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GHG Inventory

For Municipalities from Cross-Border region between Republic of Bulgaria and Republic of Macedonia

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"JOINT INTEGRATED POLICY FOR LOW-CARBON ECONOMY IN CROSS-BORDER REGION"

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Abbreviations:

CORINAIR	Methodology for preparation of national inventories of atmospheric emissions
EU	European Union
GHGs	Greenhouse Gasses
IPCC	Intergovernmental Panel on Climate Change
NGO	Nongovernmental organizations
LPG	Liquid petroleum gas
UNFCCC	United Nations Framework Convention on Climate Change

CHEMICAL SYMBOLS of GHGs

CO	carbon monoxide
CO_2	carbon dioxide
CO_2eq	carbon dioxide equivalent
CH_4	Methane
N_2O	nitrous oxide
NO_x	nitrogen oxides
NMVOCs	non-methane volatile organic compounds

INTRODUCTION

ABOUT THE PROJECT

The main objective of project “Joint Integrated Policy for Low-Carbon Economy in Cross-Border Region” of which this contract will be a part is to contribute directly to the transition of the Cross-Border Region’s Economy from Carbon-intensive to Low-carbon basis as a part EU effort to transition the Europe’s economy. To achieve this objective, the projects partners will implement a direct cross-border joint protection and monitoring of natural resources in 9 border municipalities, as well as creating prerequisite for Low-carbon Economy and Sustainable Development in this area. Joint analysis of carbon emissions in the region will show the real state of the Carbon Footprint (CO_2 emissions) and Greenhouse Gases (GHG), also giving ideas about necessity for their reduction.

All of these activities aim to craft a Joint Policy for Low-carbon Economy, which could contribute by acting as guidance for the regional authorities and other stakeholders, towards transition to Sustainable Cross-Border Development.

To achieve this, a joint research activities, inventories, information and know how exchange will be implemented. Joint network will be established with participation of all stakeholders from both sides of the border, representing Public, Private and Civil Sectors. Additionally a system for coordination, information and experience exchange between the project municipalities will be jointly developed and joint workshops will be held on in Cross-Border Area. This way the project will contribute to establishment of direct contacts between the local actors in both border regions.

In frame of this project following Municipalities are beneficiary from this project:

Bulgaria:

- Blagoevgrad
- Simitli
- Kresna
- Strumiani
- Sandanski

Macedonia:

- Berovo
- Delcevo
- Pehcevo
- Vinica

1. GREENHOUSE GASES INVENTORY

In accordance with the scientific research worldwide, is has been proven that the greenhouse gas emissions resulting from different human activities have impact on global climate. The activities that are performed at local level also have their contribution, and for this reason it is important to perform identification of the sources of these gases within the municipality.

The greenhouse gas inventory simply represents localization of the sources of greenhouse gas and quantification of the resulting emissions by means of precisely determined methodology for their calculation.

The local self-government can use these data in order to evaluate the effectiveness of the measures undertaken for greenhouse gas reduction. Accurate, complete, relevant and consistent measurements or calculations of the greenhouse gases will enable the municipality to develop appropriate strategies for struggle with climate changes that would most effectively target the sources of such emissions.

Benefits of making a greenhouse gas inventory:

Risk management: The voluntary reporting about the greenhouse gas emissions helps the local authorities and organizations to cope with risks from climate changes more successfully, by undertaking early activities for reduction of emissions of greenhouse gases.

Addressing inefficiencies: The calculation of the greenhouse gas emissions can help the municipalities to increase the efficiency in the reduction of emissions, by means of accurate targeting of sources, implementation of new innovative technologies or application of more ecological methods.

Education and informing of the affected parties: The preparation of an annual greenhouse gas inventory can help in the process of providing information for the management committee in the municipality, to educate the private sector and the public about the activities that contribute for the greenhouse gas emission.

The annual inventory and reporting of greenhouse gas emissions and removals provide an information base for the planning and monitoring of climate policy. The Kyoto Protocol obliges its parties to establish a national greenhouse gas inventory system by the end of 2006.

The national system produces data and background information on emissions and removals for the UNFCCC, the Kyoto Protocol and the EU Commission. In addition, the scope of the system covers the archiving of the data used in emission estimations, the publishing of the results, participation in inventory reviews and the quality management of the inventory.

