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	10.4	0.0	0.0	1172.2	46.6	507.2	0.4	0.0	0.0	0.0	0.0
1.A.4.c.i - Stationary	10.4			1172.2	46.6	507.2	0.4				
1.A.5 - Non-Specified	57.9	0.0	0.0	0.0	0.0	1339.7	347.5	0.0	0.0	0.0	848.0
1.A.5.a - Stationary	57.9					1339.7	347.5				848.0

Memo Items												
International Bunkers												
1.A.3.a.i - International Aviation (International Bunkers)										1231.4		

Table 59. Activity data used in energy sector for 2005 (in TJ)

	Solid fuels				**Liquid fuels**							**Gaseous fuels**	**Biomass**
2006 IPCC Categories	Lignite	Coking coal	Sub-bituminous coal	Coke Oven Coke / Lignite Coke	Residual fuel oil	Motor gasoline	Gas/Diesel oil	LPG	Refinery gas	Petroleum Coke	Jet kerosene	Natural gas	Wood/Wood waste
1.A - Fuel Combustion Activities	58845.0	68.0	1714.4	460.5	9819.8	5135.1	14685.8	2100.2	92.5	3723.3	0.0	2637.9	8647.2
1.A.1 - Energy Industries	55385.7	0.0	0.0	0.0	3530.6	0.0	91.6	0.0	92.5	0.0	0.0	549.6	1.7
1.A.1.a - Main Activity Electricity and Heat Production	55385.4	0.0	0.0	0.0	3197.8	0.0	1.9	0.0	0.0	0.0	0.0	549.6	0.0
1.A.1.a.i - Electricity Generation	55002.6				145.9		1.9						
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	382.8				10.2		0.0						
1.A.1.a.iii - Heat Plants					3041.7							549.6	
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	0.3	0.0	0.0	0.0	332.8	0.0	89.7	0.0	92.5	0.0	0.0	0.0	1.7
1.A.1.c.ii - Other Energy Industries	0.3				332.8		89.7		92.5				1.7
1.A.2 - Manufacturing Industries and Construction	2907.4	68.0	1714.4	460.5	4345.4	0.0	1483.6	272.4	0.0	3723.3	0.0	1966.5	296.0
1.A.2.a - Iron and Steel	2628.0	68.0	1712.1	444.6	1741.9		302.3	20.7		1064.0		1430.7	82.8
1.A.2.b - Non-Ferrous Metals					0.7		21.6	0.5					
1.A.2.c - Chemicals					173.2		17.4					119.1	
1.A.2.d - Pulp, Paper and Print	0.6				39.9		14.3					75.5	1.9
1.A.2.e - Food Processing, Beverages and Tobacco			2.2	15.6	622.1		457.9	12.6				255.7	11.3
1.A.2.f - Non-Metallic Minerals	0.0				1260.6		79.4	195.5		2659.2		79.7	5.0
1.A.2.g - Transport Equipment													
1.A.2.h - Machinery	16.4			0.3	119.6		58.7	15.3					2.9
1.A.2.i - Mining (excluding fuels) and Quarrying							152.0						2.0
1.A.2.j - Wood and wood products													
1.A.2.k - Construction													

1.A.2.l - Textile and Leather	262.0				249.4		87.3	4.4					62.6
1.A.2.m - Non-specified Industry	0.3				138.0		292.7	23.6				5.8	127.5
1.A.3 - Transport	0.0	0.0	0.0	0.0	0.0	5118.7	7919.0	1267.8	0.0	0.0	0.0	0.0	0.0
1.A.3.a - Civil Aviation	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.a.ii - Domestic Aviation						1.3							
1.A.3.b - Road Transportation						5117.4	7807.2	1267.8					
1.A.3.c - Railways							111.8						
1.A.4 - Other Sectors	552.0	0.0	0.0	0.0	1943.8	16.4	5191.6	560.0	0.0	0.0	0.0	121.9	8349.5
1.A.4.a - Commercial/Institutional													
1.A.4.b - Residential	249.5						1318.9	381.1					8179.2
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	4.4	0.0	0.0	0.0	933.9	16.4	80.1	6.3	0.0	0.0	0.0	0.0	41.4
1.A.4.c.i - Stationary	4.4				933.9	16.4	80.1	6.3					41.4
1.A.5 - Non-Specified	298.1	0.0	0.0	0.0	1010.0	0.0	3792.6	172.5	0.0	0.0	0.0	121.9	128.9
1.A.5.a - Stationary	298.1				1010.0		3792.6	172.5				121.9	128.9
Memo Items													
International Bunkers													
1.A.3.a.i - International Aviation (International Bunkers) (2)											281.9		

Table 60. Activity data used in energy sector for 2014 (in TJ)

	Solid fuels				Liquid fuels						Gaseous fuels	Biomass
2006 IPCC Categories	Lignite	Coking coal	Sub-bituminous coal	Coke Oven Coke / Lignite Coke	Residual fuel oil	Motor gasoline	Gas/Diesel oil	LPG	Petroleum Coke	Jet kerosene	Natural gas	Wood/Wood waste
1.A - Fuel Combustion Activities	41717.3	167.4	3186.3	39.7	4913.9	4472.8	20167.8	2898.1	2842.3	0.0	4622.1	9912.6
1.A.1 - Energy Industries	40856.2	0.0	0.0	0.0	1753.3	0.0	79.7	0.0	0.0	0.0	3218.3	3.3
1.A.1.a - Main Activity Electricity and Heat Production	40856.2	0.0	0.0	0.0	1651.0	0.0	0.0	0.0	0.0	0.0	3218.3	0.0
1.A.1.a.i - Electricity Generation	40774.1				1651.0							
1.A.1.a.ii - Combined Heat and Power Generation (CHP)	82.0										1537.0	
1.A.1.a.iii - Heat Plants											1681.4	
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	0.0	0.0	0.0	0.0	102.3	0.0	79.7	0.0	0.0	0.0	0.0	3.3
1.A.1.c.ii - Other Energy Industries					102.3		79.7					3.3

1.A.2 - Manufacturing Industries and Construction	766.1	167.4	3186.3	39.7	2796.4	0.0	1820.2	353.4	2842.3	0.0	1195.2	281.6
1.A.2.a - Iron and Steel	702.9	148.9	3186.3	32.3	1975.0		112.8	21.0	630.5		763.6	3.4
1.A.2.b - Non-Ferrous Metals							0.8	2.4			38.4	0.1
1.A.2.c - Chemicals					46.9		19.6	0.0			36.3	
1.A.2.d - Pulp, Paper and Print	0.3	0.7			9.1		8.6	0.5			15.2	0.2
1.A.2.e - Food Processing, Beverages and Tobacco	0.4			3.4	273.3		298.3	101.9			203.4	188.9
1.A.2.f - Non-Metallic Minerals	0.1	17.8			369.0		115.3	192.8	2211.9		38.7	0.7
1.A.2.g - Transport Equipment												
1.A.2.h - Machinery	0.1			4.0	16.5		21.9	31.6			95.4	6.4
1.A.2.i - Mining (excluding fuels) and Quarrying							547.7	0.0				6.2
1.A.2.j - Wood and wood products												
1.A.2.k - Construction												
1.A.2.l - Textile and Leather	62.2				74.0		162.9	2.6			1.9	45.0
1.A.2.m - Non-specified Industry	0.2				32.5		532.3	0.5			2.2	30.7
1.A.3 - Transport	0.0	0.0	0.0	0.0	0.0	4456.3	16048.5	1994.1	0.0	0.0	6.2	0.0
1.A.3.a - Civil Aviation	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.a.ii - Domestic Aviation						2.4						
1.A.3.b - Road Transportation						4453.9	15936.6	1994.1			6.2	
1.A.3.c - Railways							111.8					
1.A.4 - Other Sectors	95.1	0.0	0.0	0.0	364.3	16.4	2219.4	550.6	0.0	0.0	202.3	9627.6
1.A.4.a - Commercial/Institutional												
1.A.4.b - Residential	37.3						178.5	261.2			1.7	9398.2
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	36.7	0.0	0.0	0.0	205.5	16.4	277.1	0.9	0.0	0.0	0.0	56.7
1.A.4.c.i - Stationary	36.7				205.5	16.4	277.1	0.9				56.7
1.A.5 - Non-Specified	21.1	0.0	0.0	0.0	158.8	0.0	1763.7	288.4	0.0	0.0	200.6	172.7
1.A.5.a - Stationary	21.1				158.8		1763.7	288.4			200.6	172.7
Memo Items												
International Bunkers												
1.A.3.a.i - International Aviation (International Bunkers) (2)										519.5		

Table 61. Activity data used in energy sector for 2015 (in TJ)