The Regulation of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol obliges the Member States (MS) of the European Union (EU) to participate in the compilation of the EU's common greenhouse gas inventory and other climate policy, as well as in the monitoring and evaluation of its detailed measures. This procedure causes a two-phased submission of MS inventory reporting to the Commission with annual deadlines for submission 15 January and 15 March.

This National Inventory Report (NIR) of Bulgaria for the 2017 submission to the EU, the UNFCCC and the Kyoto Protocol includes data of the anthropogenic emissions by sources and removals by sinks of all greenhouse gases (GHGs) not controlled by the Montreal Protocol, i.e. carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), nitrogen trifluoride (NF_3) and sulphur hexafluoride (SF_6).

Indirect CO_2 emissions resulting from atmospheric oxidation of CH_4 and NMVOC emissions from non-biogenic sources are also included in the inventory. These have been separately estimated for fugitive emissions in the Energy sector and sources in the Industrial Processes and Product Use sectors using the methodology given in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006, see Section 7.2.1.5). For fossil fuel combustion, indirect emissions are included in the methodology to estimate CO_2 emissions.

The NIR includes also estimates of so-called indirect greenhouse gases carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOCs) and sulphur dioxide (SO_2) meaning sulphur oxides and other sulphur emissions calculated as SO_2. Indirect greenhouse gases and sulphur dioxide do not have a direct warming effect, but influence on the formation or destruction of direct greenhouse gases, such as troposheric ozone. These gases are not included in Annex A of the Kyoto Protocol.

The emission estimates and removals are presented by gas and by source category and refer to the year 2015. Full time series of the emissions and removals (with exception of F-gases) from 1988 to 2015 are included in the submission.

The structure of this NIR was reelaborated in order to follow the Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (Decision 24/CP.19). The annotated outline of the NIR, and the guidance contained therein, developed by the UNFCCC secretariat in 2014, has been followed. Chapter 1 provides an introduction to the **Bulgaria's National Inventory Report 2017 – Submission under UNFCCC** background of greenhouse gas inventories and the inventory preparation process and Chapter 2 presents the overall emission trend in Bulgaria from the year 1988 to the year 2014. In Chapters 3 to 9 more detailed information of GHG emission estimates are given for the seven sectors: (i) energy, (ii) industrial processes and product use, (iii) agriculture, (iv) land use, land-use change and forestry, (v) waste, (vi) other and (vii) indirect CO_2 and nitrous oxide emissions.

Each of these gases has a different warming effect. As an example, the gases HFCs, PFCs, NF3 and SF6 (so called F-gases) have much greater warming effect, in some cases over one hundred times, compared to methane (25), nitrous oxide (298) and carbon dioxide (1). Because of that, a common assessment criterion for the effect of each GHG on the atmosphere warming should be introduced. This criterion is the so-called Global Warming Potential (GWP), representing GHG emissions as CO2-eq. emissions. It allows totalling the effect of all GHGs, adjusted to a common base. For defining of GWP, the Parties to the Convention and Kyoto Protocol accept values, over a time horizon of 100 years, as mentioned in the IPCC Fourth Assessment Report of 2007. Other gases have indirect warming effect to the atmosphere (as NOx, CO and NMVOCs), or cooling effect as SOx. These gases are precursors of the greenhouse gas – troposphere ozone, and are subject of regional control protocols. They do not have global effect on the climate changes as the main GHG. That is why in the lIR only the total GHG emissions – precursors, as well as the total SOx emissions were reported. The inventories are prepared according to the UNFCCC Guidelines and establishing the NIR structure in compliance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The general objective regarding the preparation of the annual GHG inventories is to improve „TACCC” in emission estimates. The Report presents the local GHG inventory for five municipalities in the cross border region: Blagoevgrad, Simitli, Kresna, Strumiani and Sandanski (from Republic of Bulgaria) and Berovo, Delcevo, Pehcevo and Vinica (from Republic of Macedonia)

1.1. PREPARATION PROCESS OF THE GREENHOUSE GAS INVENTORY FOR THE MUNICIPALITIES

The preparation of the greenhouse gas inventory is generally performed in three stages:

- Stage 1: Identification of the sources of greenhouse gas emissions and collection of data (activity rate);
- Stage 2: Calculation of the emissions by applying appropriate emission factors;
- Stage 3: Making a report of the calculated emissions.

Data is collected by means of a questionnaire that represents a guide for the stakeholders and contains directions about the type of data that needs to be collected. Also, official demands have been delivered to the municipality and the private sector, as well as questionnaires and surveys with the residents of the municipality and the private sector and from national databases. A tool has been created (in MS Excel) for preparation of the inventory, where the emission factors have been predefined for each type of activity in the municipality.

The completed questionnaire, together with the references for the collected data, is delivered to the project expert on climate change. These data are further inserted in the tool for calculation, in order to get specific figures about the quantity of greenhouse gas which is directly emitted from different activities in the each municipality.

A final report is prepared at the end of the process, where all sources of emissions are indicated and the quantity of greenhouse gas is shown for each sector separately.

1.2. METHODOLOGY FOR CALCULATION OF THE GREENHOUSE GAS EMISSIONS

In general, two types of data are required and necessary for calculation of the greenhouse gas emissions: *activity rate and emission factor*. The activity rate is a value which will describe the quantity of an energy-generating product, product or in any quantitative manner it will describe the source of emissions of greenhouse gases and the same refers to the intensity of the process under research. For example, the activity rate for calculation of emissions from use of fertilizers on agricultural soils represents the quantity of used fertilizer. The emission factor is the already calculated relation between the quantity of the activity rate and the emissions of greenhouse gases. The emission factors are scientifically determined by means of direct measurement, laboratorial analysis or calculations made on representative sample. Therefore, for the purpose of calculation of the greenhouse gas emissions, the following basic formula applies:

Emissions = Activity rate X Emission factor

It must be noted that this formula gets its more complex form depending on the sector in question, if there are additional coefficients that should be applied in order to calculate the activity rate or the emission factor. The more complex form of the equation above can be also obtained when applying higher methodology of calculation (tier). The inventories, in regard to use of higher methodology, (tier) with use of specific emission factors that reflect the specific national conditions, are based on use of information that is specific for the municipality or the country (knowledge of the type of processes and the specific conditions in which they take place, the quality of fuels being used etc.).

The methodology for calculation of the greenhouse gas emissions is in accordance with the IPCC Guidebooks for preparation of greenhouse gas inventories and the IPCC Guidebooks for good practices. For the first time in Macedonia, the emissions are calculated according to this methodology at local level, which is also used for national inventorying of greenhouse gases. The emission factors are in accordance with the document “National emission factors for CO_2 and non-CO_2 gasses for the key Sectors of emissions in the air pursuant to the IPCC and the CORINAIR methodologies“.

IPCC methods use the following concepts: Good Practice: In order to promote the development of high quality national greenhouse gas inventories collection of methodological principals, actions and procedures were defined in the previous guidelines and collectively referred to as good practice. The 2006 Guidelines retain the concept of good practice including the definition introduced with GPG2000. This has achieved general acceptance amongst countries as the basis for inventory development and says that inventories consistent with good practice are those which contain neither over- nor under-estimates so far as can be judged, and in which uncertainties are reduced as far as practicable.

Tiers: A tier represents a level of methodological complexity. Usually three tiers are provided. Tier 1 is the basic method, Tier 2 intermediate and Tier 3 most demanding in terms of complexity and data requirements.

Tiers 2 and 3 are sometimes referred to as higher tier methods and are generally considered to be more accurate.

Default data: Tier 1 methods for all categories are designed to use readily available national or international statistics in combination with the provided default emission factors and additional parameters that are provided, and therefore should be feasible for all countries.

Key Categories: The concept of key category8 is used to identify the categories that have a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level of emissions and removals, the trend in emissions and removals, or uncertainty in emissions and removals. Key Categories should be the priority for countries during inventory resource allocation for data collection, compilation, quality assurance/quality control and reporting.

In the process of inventorying, the emissions from the direct (CO_2, CH_4, N_2O) and the indirect greenhouse gases (CO, NOx, SO_2) are calculated. The inventorying applies the potentials of the global warming from the IPCC (SAR) Second Assessment Report and they are shown in Table 1.

Table 1. Potentials of global warming from the IPCC Second Assessment Report (SAR).