	Solid fuels				Liquid fuels						Gaseous fuels	Biomass
2006 IPCC Categories	Lignite	Coking coal	Sub-bituminous coal	Coke Oven Coke / Lignite Coke	Residual fuel oil	Motor gasoline	Gas/Diesel oil	LPG	Petroleum Coke	Jet kerosene	Natural gas	Wood/Wood waste
1.A - Fuel Combustion Activities	37096.8	325.0	3241.0	15.0	4327.4	4574.3	22521.0	3285.4	2706.0	0.2	4630.6	9095.3
1.A.1 - Energy Industries	36447.5	0.0	0.0	0.0	1580.9	0.0	59.1	0.0	0.0	0.0	3325.9	1.9
1.A.1.a - Main Activity Electricity and Heat Production	36447.5	0.0	0.0	0.0	1571.8	0.0	0.0	0.0	0.0	0.0	3325.9	0.0
1.A.1.a.i - Electricity Generation	36447.5				1571.8							
1.A.1.a.ii - Combined Heat and Power Generation (CHP)											1471.4	
1.A.1.a.iii - Heat Plants											1854.6	
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	0.0	0.0	0.0	0.0	9.1	0.0	59.1	0.0	0.0	0.0	0.0	1.9
1.A.1.c.ii - Other Energy Industries					9.1		59.1					1.9
1.A.2 - Manufacturing Industries and Construction	573.8	325.0	3198.7	15.0	2207.4	0.0	1859.5	432.9	2706.0	0.0	1076.5	238.8
1.A.2.a - Iron and Steel	501.5	147.6	2626.6	6.2	1373.6		112.8	17.5	1115.0		665.7	4.0
1.A.2.b - Non-Ferrous Metals							1.4	42.0				
1.A.2.c - Chemicals					67.8		19.7	0.1			36.9	
1.A.2.d - Pulp, Paper and Print	0.3				16.9		7.0	3.3			15.4	0.2
1.A.2.e - Food Processing, Beverages and Tobacco					316.7		304.4	91.2			214.1	182.2
1.A.2.f - Non-Metallic Minerals	0.3	177.5	572.1		300.1		119.3	242.3	1591.0		34.1	0.8
1.A.2.g - Transport Equipment												
1.A.2.h - Machinery	0.0			8.8	16.3		32.6	33.6			103.8	7.4
1.A.2.i - Mining (excluding fuels) and Quarrying							573.1	0.0				3.0
1.A.2.j - Wood and wood products												
1.A.2.k - Construction												
1.A.2.l - Textile and Leather	71.5				80.7		124.3	2.4			2.5	15.5
1.A.2.m - Non-specified Industry	0.3				35.2		565.0	0.4			4.0	25.7
1.A.3 - Transport	0.0	0.0	0.0	0.0	0.0	4557.0	18140.1	2260.4	0.0	0.0	0.6	0.0
1.A.3.a - Civil Aviation	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0

1.A.3.a.ii - Domestic Aviation						2.8						
1.A.3.b - Road Transportation						4554.2	18059.4	2260.4			0.6	
1.A.3.c - Railways							80.6					
1.A.4 - Other Sectors	75.5	0.0	42.3	0.0	539.1	17.3	2462.3	592.1	0.0	0.2	227.5	8854.6
1.A.4.a - Commercial/Institutional												
1.A.4.b - Residential			42.3				177.1	292.8			2.6	8616.8
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	45.0	0.0	0.0	0.0	225.8	17.3	291.3	1.1	0.0	0.2	0.0	56.7
1.A.4.c.i - Stationary	45.0				225.8	17.3	291.3	1.1		0.2		56.7
1.A.5 - Non-Specified	30.5	0.0	0.0	0.0	313.3	0.0	1993.9	298.2	0.0	0.0	224.9	181.1
1.A.5.a - Stationary	30.5				313.3		1993.9	298.2			224.9	181.1
Memo Items												
International Bunkers												
1.A.3.a.i - International Aviation (International Bunkers) (2)										582.3		

Table 62. Activity data used in energy sector for 2016 (in TJ)

2006 IPCC Categories	Lignite	Coking coal	Sub-bituminous coal	Coke Oven Coke / Lignite Coke	Residual fuel oil	Motor gasoline	Gas/Diesel oil	LPG	Petroleum Coke	Jet kerosene	Natural gas	Wood/Wood waste
1.A - Fuel Combustion Activities	31713.5	762.3	4167.5	42.9	3645.5	4597.9	25902.8	3603.6	1293.7	1.1	7239.6	7606.5
1.A.1 - Energy Industries	31319.6	0.0	0.0	0.0	1132.4	0.0	63.0	0.0	0.0	0.0	5701.8	1.1
1.A.1.a - Main Activity Electricity and Heat Production	31319.6	0.0	0.0	0.0	1121.5	0.0	0.0	0.0	0.0	0.0	5701.8	0.0
1.A.1.a.i - Electricity Generation	31319.6				1121.5							
1.A.1.a.ii - Combined Heat and Power Generation (CHP)											4556.3	
1.A.1.a.iii - Heat Plants											1145.5	
1.A.1.c - Manufacture of Solid Fuels and Other Energy Industries	0.0	0.0	0.0	0.0	10.9	0.0	63.0	0.0	0.0	0.0	0.0	1.1
1.A.1.c.ii - Other Energy Industries					10.9		63.0					1.1
1.A.2 - Manufacturing Industries and Construction	289.6	762.3	4167.5	42.9	1979.7	0.0	1878.1	479.2	1293.7	0.0	1293.3	257.6
1.A.2.a - Iron and Steel	251.6	112.5	2537.9	40.3	1122.0		69.1	14.3	1064.0		875.0	2.4
1.A.2.b - Non-Ferrous Metals							1.5	52.7				

1.A.2.c - Chemicals					55.4		19.5	0.0				39.3
1.A.2.d - Pulp, Paper and Print	0.2	649.8	1629.6		8.9		5.0	5.6			14.2	2.0
1.A.2.e - Food Processing, Beverages and Tobacco					312.4		293.0	96.0			232.6	152.8
1.A.2.f - Non-Metallic Minerals	0.2				323.4		118.9	255.9	229.6		44.1	1.0
1.A.2.g - Transport Equipment												
1.A.2.h - Machinery	0.0			2.6	21.2		64.0	46.4			114.4	10.9
1.A.2.i - Mining (excluding fuels) and Quarrying							552.1	0.0				0.6
1.A.2.j - Wood and wood products												
1.A.2.k - Construction												
1.A.2.l - Textile and Leather	37.2				102.1		118.8	4.6			2.9	15.2
1.A.2.m - Non-specified Industry	0.4				34.3		636.3	3.7			10.1	33.5
1.A.3 - Transport	0.0	0.0	0.0	0.0	0.0	4580.3	21357.8	2481.1	0.0	0.0	6.6	0.0
1.A.3.a - Civil Aviation	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0
1.A.3.a.ii - Domestic Aviation						2.8						
1.A.3.b - Road Transportation						4577.5	21271.5	2481.1			6.6	
1.A.3.c - Railways							86.2					
1.A.4 - Other Sectors	104.3	0.0	0.0	0.0	533.5	17.6	2603.8	643.3	0.0	1.1	237.9	7347.8
1.A.4.a - Commercial/Institutional												
1.A.4.b - Residential	38.2						161.6	320.5			3.8	7122.9
1.A.4.c - Agriculture/Forestry/Fishing/Fish Farms	36.4	0.0	0.0	0.0	221.2	17.6	305.9	1.1	0.0	1.1	0.0	51.2
1.A.4.c.i - Stationary	36.4				221.2	17.6	305.9	1.1		1.1		51.2
1.A.5 - Non-Specified	29.8	0.0	0.0	0.0	312.2	0.0	2136.4	321.6	0.0	0.0	234.1	173.7
1.A.5.a - Stationary	29.8				312.2		2136.4	321.6			234.1	173.7
Memo Items												
International Bunkers												
1.A.3.a.i - International Aviation (International Bunkers) (2)										664.0		

A I.1.2 IPPU

Table 63. Activity data used in Industrial processes sector

Categories	1990	2000	2005	2014	2015	2016
2.A - Mineral Industry						
2.A.1 - Cement production (t)	732,926	870,188	886,529	686,497	695,923	882,222
2.A.2 - Lime production (t)	47,000	15,397	15,009	10,836	8,003	9,125
2.A.3 - Glass Production	1,648	230	68	56	45	241
2.A.4 - Other Process Uses of Carbonates						
2.A.4.a - Ceramics* (t)	59,290	9,199	6,767	278	216	357
2.A.4.b - Other Uses of Soda Ash (t)	6,457	3,488	3,128	2,572	2,516	2,462
2.C - Metal Industry						
2.C.1 - Iron and Steel Production (t)	274,993	168,386	647,036	189,248	122,632	170,091
2.C.2 - Ferroalloys Production (t)	85,193	57,842	79,390	91,067	63,747	35,038
2.C.3 - Aluminium production (t)	5,487	3,763	20	NO		
2.C.5 - Lead Production (t)	53,826	56,077	NO		2,648	4,472
2.C.6 - Zinc Production (t)	108,275	126,992	NO			

*Clay consumption

Table 64. Activity data used for Product uses as substitutes for ODS

Substance/Blend	Import (tones)	
	2015	2016
HFC-134a	24.9	55.4
R-404A	21.6	43.2
R-407C	1.65	8.1
R-410A	4.3	14.7
R-507	0.214	1.3
HFC-227	/	2.1
R-152A / HFC-152a	/	74.2

A I.1.3 AFOLU

Table 65. Activity data used for GHG emissions inventory in Livestock (number of heads)

Species and categories	1990	2000	2005	2014	2015	2016
Dairy Cows	166237	171745	156950	155432	156699	160603
Other Cattle	120937	93223	91235	86175	96743	94165
Sheep	2297115	1250686	1244000	619839	599869	607622
Sheep <1 Y				113671	123426	116933
Goats			62190	81346	88064	101669
Horses	66282	56486	39651	19371	18784	19263
Swine	178537	204135	155753	23511	20857	28671
Finishers				141542	174586	202758
Poultry	5728981	3713369	2617012	1939879	1761145	1865769
Layers				1884289	1423841	1705948
Broilers (year equivalent)				4355	51256	15998
Turkey (year equivalent)				3690	2910	10070
Other poultry				19477	17908	36245

Table 66. Activity data used for GHG emissions inventory in Forest land (ha)

	1990	2000	2005	2014	2015	2016
Forest land (total)	992532.3	973519.0	969258.0	1084281.5	1101467.4	1102539.0
Forest land Remaining Forest land	970978.0	957550.0	955228.0	1084048.0	1101265.0	1102352.0
Land Converted to Forest land	21554.3	15969.0	14030.0	233.5	202.4	187.0
Cropland converted to Forest Land	*4962.0*	*3128.0*	*2841.1*	*90.9*	*78.8*	*72.8*
Grassland converted to Forest Land	*15892.0*	*12428.0*	*10929.4*	*115.9*	*100.4*	*92.8*
Wetlands converted to Forest Land	*185.6*	*228.0*	*62.7*	*0.0*	*0.0*	*0.0*
Settlements converted to Forest Land	*149.7*	*69.0*	*50.9*	*0.0*	*0.0*	*0.0*
Other Land converted to Forest Land	*365.0*	*116.0*	*145.9*	*26.8*	*23.2*	*21.4*