Greenhouse gas	The potentials of global warming
CO2	1
CH4	21
N2O	310

SECTORIAL INVENTORIES

2. SECTOR: ENERGY

The inventorying of greenhouse gases in an area usually includes gases which have been discharged during the production of some product within that area. In Municipalities in Macedonia there is no production of electricity from which we can directly calculate emissions. For this reason the emissions of greenhouse gases from the sector of energetics will be calculated as part of the national emissions as a result of the consumption of electricity and fuels in the municipalities.

The energy infrastructure of Republic of Macedonia enables exploitation of the domestic primary energy, import and export of primary energy, processing of the primary energy and production of final energy, transportation and distribution of energy. Macedonia is part of the countries with exceptionally low electricity consumption per capita and with exceptionally high electricity consumption per unit of GDP. The energy infrastructure of the Republic of Macedonia consists of the electro-energetic sector, the sectors for coal, oil and oil products, for natural gas and heat production.

The data taken from the International Energy Agency and according to the data from the national greenhouse gas inventory of the Republic of Bulgaria for production of electricity, divided by the total production of electricity in the country from all types of sources, an indicative value of 0.819 t CO_2-eq for each produced MWh of electricity is obtained.

The data taken from the International Energy Agency indicate that at the level of Republic of Macedonia, 0.797t of CO_2-eq are emitted for one produced kWh of electricity. On the other hand, according to the data from the national greenhouse gas inventory of the Republic of Macedonia for production of electricity, divided by the total production of electricity in the country from all types of sources, an indicative value of 0.993t CO_2-eq for each produced kWh of electricity is obtained. This number is used for calculation of the greenhouse gas footprint for the municipalities in Macedonia, that is, to determine the value of emissions that result from the consumption of electricity at the level of the municipality.

2.1. HEATING/COOLING

Regarding the installed heating and cooling systems in households and public, commercial and private premises the received data are very limited because the Municipalities doesn't have any additional register of installed heating and cooling systems in households and other type of premises, so there is a lack of now-days relevant data. According the existing data, it is evident that most of the households, use wood (biomass) for heating. The biomass consumed for production of heat is not part of the net value of the greenhouse gas emissions, since it is considered a renewable source of energy.

Most of the remaining part of the population uses electricity for heating but the questionnaires did not provide any data about the electricity consumption, neither about the other heating sources by the community in the municipalities. The consumption of coal is calculated based on the average quantities needed to heat an apartment of 60 m^2. For the purpose of the calculation is accepted that the operational period is 8 hours per day. The specific heat load per m3 is equal to 0.055kWh/m3

Table 2. Type of heating of households in Municipalities in Republic of Bulgaria

Municipality	Households/ residence	Central Heating System	Individual Heating System					
			Electricity	Coal	Biomass /pellets	Liquid Fuels	Gas	Woods
Blagoevgrad	31571	n/a	11685	7636	107	61	569	11558
Simitli	6139	n/a	1227	2335	n/a	n/a	122	2455
Kresna	2250	n/a	225	n/a	n/a	n/a	n/a	2025
Strumiani	2080	n/a	208	n/a	n/a	n/a	n/a	1872
Sandanski	10343	n/a	3826	2174	n/a	n/a	206	4137

Table 3. Coal consumption by households in the Municipalities in Republic of Bulgaria for 2016

	Coal Consumption Tj/year	EF t CO2/tj	Emissions t CO2/tj	Emissions t CO2e/tj
Blagoevgrad	378	94.17	35 596	
Simitli	115	94.17	10 829	
Kresna	n/a	94.17	n/a	
Strumiani	n/a	94.17	n/a	
Sandanski	107	94.17	10 076	
total			56 501	56 501
	Coal Consumption Tj/year	EF kg CH4/tj	Emissions t CH4/tj	Emissions T CO2e/tj
Blagoevgrad	378	300	113. 4	2381,4

Simitli	115	300	34. 5	724,5
Kresna	n/a	300	n/a	
Strumiani	n/a	300	n/a	
Sandanski	107	300	32. 1	674,1
total			180	3780
	Coal Consumption Tj/year	EF kg N2O/tj	Emissions t N2O/tj	Emissions T CO2e/tj
Blagoevgrad	378	1.5	0.567	175,11
Simitli	115	1.5	0.172	53,32
Kresna	n/a	1.5	n/a	
Strumiani	n/a	1.5	n/a	
Sandanski	107	1.5	0.160	49,6
total			0.89	278,69

The total GHG emissions from coal consumption by households in the five municipalities are 60.558,23 t CO2e/tj

According the existing data for Macedonia It is evident that most of the households, more than 96%, use wood (biomass) for heating. The biomass consumed for production of heat is not part of the net value of the greenhouse gas emissions, since it is considered a renewable source of energy. Most of the remaining part of the population uses electricity for heating, whose emissions have been calculated according to the consumption of electricity per household, by data received by EVN Macedonia.

Table 4. Type of heating of households in Municipalities in Republic of Macedonia

Municipality	Households/ residence	Central Heating System	Individual Heating System						Other type of heating	Heating with a stove					
			Electricity	Coal	Biomass (woods/pellets)	Liquid Fuels	Gas	Other fuels		Electricity	Coal	Biomass (woods/pellets)	Liquid fuels	Gas	Other fuels
Berovo	4715	0	5	1	65	9	-	-	-	8	2	4619	4	1	1
Delcevo	5568	1	5	4	100	15	-	1	-	55	1	5371	15	-	-
Pehcevo	2026	0	1	-	29	1	-	1	9	1	2	1969	6	-	7
Vinica	5600	0	5	-	123	36	-	1	-	42	2	5375	9		7
TOTAL	**17909**	**1**	**16**	**5**	**317**	**61**	**-**	**3**	**9**	**106**	**7**	**17277**	**34**	**1**	**15**
	100%	0	0,09%		1,77%		0			0,6%		96,5%		0	

2.2. ELECTRICITY CONSUMPTION

In order to calculate the CO2 emissions to be attributed to electricity consumption, it is necessary to determine the emission factor. The same emission factor will be used for all electricity consumption, including in the rail transportation. The general principle is that the national or a European emission factor may be used. In addition, if the local authority has decided to include measures related to local electricity production in the SEAP, or if it purchases certified green electricity, then a local emission factor for electricity will be calculated, which reflects the CO2 gains that these measures provide. The following simple rule may be used in such cases:

EFE = [(TCE - LPE - GEP) * NEEFE + CO2LPE + CO2GEP] / (TCE)

Where:

- EFE = local emission factor for electricity [t/MWhe]
- TCE = Total electricity consumption in the local authority (as per Table A of the template) [MWhe]
- LPE = Local electricity production (as per Table C of the template) [MWhe]
- GEP = Green electricity purchases by the local authority (as per Table A) [MWhe]
- NEEFE = national or European emission factor for electricity (to be chosen) [t/MWhe]
- CO2LPE = CO2 emissions due to the local production of electricity (as per Table C) [t]
- CO2GEP = CO2 emissions due to the production of certified green electricity [t]

In the exceptional case where the local authority would be a net exporter of electricity, then the calculation formula would be:

EFE = (CO2LPE + CO2GEP) / (LPE + GEP

For local emission factor for electricity consumption in the local authority is accepted the national EF for electricity consumption, which for Bulgharia is 0.819 t CO2/MWhe and the emissions of CO2 are calculated by the following formula

Emissions=AD*EF

Table 5. Electricity consumption by the Municipalities as whole in Republic of Bulgaria for 2016

Municipality	Electricity Consumption MWhe	EF t CO2/MWhe	Emissions t CO2/MWhe
Blagoevgrad & Simitli	142,950	0.819	117,076.05
Kresna & Strumiani & Sandanski	70,370	0.819	57,633.03
TOTAL>	**213,320**	**0.819**	**174,709.08**

The total CO2 emissions in the five municipalities are 174 709.08 CO2e t/MWhe

Table 6. Electricity consumption in Municipalities in Republic of Macedonia by sectors. Source EVN Macedonia

Municipality	Registered users	Total electricity consumption by households (MWh)	Total electricity consumption by public entities (MWh)	Total electricity consumption by business companies and industry год. (MWh)	Total electricity consumption by public streetlight (MWh)	TOTAL Electricity Consumption (MWh)
Delcevo	7009	13.696	1.745	11.121	1.139	27.701
Berovo	6324	12.824	1.367	6.579	705	21.476
Pehcevo	2219	4.334	252	4.471	254	9.311
Vinica	7090	16.986	2.875	20.811	474	41.147