Table 67. Activity data used for GHG emissions inventory in Cropland (ha)

	1990	2000	2005	2014	2015	2016
Cropland (total)	542667.9	508399.1	516312.4	513271.9	512881.8	512303.1
Cropland Remaining Cropland	525559.0	496170.0	505176.0	513078.2	512713.9	512148.0
Land Converted to Cropland	17108.9	12229.1	11136.4	193.7	167.9	155.1
Forest Land converted to Cropland	*9985.3*	*6476.0*	*6302.9*	*86.0*	*74.5*	*68.8*
Grassland converted to Cropland	*6584.3*	*4138.4*	*4519.0*	*105.2*	*91.2*	*84.3*
Wetlands converted to Cropland	*96.1*	*1283.7*	*39.4*	*0.0*	*0.0*	*0.0*
Settlements converted to Cropland	*289.0*	*183.5*	*165.0*	*0.3*	*0.2*	*0.2*
Other Land converted to Cropland	*154.2*	*147.5*	*110.3*	*2.2*	*1.9*	*1.8*

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

	1990	2000	2005	2014	2015	2016
Grassland (total)	637103.1	667146.1	645420.6	616296.7	615980.4	615700.5
Grassland Remaining Grassland	616821.1	653847.10	632218.75	616082.14	615794.49	615528.71
Land Converted to Grassland	20282.0	13298.98	13201.89	214.52	185.93	171.80
Forest Land converted to Grassland	*13056.13*	*8682.00*	*8412.62*	*49.88*	*43.23*	*39.95*
Cropland converted to Grassland	*6346.54*	*3655.45*	*4065.30*	*145.06*	*125.73*	*116.17*
Wetlands converted to Grassland	*169.00*	*183.26*	*102.27*	*19.58*	*16.97*	*15.68*
Settlements converted to Grassland	*499.63*	*476.79*	*384.78*	*0.00*	*0.00*	*0.00*
Other Land converted to Grassland	*210.74*	*301.48*	*236.92*	*0.00*	*0.00*	*0.00*

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

	1990	2000	2005	2014	2015	2016
Wetlands (total)	**29975.55**	**31785.07**	**34275.73**	**34597.09**	**34617.67**	**34638.3**
Wetlands Remaining Wetlands	28259.40	30609.68	33158.31	34568.73	34593.08	34615.58
Land Converted to Wetlands	1716.15	1175.39	1117.42	28.36	24.59	22.72
Forest Land converted to Wetlands	*114.03*	*79.00*	*70.07*	*2.48*	*2.15*	*1.99*
Cropland converted to Wetlands	*591.96*	*262.44*	*282.56*	*20.31*	*17.61*	*16.27*
Grassland converted to Wetlands	*894.56*	*764.23*	*705.80*	*5.57*	*4.83*	*4.46*
Settlements converted to Wetlands	*45.70*	*21.01*	*22.84*	*0.00*	*0.00*	*0.00*
Other Land converted to Wetlands	*69.90*	*48.71*	*36.15*	*0.00*	*0.00*	*0.00*

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

	1990	2000	2005	2014	2015	2016
Settlements (total)	**29975.55**	**31785.07**	**34275.73**	**34597.09**	**34617.67**	**34638.3**
Settlements Remaining Settlements	28259.40	30609.68	33158.31	34568.73	34593.08	34615.58
Land Converted to Settlements	1716.15	1175.39	1117.42	28.36	24.59	22.72
Forest Land converted to Settlements	*114.03*	*79.00*	*70.07*	*2.48*	*2.15*	*1.99*
Cropland converted to Settlements	*591.96*	*262.44*	*282.56*	*20.31*	*17.61*	*16.27*
Grassland converted to Settlements	*894.56*	*764.23*	*705.80*	*5.57*	*4.83*	*4.46*
Wetlands converted to Settlements	*45.70*	*21.01*	*22.84*	*0.00*	*0.00*	*0.00*
Other Land converted to Settlements	*69.90*	*48.71*	*36.15*	*0.00*	*0.00*	*0.00*

Table 71. Activity data used for GHG emissions inventory in Other Land (ha)

	1990	2000	2005	2014	2015	2016
Other Land (total)	**323056.26**	**335061.5**	**349939.9**	**222338**	**205774.2**	**217210.6**
Other land Remaining Other land	321306.00	333342.95	348800.69	220253.76	203967.84	215541.50
Land Converted to Other land	1750.26	1718.50	1139.20	2084.20	1806.40	1669.10
Forest Land converted to Other Land	*513.30*	*397.00*	*287.80*	*1449.20*	*1256.00*	*1160.60*
Cropland converted to Other Land	*601.30*	*550.23*	*330.90*	*319.60*	*277.00*	*255.90*
Grassland converted to Other Land	*468.20*	*650.23*	*414.80*	*315.40*	*273.40*	*252.60*
Wetlands converted to Other Land	*18.96*	*39.26*	*16.90*	*0.00*	*0.00*	*0.00*
Settlements converted to Other Land	*148.50*	*81.78*	*88.80*	*0.00*	*0.00*	*0.00*

A I.1.4 Waste

Table 72. 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**	**2015**	**2016**								
	2.05728	2.05979	2.06229	2.06577	2.06917	2.071278	2.07371								

Table 73. Other activity data used for estimation of GHG emission from Municipal Solid Waste

	IPCC Regional Default	National					
		1990	**2000**	**2005**	**2014**	**2015**	**2016**
Waste per capita (kg/cap/yr)	520	197	197	281	370	380	376
% to SWDS	90	90	90	90	90	90	90

Table 74. Composition of waste going to the Municipal solid waste disposal sites

food	garden	paper	wood	textile	nappies	other
(%)	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**	**(%)**
36.73	10.72	10.84	0.39	3.68	5.03	32.61

Table 75. 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
Year	**2015**	**2016**													
	10,065	10,672													

Table 76. Other activity data used for estimation of GHG emission from Industrial Waste

	National					
	1990	2000	2005	2014	2015	2016
Waste Generation Rate (Gg/$mGDP/yr)	0.139	0.139	0.139	0.144	0.139	0.139
% to SWDS	90	90	90	90	90	90

Table 77. Total annual amount of solid waste treated by biological treatment facilities (in Gg)

Biological Treatment System	Waste Category	Type of Waste	Waste basis	1990	2000	2005	2014	2015	2016
Composting	Municipal Solid Waste	Total MSW	Dry		NO		1.945	2.807	2.239

Table 78. Activity data for waste incineration

	2000	2005	2014	2015	2016
Clinical waste (t)	114.90	375.65	572.88	774.87	869.44

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

Parametar	Unit	1990	2000	2005	2014	2015	2016
Population - P	(Capita)	1996227	2004873	2036855	2069172	2071278	2073710
Fraction of Population Burning Waste - P frac	(Fraction)	0.1	0.1	0.1	0.1	0.1	0.1
Per Capita Waste Generation - MSWp	(kg waste/capita/day)	0.5	0.54	0.77	1.01	1.04	1.03
Fraction of the waste amount burned relative to the total amount of waste treated - Bfrac	(Fraction)	1	1	1	1	1	1
Number of days by year	(Day)	365	365	365	365	365	365

A I.2 Methods applied

Table 80. Methods and tiers applied in the preparation of the GHG Inventory (for 2016)

Categories	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. 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,NE**	**NO, NE**
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						

Categories	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor
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	NO	NO										
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										
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	NE	NE
2.G.3 - N_2O 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										
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												

Categories	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor	Method used	Emiss. factor
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					NE	NE						
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 I.3 Emission factors

A I.3.1 Energy

Table 81. 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 I.3.2 IPPU

Table 82. 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			
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 I.3.3 AFOLU

Table 83. Emission factors used for GHG emissions inventory in livestock activities

Emission factor	3rd BUR	Comment
Livestock		
Dairy cows (enteric - CH_4)	99 kg/head/year	
Other cattle (enteric- CH_4)	58 kg/head/year	
Sheep (enteric- CH_4)	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	
Horses (enteric- CH_4)	18 kg/head/year	
Swine (enteric- CH_4)	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	
Dairy cows (manure - N_2O)	0.35 kg/1000 kg/day 18% liquid slurry (40% N loss); 67% solid storage slurry (40% N loss); 1% daily spread slurry (22% N loss) 13% pasture 0.005 Direct N_2O - N	
Other cattle (manure- CH_4)	9 kg/head/year	
Other cattle (manure- N_2O)	0.35 kg/1000 kg/day 18% liquid slurry (40% N loss); 67% solid storage slurry (40% N loss); 1% daily spread slurry (22% N loss) 13% pasture 0.005 Direct N_2O - N	
Sheep (manure- CH_4)	0.15 kg/head/year	t
Sheep (manure- N_2O)	0.9 kg/1000 kg/day 20% solid storage 80% pasture 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 20% solid storage 80% pasture 0.005 Direct N_2O - N	Sheep < 1 Y with 28kg live weight
Goat (manure- CH_4)	0.17 kg/head/year	
Goat (manure- N_2O)	1.28 kg/1000 kg/day 20% solid storage 80% pasture 0.005 Direct N_2O - N	
Horses (manure- CH_4)	1.64 kg/head/year	
Horses (manure- N_2O)	100% pasture	
Swine (manure- CH_4)	6 kg/head/year	180 kg live weight
Swine (manure- N_2O)	0.46 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	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 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)	-	1.8 kg live weight

Poultry (manure- N_2O)	-	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 I.3.4 Waste