Table 7. Electricity consumption in Municipalities in Republic of Macedonia for 2016

Municipality	Electricity Consumption MWhe	EF t CO2/MWhe	Emissions t CO2/MWhe
Delcevo	27.701	0,993	27.507,09
Berovo	21.476	0,993	21.325,69
Pehcevo	9.311	0,993	9.245,82
Vinica	41.147	0,993	40.858,97
Total	**99.635**	**0,993**	**98.937,58**

The total CO2 emissions in the four municipalities are 93.937,58 CO2e t/MWhe

2.3. TRANSPORTATION

Road transport is defined as a key category, as a result of the considerable amount of CO2 emissions from the use of diesel, gasoline, LPG presented below.

A unique feature of the Bulgarian vehicle fleet is its age structure. In 2015 more than 86% from the vehicles are above 10 years old, while new vehicles (1 to 5 years) are 4% from the total and 11% are 5 to 10 years old. Road transport has the biggest share in total fuel consumption in Transport subsector in the investigated municipalities. In 2015 road transport consumed 94.4% from the total energy in the sector. The most significant contributor to GHG emissions are passenger cars, followed by heavy-duty vehicles, light-duty vehicles and motorcycles and mopeds. Passenger cars account for 65.1%, light-duty vehicles are responsible for 13.7%, and heavy duty vehicles (incl. buses) account for 20.9% of total GHG CO2e emissions, with the share of passenger cars increasing over the time series. The remaining 0.3% were shared among and mopeds and motorcycles. Whereas CO2 emissions are closely linked to fuel consumption, CH4 and N2O emissions are considerably impacted by engine technology and do not follow the trend in the fuel consumption. As it can be observed in the following figure N2O emissions and implied emission factors tend to fluctuate for the period of the inventory following the introduction to the market of different engine technologies implementing EURO emission standards and different fuel quality standards (e.g. lead and sulphur content). The CO2 emissions are best calculated based on the amount and type of fuel combusted and its carbon content. The emissions of CH4 and N2O are more difficult to be estimated accurately because emission factors depend on vehicle technology, fuel and operating characteristics. *Emission factors*

According to the IPCC guidelines, an emission factor is defined as the average emission rate of a given GHG for a given source, relative to units of activity. Whereas, an implied emission factor (IEF) is defined as emissions divided by the relevant measure of activity:

IEF = Emissions / Activity data

IEF are not equivalent to the emissions factors for emissions calculations. IEF are more as of results providing average values for complex categories such as road transport, where the emissions are dependent on many parameters related to the vehicle fleet distribution. The emission factors used for the calculations of GHG emissions form road transport subsector are based on the algorithms of COPERT 4, version 11. The emission factors are internal parameters that depend both on the input data (e.g. average trip distance, driving and climatic conditions, etc.) and COPERT algorithms. However, COPERT model uses different emission factors for each vehicle category and technology. Thus, it is only possible to provide the implied emission factors which take into account the calculated emissions of greenhouse gases per fuel by the model related to the reported fuel consumption.

The decrease in the CH4 implied emission factor (IEF) for gasoline and diesel fuel is a result of the gradual increase in the number of vehicles that meet the standards set out in the EU directive on emissions from motor vehicles (mostly EURO 2 and EURO 3 vehicles), which slowly replaced the older technologies. It has to be noted, that in Bulgaria are mostly sold second hand vehicles, imported from Western Europe, which leads to a delay of the introduction of each new vehicle technology by 4 to 7 years compared to other countries. It is also a bit more complex to model the vehicle distribution matrix, since it is influenced both by the sales of new vehicles and by the imports of second hand vehicles. At the same time there is still a very large number of very old vehicles –the average vehicle age is much higher than in the other European countries. For inventarization of the GHG in the project area are used EF from the national report for inventarization of the GHG in Bulgaria for year 2014. Again as in the first case which regarding the use of electricity the questionnaires failed to provide detail information about the used of fuel by type in local communities. The only data that were collected regards the use of fuel by the local governments.

Table 8. Emission factors for the sector of Transportation in Bulgaria– Road traffic

	Unit	Emission Factor CO2 t/tj	Emission Factor CH4 kg/tj	Emission Factor N20 kg/tj
Motor gasoline	kg/TJ	72.30	16.57	2.62
Diesel	kg/TJ	75.12	3.15	1.72
LPG	kg/TJ	65.95	13.37	2.88

Table 9. Greenhouse gas emissions from road traffic in Bulgarian Municipalities

Municipality	EF CO2 t/tj	EF CH4 kg/tj	EF N20 kg/tj	Fuel Consumption tj	Fuel types	Emissions CO2 t/tj	Emissions CH4 kg/tj	Emissions N20 kg/tj
Blagoevgrad	72.30	16.57	2.62	418	Gasoline	30221	6926	1095
	75.12	3.15	1.72	377	Diesel	28 320	1187	648
	65.95	13.37	2.88	52	LPG	3429	695	149
Simitli	72.30	16.57	2.62	104	Gasoline	7519	1723	272
	75.12	3.15	1.72	94	Diesel	7061	296	161
	65.95	13.37	2.88	13	LPG	857	173	37
Kresna	72.30	16.57	2.62	41,6	Gasoline	3007	689	108
	75.12	3.15	1.72	37.6	Diesel	2824	118	64
	65.95	13.37	2.88	5.2	LPG	342	69	15
Strumiani	72.30	16.57	2.62	39,8	Gasoline	2877	659	104
	75.12	3.15	1.72	35,7	Diesel	2681	112	61
	65.95	13.37	2.88	5	LPG	329	66	14.4
Sandanski	72.30	16.57	2.62	167.2	Gasoline	12 088	2770	438
	75.12	3.15	1.72	150.8	Diesel	11 268	475	259.37
	65.95	13.37	2.88	20.8	LPG	1371	278	59.9
Total in all municipalities						114 194/ T CO2	405/ tCO2e	1045/ tCO2e

In total the GHG emissions from road traffic in the five municipalities are 115 616 t CO2eq/y.

The transportation sector includes the greenhouse gas emissions of many types of transportation vehicles, such as cars, trucks, tractors, motorcycles etc. These transportation vehicles run on different types of fuels: gasoline, diesel and LPG, the use of which causes emission of greenhouse gases CO_2 (carbon dioxide), CH_4 (methane) and N_2O (nitrous oxide) as well as other gases (CO, NMVOCs, PM, NOx) which cause air pollution in the municipality. The greenhouse gas emissions can be calculated according to the used fuel on the territory of the municipality (the fuel sold at the petrol stations) or according to the mileage traveled by the vehicles in the municipality. The major manufacturers, importers and distributors of these fuels in the Republic of Macedonia are OKTA a.d. Skopje, MAKPETROL a.d. Skopje and LUKOIL MACEDONIA dooel, Skopje. The data about the quality of liquid fuels of these companies are officially published on their WEB pages, according to which it is a matter of unified types of fuels that are in accordance with the Rulebook on quality of liquid fuels ("Official Gazette of RM" no. 88/2007, 91/2007, 97/2007, 105/2007, 157/2007, 15/2008, 78/2008, 156/2008 и 81/2009) and the appropriate standards (MKS EN 228; MKS EN 590; MKS EN 14214; MKS 1001 and MKS B.H2 430).

The determination of the emission factors for CO_2 is made by selecting the standard CO_2 emission factors for each fuel type. For CH_4 and N_2O, the applied emission factors are appropriate to the type of fuel and the type of vehicle. These emission factors are in accordance with the national selection of emission factors proposed in the document "National emission factors" for CO_2 and non-CO_2 gases for the key Sectors of emissions in the air pursuant to the IPCC and CORINAIR methodologies“ and they are shown in Table 10.

Table 10. Emission factors for the sector of Road Traffic for Macedonian Municipalities

Transport/Traffic	Unit	kg CO2	kg CH4	kg N2O	kg CO_2-екв
Motor Gasoline	1 L	2,4019	0,0011	0,0002	2,49
Diesel	1 L	2,8662	0,0002	0,0002	2,92
Liquid petroleum gas (LPG)	1 L	1,9266	0,0001	0,0001	1,96

According to the received data from Municipalities partner in the project the calculated greenhouse gas emissions for road traffic are shown in Table 11.