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

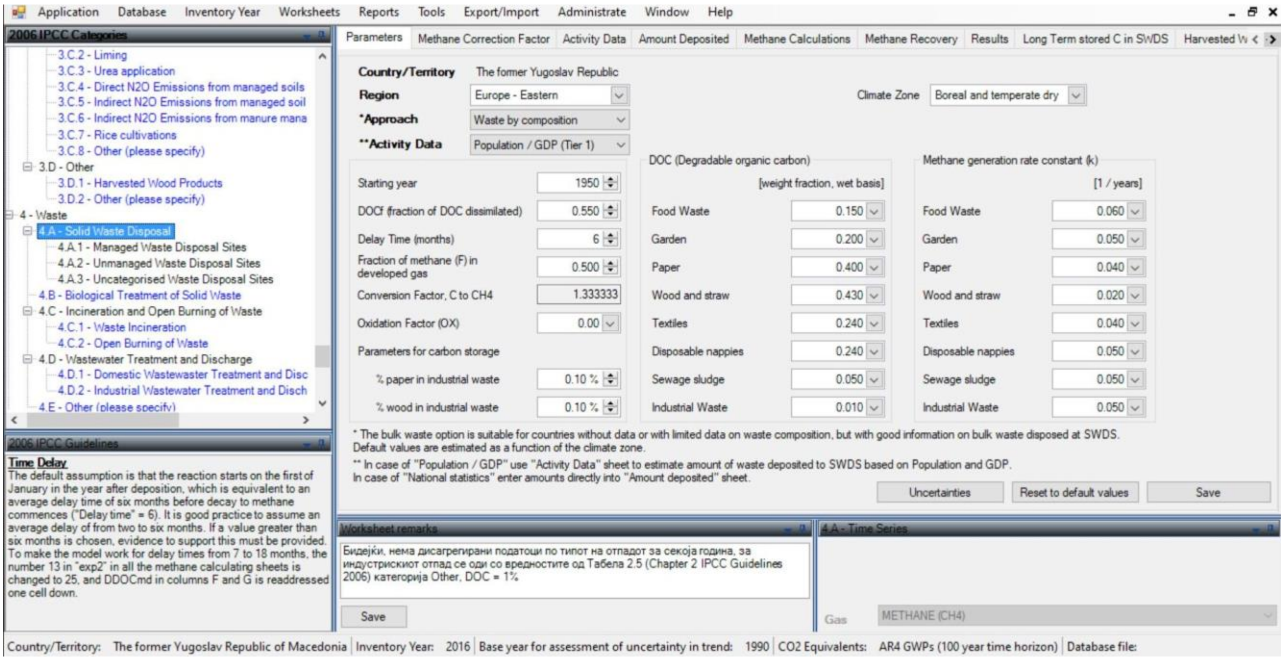


Table 84. Methane correction factor and distribution of waste by type of SWDS

	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 85. 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 86. 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 87. Parameters used for estimation of emissions from Domestic and Industrial Wastewater Treatment and Discharge

Estimation of CH_4 emission factor for Domestic Wastewater	
Type of treatment or discharge	Sea, river and lake discharge
Maximum methane producing capacity - B0 (kg CH_4/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 N_2O 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 N_2O-N/kg N)	0.005
Estimation of CH_4 emission factor for Industrial Wastewater	
Type of treatment or discharge	Sea, river and lake discharge
Maximum Methane Producing Capacity (B0) (kg CH_4/kg COD)	0.25

Appendix II Detailed tables of the GHG Inventory

Table 88. Detailed results for 1990

Categories	Emissions (Gg)			Emissions CO2 Equivalents (Gg)					Emissions (Gg)			
	Net CO2*	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
Total National Emissions and Removals	9978.11	69.61	1.55	NO	91.65	NA, NE			24.99	41.47	17.69	96.47
1 - Energy	9339.25	10.27	0.18						23.98	38.09	11.16	95.97
1.A - Fuel Combustion Activities	9333.63	2.77	0.18						23.98	38.09	5.58	95.97
1.A.1 - Energy Industries	6179.59	0.07	0.08						13.51	0.54	0.09	88.96
1.A.2 - Manufacturing Industries and Construction	1788.77	0.10	0.02	NA					9.18	6.47	0.92	5.99
1.A.3 - Transport	771.48	0.25	0.04						0.02	0.00	0.00	NO
1.A.4 - Other Sectors	568.58	2.34	0.03						1.24	30.87	4.56	0.82
1.A.5 - Non-Specified	25.20	0.00	0.00						0.04	0.21	0.02	0.20
1.B - Fugitive emissions from fuels	5.62	7.51									5.58	0.00
1.B.1 - Solid Fuels	5.62	7.48									5.58	NO
1.B.2 - Oil and Natural Gas	NO	0.03	NA								NO	0.00
1.B.3 - Other emissions from Energy Production	NO	NO									NO	
1.C - Carbon dioxide Transport and Storage												
1.C.1 - Transport of CO2												
1.C.2 - Injection and Storage	NO	NA										
1.C.3 - Other												
2 - Industrial Processes and Product Use	839.27	0.05	NO,NA		91.65	NO,NA			0.78	1.35	0.02	0.49
2.A - Mineral Industry	333.10								0.74	0.88	0.01	0.22
2.A.1 - Cement production	293.75								0.67	0.79	0.01	0.20
2.A.2 - Lime production	33.72	NA							0.06	0.09	NO	0.02
2.A.3 - Glass Production	0.33								0.01	NO		0.00
2.A.4 - Other Process Uses of Carbonates	5.30								NO			

2.A.5 - Other (please specify)	NO									
2.B - Chemical Industry	NO, NA	NO,NA	NO,NA							
2.B.1 - Ammonia Production	NO		NA							
2.B.2 - Nitric Acid Production		NA								
2.B.3 - Adipic Acid Production	NA		NO							
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production										
2.B.5 - Carbide Production		NO		NA			NO, NA			
2.B.6 - Titanium Dioxide Production										
2.B.7 - Soda Ash Production	NO	NA								
2.B.8 - Petrochemical and Carbon Black Production		NO	NA							
2.B.9 - Fluorochemical Production	NA	NA								
2.B.10 - Other (Please specify)	NO	NO								
2.C - Metal Industry	506.17	0.05	NA	NA	91.65	NA	0.04	0.47	0.01	0.27
2.C.1 - Iron and Steel Production	24.75	NA					0.04	0.47	0.01	0.02
2.C.2 - Ferroalloys Production	264.32	0.05	NA							
2.C.3 - Aluminium production	8.78	NA			91.65	NA		0.00	NA	
2.C.4 - Magnesium production	NO, NA									
2.C.5 - Lead Production	22.09	NA								0.11
2.C.6 - Zinc Production	186.23	NA								0.15
2.C.7 - Other (please specify)	NO									
2.D - Non-Energy Products from Fuels and Solvent Use	NO,NA									
2.D.1 - Lubricant Use	NO									
2.D.2 - Paraffin Wax Use		NA								
2.D.3 - Solvent Use	NA									
2.D.4 - Other (please specify)	NO									
2.E - Electronics Industry										
2.E.1 - Integrated Circuit or Semiconductor										
2.E.2 - TFT Flat Panel Display										
2.E.3 - Photovoltaics	NA			NA, NO						
2.E.4 - Heat Transfer Fluid										
2.E.5 - Other (please specify)										
2.F - Product Uses as Substitutes for Ozone Depleting Substances										
2.F.1 - Refrigeration and Air Conditioning										
2.F.2 - Foam Blowing Agents	NA			NO	NA, NO	NA	NA			
2.F.3 - Fire Protection										
2.F.4 - Aerosols										

2.F.5 - Solvents								
2.F.6 - Other Applications (please specify)								
2.G - Other Product Manufacture and Use								
2.G.1 - Electrical Equipment								
2.G.2 - SF6 and PFCs from Other Product Uses	NA			NE	NA			
2.G.3 - N2O from Product Uses								
2.G.4 - Other (Please specify)								
2.H - Other								
2.H.1 - Pulp and Paper Industry	NA			NO, NA	NA			
2.H.2 - Food and Beverages Industry								
2.H.3 - Other (please specify)								
3 - Agriculture, Forestry, and Other Land Use	-203.26	44.45	1.26	NA	0.11	NA	5.91	NA
3.A - Livestock	NA	42.36	0.16	NA	0.11	NA	5.87	NA
3.A.1 - Enteric Fermentation		36.33	NO		NA			
3.A.2 - Manure Management		6.03	0.16		0.11	NA	5.87	NA
3.B - Land	-206.31	NO						
3.B.1 - Forest land	-206.31	NO						
3.B.2 - Cropland								
3.B.3 - Grassland								
3.B.4 - Wetlands	NE	NA						
3.B.5 - Settlements								
3.B.6 - Other Land								
3.C - Aggregate sources and non-CO2 emissions sources on land	3.74	2.09	1.09	NA			0.05	NA
3.C.1 - Emissions from biomass burning	NA	NO	NO	NA			0.05	NAO
3.C.2 - Liming	NO	NA	NA	NA				
3.C.3 - Urea application	3.74	NA	NA					
3.C.4 - Direct N2O Emissions from managed soils	NA	NA	0.71					
3.C.5 - Indirect N2O Emissions from managed soils	NA	NA	0.28	NA				
3.C.6 - Indirect N2O Emissions from manure management	NA	NA	0.11					
3.C.7 - Rice cultivations	NA	2.09	NO					
3.C.8 - Other (please specify)	NO							
3.D - Other	-0.69	NO						
3.D.1 - Harvested Wood Products	-0.69	NO						
3.D.2 - Other (please specify)	NO							
4 - Waste	2.86	14.83	0.11	NA	0.12	2.03	0.60	0.00
4.A - Solid Waste Disposal	NA	10.62	NA				0.55	NA

4.B - Biological Treatment of Solid Waste	NO											
4.C - Incineration and Open Burning of Waste	2.86	0.24	0.00	NA					0.12	2.03	0.05	0.00
4.D - Wastewater Treatment and Discharge	NA	3.97	0.11	NA								
4.E - Other (please specify)	NO											
5 - Other	NE, NO											
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	NE											
5.B - Other (please specify)	NO											
Memo Items (5)												
International Bunkers	15.77	0.00	0.00	NA					NE			
1.A.3.a.i - International Aviation (International Bunkers)	15.77	0.00	0.00	NA					NE			
1.A.3.d.i - International water-borne navigation (International bunkers)	NO			NA					NO			
1.A.5.c - Multilateral Operations	NO											

NO - Not occurring, NA – Not Applicable, NE – Not Estimated

**CO_2 net emissions (emission minus removals)*

Table 89. Detailed results for 2000

	Emissions (Gg)			Emissions CO2 Equivalents (Gg)					Emissions (Gg)			
Categories	Net CO2*	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
Total National Emissions and Removals	20696.50	62.84	1.39	4.77	62.86	NA, NE, NO			22.33	42.66	31.53	102.96
1 - Energy	9423.60	11.16	0.19	NA					21.26	39.20	11.86	102.41
1.A - Fuel Combustion Activities	9417.55	3.08	0.19						21.26	39.20	5.84	102.41
1.A.1 - Energy Industries	6969.22	0.10	0.09						15.05	0.74	0.11	96.07
1.A.2 - Manufacturing Industries and Construction	1075.61	0.07	0.01						4.24	5.99	0.71	5.63
1.A.3 - Transport	986.11	0.24	0.05						0.01	0.02	0.00	NO
1.A.4 - Other Sectors	258.95	2.39	0.03						1.01	31.80	4.72	0.56
1.A.5 - Non-Specified	127.66	0.29	0.00						0.95	0.65	0.30	0.14
1.B - Fugitive emissions from fuels	6.05	8.08	NA								6.01	0.00
1.B.1 - Solid Fuels	6.05	8.06									6.01	NA

1.B.2 - Oil and Natural Gas	NO	0.02							NO	0.00
1.B.3 - Other emissions from Energy Production						NA				
1.C - Carbon dioxide Transport and Storage	NO					NA				
1.C.1 - Transport of CO2										
1.C.2 - Injection and Storage										
1.C.3 - Other										
2 - Industrial Processes and Product Use	819.76	0.04	NO	4.77	62.86	NE, NA,NO	0.84	1.25	0.02	0.54
2.A - Mineral Industry	361.83					NA	0.82	0.97	0.01	0.25
2.A.1 - Cement production	348.77						0.80	0.94	0.01	0.24
2.A.2 - Lime production	11.17						0.02	0.03	NA	0.01
2.A.3 - Glass Production	0.05					NA	0.00	NA		
2.A.4 - Other Process Uses of Carbonates	1.85						Na			
2.A.5 - Other (please specify)	NO						NO			
2.B - Chemical Industry	NO, NA	NA,NO				NA	NA, NO			
2.B.1 - Ammonia Production	NO	NA								
2.B.2 - Nitric Acid Production	NA	NA	NO							
2.B.3 - Adipic Acid Production										
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production										
2.B.5 - Carbide Production	NO	NO	NA							
2.B.6 - Titanium Dioxide Production		NA								
2.B.7 - Soda Ash Production		NA								
2.B.8 - Petrochemical and Carbon Black Production		NO								
2.B.9 - Fluorochemical Production	NA									
2.B.10 - Other (Please specify)	NO									
2.C - Metal Industry	457.93	0.04	NA		62.86	NA, NO	0.02	0.29	0.01	0.30
2.C.1 - Iron and Steel Production	15.15					NA	0.02	0.29	0.01	0.01
2.C.2 - Ferroalloys Production	195.36	0.04				NA				
2.C.3 - Aluminium production	6.02	NA			62.86	NA				
2.C.4 - Magnesium production						NO				
2.C.5 - Lead Production	22.97					NA				0.12
2.C.6 - Zinc Production	218.43					NA				0.17
2.C.7 - Other (please specify)						NO				
2.D - Non-Energy Products from Fuels and Solvent Use	NO					NA				
2.D.1 - Lubricant Use										
2.D.2 - Paraffin Wax Use										
2.D.3 - Solvent Use										

2.D.4 - Other (please specify)										
2.E - Electronics Industry	NA			NO, NA			NA			
2.E.1 - Integrated Circuit or Semiconductor										
2.E.2 - TFT Flat Panel Display										
2.E.3 - Photovoltaics										
2.E.4 - Heat Transfer Fluid										
2.E.5 - Other (please specify)										
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA			4.77	NO,NA	NA				
2.F.1 - Refrigeration and Air Conditioning	NA			4.77	NA	NA				
2.F.2 - Foam Blowing Agents	NA			NO	NO	NA				
2.F.3 - Fire Protection										
2.F.4 - Aerosols										
2.F.5 - Solvents										
2.F.6 - Other Applications (please specify)										
2.G - Other Product Manufacture and Use	NA				NE	NA				
2.G.1 - Electrical Equipment										
2.G.2 - SF6 and PFCs from Other Product Uses										
2.G.3 - N2O from Product Uses										
2.G.4 - Other (Please specify)										
2.H - Other	NO			NA			NO			
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	10449.95	36.64	1.09	NO			0.10	NA	19.05	NA
3.A - Livestock	NA	35.74	0.14	NA			0.10	NA	5.18	NA
3.A.1 - Enteric Fermentation		29.88	NO				NA			
3.A.2 - Manure Management		5.85	0.14				0.10	NA	5.18	NA
3.B - Land	10441.56	NA								
3.B.1 - Forest land	9159.83									
3.B.2 - Cropland	657.48									
3.B.3 - Grassland	480.96									
3.B.4 - Wetlands										
3.B.5 - Settlements	126.48									
3.B.6 - Other Land	16.81									
3.C - Aggregate sources and non-CO2 emissions sources on land	9.09	0.91	0.94	NA					13.87	NA
3.C.1 - Emissions from biomass burning	NA	NO		NA					13.87	NA

3.C.2 - Liming	NO	NA						
3.C.3 - Urea application	9.09	NA						
3.C.4 - Direct N2O Emissions from managed soils	NA		0.62	NA				
3.C.5 - Indirect N2O Emissions from managed soils	NA		0.23					
3.C.6 - Indirect N2O Emissions from manure management	NA NA		0.10					
3.C.7 - Rice cultivations	NA	0.91	NA					
3.C.8 - Other (please specify)	NO							
3.D - Other	-0.70	NO						
3.D.1 - Harvested Wood Products	-0.70	NO						
3.D.2 - Other (please specify)	NO							
4 - Waste	3.20	15.00	0.12	NA, NO	0.13	2.21	0.60	0.00
4.A - Solid Waste Disposal	NA	11.98	NA				0.56	NA
4.B - Biological Treatment of Solid Waste	NO							
4.C - Incineration and Open Burning of Waste	3.20	0.26	0.00	NA	0.13	2.21	0.05	0.00
4.D - Wastewater Treatment and Discharge	NA	2.77	0.12	NA				
4.E - Other (please specify)	NO							
5 - Other	NE, NO							
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	NE							
5.B - Other (please specify)	NO							
Memo Items (5)								
International Bunkers	88.05	0.00	0.00	NA	NE, NO			
1.A.3.a.i - International Aviation (International Bunkers)	88.05	0.00	0.00	NA	NE			
1.A.3.d.i - International water-borne navigation (International bunkers)	NO			NA	NO			
1.A.5.c - Multilateral Operations	NO			NA	NO			

NO - Not occurring, NA – Not Applicable, NE – Not Estimated

**CO_2 net emissions (emission minus removals)*

Table 90. Detailed results for 2005

	Emissions (Gg)			Emissions CO2 Equivalents (Gg)					Emissions (Gg)			
Categories	Net CO2*	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
Total National Emissions and Removals	8170.70	60.38	1.50	102.84	0.33	NA, NE, NO			23.56	48.51	18.04	103.45
1 - Energy	8930.51	10.58	0.19	NA					22.37	43.23	11.83	103.16
1.A - Fuel Combustion Activities	8924.97	3.18	0.19						22.37	43.23	6.32	103.16
1.A.1 - Energy Industries	5913.37	0.07	0.09						14.25	0.56	0.09	94.80
1.A.2 - Manufacturing Industries and Construction	1349.75	0.09	0.01						4.65	7.90	0.98	7.32
1.A.3 - Transport	1021.52	0.28	0.05						0.01	0.00	0.00	
1.A.4 - Other Sectors	228.16	2.57	0.03						0.85	34.09	5.06	0.54
1.A.5 - Non-Specified	412.17	0.18	0.00						2.63	0.68	0.19	0.50
1.B - Fugitive emissions from fuels	5.54	7.40	NA						0.00	0.00	5.50	0.00
1.B.1 - Solid Fuels	5.54	7.38							NA	NA	5.50	NA
1.B.2 - Oil and Natural Gas	NA	0.02							0.00	0.00	0.00	0.00
1.B.3 - Other emissions from Energy Production	NO								NO			
1.C - Carbon dioxide Transport and Storage	NO	NA										
1.C.1 - Transport of CO2												
1.C.2 - Injection and Storage												
1.C.3 - Other												
2 - Industrial Processes and Product Use	756.70	0.07	NO	102.84	0.33	NA, NE, NO			0.92	2.08	0.04	0.29
2.A - Mineral Industry	368.05	NA							0.84	0.98	0.01	0.25
2.A.1 - Cement production	355.32								0.81	0.95	0.01	0.25
2.A.2 - Lime production	11.13								0.02	0.03	NO	0.01
2.A.3 - Glass Production	0.01								NA			0.00
2.A.4 - Other Process Uses of Carbonates	1.60								NA			
2.A.5 - Other (please specify)	NO								NO			
2.B - Chemical Industry	NA, NO			NA					NA,NO			
2.B.1 - Ammonia Production	NO	NA	NA									
2.B.2 - Nitric Acid Production	NA		NO									

2.B.3 - Adipic Acid Production										
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production										
2.B.5 - Carbide Production	NO	NO	NA							
2.B.6 - Titanium Dioxide Production		NA								
2.B.7 - Soda Ash Production										
2.B.8 - Petrochemical and Carbon Black Production		NO	NA							
2.B.9 - Fluorochemical Production	NA									
2.B.10 - Other (Please specify)	NO									
2.C - Metal Industry										
2.C.1 - Iron and Steel Production	58.23	NO					0.08	1.10	0.03	0.04
2.C.2 - Ferroalloys Production	330.39	0.07	NA							
2.C.3 - Aluminium production	0.03	NA			0.33	NA				
2.C.4 - Magnesium production	NO	NA					NO			
2.C.5 - Lead Production										
2.C.6 - Zinc Production										
2.C.7 - Other (please specify)										
2.D - Non-Energy Products from Fuels and Solvent Use	NO	NA								
2.D.1 - Lubricant Use										
2.D.2 - Paraffin Wax Use										
2.D.3 - Solvent Use										
2.D.4 - Other (please specify)										
2.E - Electronics Industry	NA				NO, NA		NA			
2.E.1 - Integrated Circuit or Semiconductor										
2.E.2 - TFT Flat Panel Display										
2.E.3 - Photovoltaics										
2.E.4 - Heat Transfer Fluid										
2.E.5 - Other (please specify)										
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA			102.84	NO,NA	NA				
2.F.1 - Refrigeration and Air Conditioning	NA			102.84	NA	NA				
2.F.2 - Foam Blowing Agents	NA			NO	NO	NA				
2.F.3 - Fire Protection										
2.F.4 - Aerosols										
2.F.5 - Solvents										
2.F.6 - Other Applications (please specify)										
2.G - Other Product Manufacture and Use	NA				NE, NA	NA				
2.G.1 - Electrical Equipment										

2.G.2 - SF6 and PFCs from Other Product Uses										
2.G.3 - N2O from Product Uses										
2.G.4 - Other (Please specify)										
2.H - Other										
2.H.1 - Pulp and Paper Industry	NO		NA							
2.H.2 - Food and Beverages Industry										
2.H.3 - Other (please specify)										
3 - Agriculture, Forestry, and Other Land Use	-1521.33	33.92	1.19	NA			0.08	NA	5.30	NA
3.A - Livestock		33.44	0.14				0.08	NA	4.67	NA
3.A.1 - Enteric Fermentation	NA	28.23	NA	NA			NA			
3.A.2 - Manure Management		5.21	0.14				0.08	NA	4.67	NA
3.B - Land	-1521.57									
3.B.1 - Forest land	-2825.49									
3.B.2 - Cropland	669.12									
3.B.3 - Grassland	503.29	NA								
3.B.4 - Wetlands										
3.B.5 - Settlements	121.12									
3.B.6 - Other Land	10.39									
3.C - Aggregate sources and non-CO2 emissions sources on land	1.28	0.48	1.05	NA, NO					0.63	NA
3.C.1 - Emissions from biomass burning	NA	NO		NA					0.63	NA
3.C.2 - Liming	NO	NA								
3.C.3 - Urea application	1.28	NA								
3.C.4 - Direct N2O Emissions from managed soils	NA		0.71							
3.C.5 - Indirect N2O Emissions from managed soils	NA		0.26							
3.C.6 - Indirect N2O Emissions from manure management	NA		0.09	NA						
3.C.7 - Rice cultivations	NA	0.48	NA							
3.C.8 - Other (please specify)	NA	NO								
3.D - Other	-1.04									
3.D.1 - Harvested Wood Products	-1.04	NA								
3.D.2 - Other (please specify)	NO									
4 - Waste	4.82	15.80	0.12	NA, NO			0.18	3.20	0.87	0.01
4.A - Solid Waste Disposal	NA	12.64	NA						0.80	NA
4.B - Biological Treatment of Solid Waste	NO									
4.C - Incineration and Open Burning of Waste	4.82	0.37	0.00	NA			0.18	3.20	0.07	0.01
4.D - Wastewater Treatment and Discharge	NA	2.79	0.12	NA					0.00	NA
4.E - Other (please specify)	NA									

5 - Other	NE, NO											
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	NE											
5.B - Other (please specify)	NO											
Memo Items (5)												
International Bunkers	20.16	0.00	0.00	NA					NE, NO			
1.A.3.a.i - International Aviation (International Bunkers)	20.16	0.00	0.00	NA					NE			
1.A.3.d.i - International water-borne navigation (International bunkers)	NO			NA					NO			
1.A.5.c - Multilateral Operations	NO			NA					NO			

NO - Not occurring, NA – Not Applicable, NE – Not Estimated

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

Table 91. Detailed results for 2014

	Emissions (Gg)			Emissions CO2 Equivalents (Gg)					Emissions (Gg)			
Categories	Net CO2*	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
Total National Emissions and Removals	4824.71	62.53	1.51	206.60	NA, NE, NO				18.00	54.08	18.42	76.64
1 - Energy	7734.17	10.35	0.20	NA					17.01	48.74	12.73	76.43
1.A - Fuel Combustion Activities	7728.95	3.40	0.20						16.34	45.73	6.68	76.42
1.A.1 - Energy Industries	4727.49	0.05	0.06						10.63	0.51	0.07	69.51
1.A.2 - Manufacturing Industries and Construction	1127.36	0.07	0.01						3.88	7.04	0.81	6.54
1.A.3 - Transport	1624.18	0.33	0.08						0.01	0.00	0.00	NO
1.A.4 - Other Sectors	75.31	2.87	0.04						0.66	37.90	5.69	0.25
1.A.5 - Non-Specified	174.61	0.08	0.00						1.17	0.27	0.11	0.13
1.B - Fugitive emissions from fuels	5.22	6.95	NA						0.67	3.01	6.05	0.01
1.B.1 - Solid Fuels	5.22	6.95							NA	NA	5.19	NA
1.B.2 - Oil and Natural Gas	0.00	0.00							0.67	3.01	0.86	0.01
1.B.3 - Other emissions from Energy Production	NO			NA								
1.C - Carbon dioxide Transport and Storage	NO	NA										
1.C.1 - Transport of CO2												
1.C.2 - Injection and Storage												

1.C.3 - Other									
2 - Industrial Processes and Product Use	677.76	0.07		206.60	NA, NE, NO	0.67	1.08	0.02	0.20
2.A - Mineral Industry	283.16				NA	0.65	0.76	0.01	0.19
2.A.1 - Cement production	275.68					0.63	0.74	0.01	0.19
2.A.2 - Lime production	6.39				NA	0.02	0.02	NO	0.00
2.A.3 - Glass Production	0.01					NO	NO	NO	0.00
2.A.4 - Other Process Uses of Carbonates	1.08					NO	NO	NO	NO
2.A.5 - Other (please specify)					NO				
2.B - Chemical Industry	NO, NA								
2.B.1 - Ammonia Production	NO								
2.B.2 - Nitric Acid Production									
2.B.3 - Adipic Acid Production	NA		NO						
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production									
2.B.5 - Carbide Production		NO	NA		NA		NA		
2.B.6 - Titanium Dioxide Production	NO	NA							
2.B.7 - Soda Ash Production									
2.B.8 - Petrochemical and Carbon Black Production		NO	NA						
2.B.9 - Fluorochemical Production	NA								
2.B.10 - Other (Please specify)	NO								
2.C - Metal Industry	394.60	0.07			NA, NO	0.03	0.32	0.01	0.01
2.C.1 - Iron and Steel Production	17.03				NA	0.03	0.32	0.01	0.01
2.C.2 - Ferroalloys Production	377.56	0.07			NA				
2.C.3 - Aluminium production									
2.C.4 - Magnesium production							NA,NO		
2.C.5 - Lead Production	NO				NA,NO				
2.C.6 - Zinc Production									
2.C.7 - Other (please specify)									
2.D - Non-Energy Products from Fuels and Solvent Use									
2.D.1 - Lubricant Use									
2.D.2 - Paraffin Wax Use	NO				NA		NA		
2.D.3 - Solvent Use									
2.D.4 - Other (please specify)									
2.E - Electronics Industry									
2.E.1 - Integrated Circuit or Semiconductor	NA				NO,NA		NA		
2.E.2 - TFT Flat Panel Display									
2.E.3 - Photovoltaics									

2.E.4 - Heat Transfer Fluid										
2.E.5 - Other (please specify)										
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA			206.60	NO, NA	NA				
2.F.1 - Refrigeration and Air Conditioning	NA			206.60	NA	NA				
2.F.2 - Foam Blowing Agents										
2.F.3 - Fire Protection										
2.F.4 - Aerosols	NA			NO	NO, NA	NA				
2.F.5 - Solvents										
2.F.6 - Other Applications (please specify)										
2.G - Other Product Manufacture and Use										
2.G.1 - Electrical Equipment										
2.G.2 - SF6 and PFCs from Other Product Uses	NA				NE, NA	NA				
2.G.3 - N2O from Product Uses										
2.G.4 - Other (Please specify)										
2.H - Other										
2.H.1 - Pulp and Paper Industry	NO		NA							
2.H.2 - Food and Beverages Industry										
2.H.3 - Other (please specify)										
3 - Agriculture, Forestry, and Other Land Use	-3593.70	31.11	1.17	NA			0.08	NA	4.51	NA
3.A - Livestock		30.15	0.13	NA			0.08	NA	4.25	NA
3.A.1 - Enteric Fermentation	NA	25.01	NA	NA			NA			
3.A.2 - Manure Management		5.14	0.13				0.08		4.25	
3.B - Land	-3595.88									
3.B.1 - Forest land	-3632.75									
3.B.2 - Cropland	7.34									
3.B.3 - Grassland	17.39	NA								
3.B.4 - Wetlands										
3.B.5 - Settlements	3.10									
3.B.6 - Other Land	9.04									
3.C - Aggregate sources and non-CO2 emissions sources on land	3.67	0.96	1.04	NA					0.26	NO
3.C.1 - Emissions from biomass burning	NA	NO		NA					0.26	NA
3.C.2 - Liming	NO	NA								
3.C.3 - Urea application	3.67	NA	NA							
3.C.4 - Direct N2O Emissions from managed soils			0.70	NA						
3.C.5 - Indirect N2O Emissions from managed soils	NA		0.25							
3.C.6 - Indirect N2O Emissions from manure management			0.09							

3.C.7 - Rice cultivations	NA	0.96	NA									
3.C.8 - Other (please specify)	NO											
3.D - Other	-1.48	NA										
3.D.1 - Harvested Wood Products	-1.48											
3.D.2 - Other (please specify)	NA											
4 - Waste	6.48	21.00	0.14	NA					0.24	4.26	1.17	0.01
4.A - Solid Waste Disposal	NA	17.65	NA						NA		1.08	NA
4.B - Biological Treatment of Solid Waste	NA	0.02	0.00						NA	0.00	NA	
4.C - Incineration and Open Burning of Waste	6.48	0.50	0.01						0.24	4.26	0.09	0.01
4.D - Wastewater Treatment and Discharge	NA	2.83	0.13						NA		0.00	NA
4.E - Other (please specify)	NO								NA			
5 - Other	NE, NO											
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	NE											
5.B - Other (please specify)	NO											
Memo Items (5)												
International Bunkers	37.14	0.00	0.00	NA					NE, NO			
1.A.3.a.i - International Aviation (International Bunkers)	37.14	0.00	0.00					NA				NE
1.A.3.d.i - International water-borne navigation (International bunkers)	NO							NA				NO
1.A.5.c - Multilateral Operations	NO							NA				NO

NO - Not occurring, NA – Not Applicable, NE – Not Estimated

**CO_2 net emissions (emission minus removals)*

Table 92. Detailed results for 2015

	Emissions (Gg)			Emissions CO2 Equivalents (Gg)					Emissions (Gg)			
Categories	Net CO2*	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
Total National Emissions and Removals	6632.71	63.81	1.52	219.06	NA, NE, NO				17.06	53.69	19.70	69.01
1 - Energy	7400.61	9.71	0.19	NA					16.05	48.30	12.40	68.79
1.A - Fuel Combustion Activities	7395.83	3.34	0.19						15.16	44.30	6.51	68.78
1.A.1 - Energy Industries	4242.83	0.04	0.06						9.53	0.47	0.06	62.02

1.A.2 - Manufacturing Industries and Construction	1061.99	0.07	0.01			3.59	6.81	0.81	6.35
1.A.3 - Transport	1802.65	0.36	0.09			0.00	0.00	NA	NA
1.A.4 - Other Sectors	81.65	2.78	0.04			0.66	36.70	5.51	0.26
1.A.5 - Non-Specified	206.70	0.09	0.00			1.38	0.31	0.13	0.15
1.B - Fugitive emissions from fuels	4.78	6.36	NA			0.89	4.01	5.89	0.01
1.B.1 - Solid Fuels	4.78	6.36				NA		4.75	NA
1.B.2 - Oil and Natural Gas	0.00	0.00				0.89	4.01	1.15	0.01
1.B.3 - Other emissions from Energy Production	NA					NA			
1.C - Carbon dioxide Transport and Storage	NO	NA							
1.C.1 - Transport of CO2									
1.C.2 - Injection and Storage									
1.C.3 - Other									
2 - Industrial Processes and Product Use	570.32	0.05	NA	219.06	NA	0.69	1.00	0.02	0.21
2.A - Mineral Industry	294.43	NA				0.67	0.79	0.01	0.20
2.A.1 - Cement production	288.64					0.66	0.78	0.01	0.20
2.A.2 - Lime production	4.72					0.01	0.02	NA	0.00
2.A.3 - Glass Production	0.01					NA			0.00
2.A.4 - Other Process Uses of Carbonates	1.05								NA
2.A.5 - Other (please specify)	NO								
2.B - Chemical Industry	NO, NA			NA		NA			
2.B.1 - Ammonia Production	NO	NA							
2.B.2 - Nitric Acid Production	NA		NO						
2.B.3 - Adipic Acid Production									
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production									
2.B.5 - Carbide Production	NO	NO							
2.B.6 - Titanium Dioxide Production		NA							
2.B.7 - Soda Ash Production									
2.B.8 - Petrochemical and Carbon Black Production		NO							
2.B.9 - Fluorochemical Production									
2.B.10 - Other (Please specify)	NO								
2.C - Metal Industry	275.89	0.05	NA			0.02	0.21	0.01	0.01
2.C.1 - Iron and Steel Production	11.04	NA				0.02	0.21	0.01	0.01
2.C.2 - Ferroalloys Production	263.47	0.05	NA						
2.C.3 - Aluminium production	NO, NA								
2.C.4 - Magnesium production									
2.C.5 - Lead Production	1.38	NA							0.01

2.C.6 - Zinc Production	NO	NA,									
2.C.7 - Other (please specify)											
2.D - Non-Energy Products from Fuels and Solvent Use	NO	NA									
2.D.1 - Lubricant Use											
2.D.2 - Paraffin Wax Use											
2.D.3 - Solvent Use											
2.D.4 - Other (please specify)											
2.E - Electronics Industry	NA			NO, NA				NA			
2.E.1 - Integrated Circuit or Semiconductor											
2.E.2 - TFT Flat Panel Display											
2.E.3 - Photovoltaics											
2.E.4 - Heat Transfer Fluid											
2.E.5 - Other (please specify)											
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA			219.06	NO, NA	NA					
2.F.1 - Refrigeration and Air Conditioning	NA			219.06	NA	NA					
2.F.2 - Foam Blowing Agents	NA			NO	NO,NA	NA					
2.F.3 - Fire Protection											
2.F.4 - Aerosols											
2.F.5 - Solvents											
2.F.6 - Other Applications (please specify)											
2.G - Other Product Manufacture and Use	NA				NE, NO		NA	NA			
2.G.1 - Electrical Equipment											
2.G.2 - SF6 and PFCs from Other Product Uses											
2.G.3 - N2O from Product Uses											
2.G.4 - Other (Please specify)											
2.H - Other	NO	NA									
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	-1345.06	32.19	1.18	NA				0.08	NA	6.08	NA
3.A - Livestock	NA	31.26	0.14	NA				0.08	NA	4.35	NA
3.A.1 - Enteric Fermentation		25.78	NA					NA			
3.A.2 - Manure Management		5.48	0.14					0.08		4.35	
3.B - Land	-1347.09	NA									
3.B.1 - Forest land	-1697.39										
3.B.2 - Cropland	28.84										

3.B.3 - Grassland	27.94								
3.B.4 - Wetlands									
3.B.5 - Settlements	9.36								
3.B.6 - Other Land	284.16								
3.C - Aggregate sources and non-CO2 emissions sources on land	3.51	0.93	1.04	NA				1.73	NA
3.C.1 - Emissions from biomass burning	NA	NO						1.73	NA
3.C.2 - Liming	NO	NA	NA						
3.C.3 - Urea application	3.51	NA	NA						
3.C.4 - Direct N2O Emissions from managed soils			0.70						
3.C.5 - Indirect N2O Emissions from managed soils	NA		0.25						
3.C.6 - Indirect N2O Emissions from manure management			0.09						
3.C.7 - Rice cultivations	NA	0.93	NA	NA					
3.C.8 - Other (please specify)	NA								
3.D - Other	-1.48								
3.D.1 - Harvested Wood Products	-1.48	NA	NA						
3.D.2 - Other (please specify)									
4 - Waste	6.85	21.87	0.14	NA		0.25	4.39	1.20	0.01
4.A - Solid Waste Disposal	NA	18.30	NA			NA	NA	1.11	NA
4.B - Biological Treatment of Solid Waste	NA	0.03	0.00	NA		NA	0.00	NA	NA
4.C - Incineration and Open Burning of Waste	6.85	0.51	0.01			0.25	4.39	0.10	0.01
4.D - Wastewater Treatment and Discharge	NA	3.03	0.13			NA	NA	0.00	NA
4.E - Other (please specify)	NA								
5 - Other	NE, NO								
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	NE								
5.B - Other (please specify)	NO								
Memo Items (5)									
International Bunkers	41.64	0.00	0.00	NA	NE, NO				
1.A.3.a.i - International Aviation (International Bunkers)	41.64	0.00	0.00	NA	NE				
1.A.3.d.i - International water-borne navigation (International bunkers)	NO			NA	NO				
1.A.5.c - Multilateral Operations	NO			NA	NO				

NO - Not occurring, NA – Not Applicable, NE – Not Estimated

**CO_2 net emissions (emission minus removals)*

Table 93. Detailed results for 2016

	Emissions (Gg)			Emissions CO2 Equivalents (Gg)					Emissions (Gg)			
Categories	Net CO2*	CH4	N2O	HFCs	PFCs	SF6	Other halogenated gases with CO2 equivalent conversion factors	Other halogenated gases without CO2 equivalent conversion factors	NOx	CO	NMVOCs	SO2
Total National Emissions and Removals	5896.75	63.53	1.60	315.72	NA				15.93	47.54	17.38	59.98
1 - Energy	7179.56	8.47	0.19						14.71	41.88	10.74	59.69
1.A - Fuel Combustion Activities	7175.41	2.95	0.19						13.94	38.44	5.64	59.68
1.A.1 - Energy Industries	3785.76	0.04	0.05						8.41	0.51	0.06	53.18
1.A.2 - Manufacturing Industries and Construction	1031.89	0.08	0.01	NA					3.48	6.55	0.79	6.11
1.A.3 - Transport	2056.95	0.39	0.10						0.01	0.00	NA	
1.A.4 - Other Sectors	81.75	2.35	0.03						0.59	31.05	4.66	0.24
1.A.5 - Non-Specified	219.07	0.09	0.00						1.46	0.32	0.13	0.16
1.B - Fugitive emissions from fuels	4.15	5.52							0.77	3.44	5.11	0.01
1.B.1 - Solid Fuels	4.15	5.52	NA						NA		4.12	NA
1.B.2 - Oil and Natural Gas	0.00	0.00							0.77	3.44	0.98	0.01
1.B.3 - Other emissions from Energy Production	NA								NA			
1.C - Carbon dioxide Transport and Storage	NO	NA										
1.C.1 - Transport of CO2												
1.C.2 - Injection and Storage												
1.C.3 - Other												
2 - Industrial Processes and Product Use	541.70	0.02	NO	315.72	NA, NE, NO				0.89	1.31	0.02	0.28
2.A - Mineral Industry	379.39								0.87	1.02	0.01	0.26
2.A.1 - Cement production	372.92								0.85	1.00	0.01	0.26
2.A.2 - Lime production	5.38	NA							0.01	0.02	NA	0.00
2.A.3 - Glass Production	0.05								0.00	NA		0.00
2.A.4 - Other Process Uses of Carbonates	1.04								NA			
2.A.5 - Other (please specify)	NO											
2.B - Chemical Industry	NO, NA			NA					NA			
2.B.1 - Ammonia Production	NO	NA										
2.B.2 - Nitric Acid Production	NA		NO									
2.B.3 - Adipic Acid Production												
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production												

2.B.5 - Carbide Production	NO	NO	NA								
2.B.6 - Titanium Dioxide Production		NA									
2.B.7 - Soda Ash Production											
2.B.8 - Petrochemical and Carbon Black Production		NO	NA								
2.B.9 - Fluorochemical Production	NA										
2.B.10 - Other (Please specify)	NO										
2.C - Metal Industry	162.31	0.02	NA					0.02	0.29	0.01	0.02
2.C.1 - Iron and Steel Production	15.31	NA						0.02	0.29	0.01	0.01
2.C.2 - Ferroalloys Production	144.67	0.02	NA								
2.C.3 - Aluminium production	NO, NA										
2.C.4 - Magnesium production											
2.C.5 - Lead Production	2.33	NA									0.01
2.C.6 - Zinc Production	NO, NA										
2.C.7 - Other (please specify)											
2.D - Non-Energy Products from Fuels and Solvent Use	NO	NA									
2.D.1 - Lubricant Use											
2.D.2 - Paraffin Wax Use											
2.D.3 - Solvent Use											
2.D.4 - Other (please specify)											
2.E - Electronics Industry	NA				NO, NA		NA				
2.E.1 - Integrated Circuit or Semiconductor											
2.E.2 - TFT Flat Panel Display											
2.E.3 - Photovoltaics											
2.E.4 - Heat Transfer Fluid											
2.E.5 - Other (please specify)											
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA			315.72	NA,NO	NA					
2.F.1 - Refrigeration and Air Conditioning	NA			315.72	NA	NA					
2.F.2 - Foam Blowing Agents	NA			NO	NO, NA	NA					
2.F.3 - Fire Protection											
2.F.4 - Aerosols											
2.F.5 - Solvents											
2.F.6 - Other Applications (please specify)											
2.G - Other Product Manufacture and Use	NA				NE,NA		NA				
2.G.1 - Electrical Equipment											
2.G.2 - SF6 and PFCs from Other Product Uses											
2.G.3 - N2O from Product Uses											

2.G.4 - Other (Please specify)								
2.H - Other	NO	NA						
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	-1831.16	32.62	1.26	NA	0.08	NA	5.43	NA
3.A - Livestock	NA	31.68	0.14	NA	0.08	NA	4.44	NA
3.A.1 - Enteric Fermentation		26.06	NA		NA			
3.A.2 - Manure Management		5.62	0.14		0.08	NA	4.44	NA
3.B - Land	-1834.34	NA						
3.B.1 - Forest land	-2156.85							
3.B.2 - Cropland	31.22							
3.B.3 - Grassland	25.80							
3.B.4 - Wetlands								
3.B.5 - Settlements	2.92							
3.B.6 - Other Land	262.57							
3.C - Aggregate sources and non-CO2 emissions sources on land	3.19	0.94	1.12	NA			0.99	NA
3.C.1 - Emissions from biomass burning	NA	NO		NA			0.99	NA
3.C.2 - Liming	NO	NA		NA				
3.C.3 - Urea application	3.19	NA	NA					
3.C.4 - Direct N2O Emissions from managed soils	NA		0.75					
3.C.5 - Indirect N2O Emissions from managed soils			0.27					
3.C.6 - Indirect N2O Emissions from manure management			0.09					
3.C.7 - Rice cultivations	NA	0.94	NA					
3.C.8 - Other (please specify)	NO							
3.D - Other	NO	NA						
3.D.1 - Harvested Wood Products								
3.D.2 - Other (please specify)								
4 - Waste	6.65	22.42	0.14	NA	0.25	4.35	1.19	0.01
4.A - Solid Waste Disposal	NA	18.93	NA	NA	NA	NA	1.10	NA
4.B - Biological Treatment of Solid Waste	NA	0.02	0.00		NA	0.00	NA	NA
4.C - Incineration and Open Burning of Waste	6.65	0.51	0.01		0.25	4.35	0.10	0.01
4.D - Wastewater Treatment and Discharge	NA	2.96	0.13		NA	NA	0.00	NA
4.E - Other (please specify)	NA							
5 - Other	NE, NO							
5.A - Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	NE							

5.B - Other (please specify)	NO				
Memo Items (5)					
International Bunkers	47.48	0.00	0.00	NA	NE, NO
1.A.3.a.i - International Aviation (International Bunkers)	47.48	0.00	0.00	NA	NE
1.A.3.d.i - International water-borne navigation (International bunkers)	NO			NA	NO
1.A.5.c - Multilateral Operations	NO			NA	NO

NO - Not occurring, NA – Not Applicable, NE – Not Estimated

**CO_2 net emissions (emission minus removals)*

Appendix III Detailed tables of the key category analysis

Table 94 presents the level assessment of key categories in 2016 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 95 gives an overview of the trend assessment relating to 1990 and 2016, 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 94. Level assessment of key categories in 2016

IPCC Category code	IPCC Category	Green-house gas	2016 Ex,t (Gg CO2 Eq)	|Ex,t| (Gg CO2 Eq)	Lx,t	Cumulative Total of Lx,t
1.A.1	Energy Industries - Solid Fuels	CO_2	3378.73	3378.73	0.27	0.27
3.B.1.a	Forest land Remaining Forest land	CO_2	-2154.20	2154.20	0.17	0.45
1.A.3.b	Road Transportation	CO_2	2050.37	2050.37	0.17	0.61
3.A.1	Enteric Fermentation	CH_4	651.53	651.53	0.05	0.67
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	508.45	508.45	0.04	0.71
4.A	Solid Waste Disposal	CH_4	473.16	473.16	0.04	0.75
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	450.06	450.06	0.04	0.78
2.A.1	Cement production	CO_2	372.92	372.92	0.03	0.81
2.F.1	Refrigeration and Air Conditioning	PFC	315.72	315.72	0.03	0.84
1.A.1	Energy Industries - Gaseous Fuels	CO_2	313.98	313.98	0.03	0.86
3.C.4	Direct N2O Emissions from managed soils	N_2O	224.45	224.45	0.02	0.88
1.A.5	Non-Specified - Liquid Fuels	CO_2	202.97	202.97	0.02	0.90
2.C.2	Ferroalloys Production	CO_2	144.67	144.67	0.01	0.91
3.A.2	Manure Management	CH_4	140.56	140.56	0.01	0.92
1.B.1	Fugitive emissions - Solid Fuels	CH_4	138.08	138.08	0.01	0.93
1.A.1	Energy Industries - Liquid Fuels	CO_2	93.05	93.05	0.01	1.00

Table 95. Trend assessment of key categories (1990, 2016)

IPCC Cate-gory code	IPCC Category	Green-house gas	1990 Year Estimate Ex0 (Gg CO2 Eq)	2016 Year Estimate Ext (Gg CO2 Eq)	Trend Assess-ment (Txt)	% Contri-bution to Trend	Cumulative Total of Contrib. to Trend
3.B.1.a	Forest land Remaining Forest land	CO_2	-206.31	-2154.20	0.15	0.27	0.27
1.A.3.b	Road Transportation	CO_2	749.17	2050.37	0.12	0.23	0.50
1.A.1	Energy Industries - Solid Fuels	CO_2	5698.04	3378.73	0.03	0.05	0.55
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	1197.05	450.06	0.03	0.05	0.60
2.F.1	Refrigeration and Air Conditioning	PFC	0.00	315.72	0.02	0.05	0.65
1.A.1	Energy Industries - Gaseous Fuels	CO_2	0.00	313.98	0.02	0.05	0.69
4.A	Solid Waste Disposal	CH_4	265.61	473.16	0.02	0.04	0.74
1.A.4	Other Sectors - Liquid Fuels	CO_2	545.31	73.50	0.02	0.04	0.78
1.A.1	Energy Industries - Liquid Fuels	CO_2	481.55	93.05	0.02	0.03	0.81
1.A.5	Non-Specified - Liquid Fuels	CO_2	0.00	202.97	0.02	0.03	0.84
2.A.1	Cement production	CO_2	293.75	372.92	0.01	0.03	0.87
2.C.6	Zinc Production	CO_2	186.23	0.00	0.01	0.02	0.88
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	591.72	508.45	0.01	0.02	0.90
3.C.4	Direct N2O Emissions from managed soils	N_2O	211.97	224.45	0.01	0.01	0.91
1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	0.00	73.38	0.01	0.01	0.92
2.C.3	Aluminium production	PFCs	91.65	0.00	0.00	0.01	0.93
3.A.1	Enteric Fermentation	CH_4	908.22	651.53	0.00	0.01	0.94
3.A.2	Manure Management	CH_4	150.83	140.56	0.00	0.01	0.95
3.B.2.b	Land Converted to Cropland	CO_2	0.00	32.60	0.00	0.00	0.95