Table 11. Greenhouse gas emissions from the road traffic in the Municipalities in Macedonia

Municipality	Fuel Type	TJ	Emissions [tons CO_2]	Emissions [tons CH_4]	Emissions [tons N_2O]
Berovo	Motor Gasoline	44,6	3090,77	1,47	0,25
	Diesel	58,7	4349,53	0,23	0,23
	Liquid petroleum gas	5,8	429,76	0,025	0,025
				Total [tons CO2-eq]	**7867,83**
Delcevo	Motor Gasoline	92,99	6444,07	3,07	0,52
	Diesel	99,69	7386,79	0,39	0,39
	Liquid petroleum gas	11,56	856,57	0,05	0,05
				Total [tons CO2-eq]	**14 185,41**
Vinica	Motor Gasoline	204,66	14182,92	6,75	1,15
	Diesel	76,40	5661,32	0,3	0,30
	Liquid petroleum gas	9,89	733,46	0,04	0,04
				Total [tons CO2-eq]	**20 439,98**
Pehcevo	Motor Gasoline	9,11	631,13	0,3	0,05
	Diesel	10,48	776,31	0,04	0,04
	Liquid petroleum gas	0,94	69,36	0	0
				Total [tons CO2-eq]	**1 443,09**

TOTAL four Municipalities	TJ	Emissions [tons CO_2]	Emissions [tons CH_4]	Emissions [tons N_2O]
Motor Gasoline	351,36	24348,89	11,59	1,97
Diesel	245,27	18173,95	0,96	0,96
Liquid petroleum gas	28,19	2089,15	0,115	0,115
			Total [tons CO2-eq]	43936,31

3. SECTOR: AGRICULTURE

The estimation of greenhouse gas emissions from Sector Agriculture were calculated based on the following categories:

- Domestic livestock activities with enteric fermentation and manure management,
- Urea fertilization.
- Agricultural soils, and
- Agricultural residue burning.

3.1. METHANE EMISSIONS FROM ENTERIC FERMENTATION

Methane is emitted as part of the normal digestive process in animals. The quantity of emitted methane depends on two basic things:

• The type of digestive system in animals has an important impact on the rate of emissions of methane. Ruminants have the highest rate of emissions since significant quantity of methane is produced during the fermentation of food in the rumen (front stomach). In the calculations for the inventory, ruminants that have been considered include cattle, goats and sheep. The pseudo-ruminants (horses, mules and donkeys) and monogastric animals (pigs) emit relatively less methane during food digestion.

• The type and quantity of food that animals eat has an important role in the quantity of emitted methane. Logically, larger quantity of food leads to higher emissions. The quantity of consumed food depends on the size of the animal, the speed of growth and the production (such as production of milk, production of wool, pregnancy etc.).

For the purpose of assessment of methane emissions from enteric fermentation, a methodology has been used which is in accordance with the Revised IPCC guidelines and the same has been conducted in 3 basic steps:

Step 1: Division of the population of domestic animals into subgroups and characterization of each one of them. It is recommendable to use average annual values, taking into consideration the production cycles and the seasonal impacts on the number of population.

Step 2: Assessment of emission factors by subgroup, expressed in kilograms of methane per animal per year.

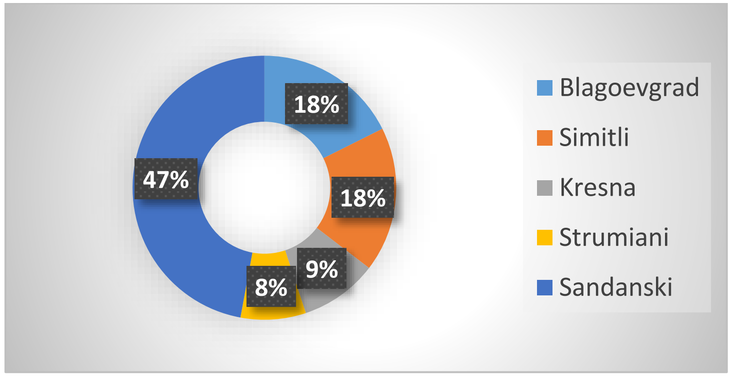
Step 3: Multiplication of the emission factors of the subgroups with the population of the subgroups in order to assess the emissions of a given subgroup and collection of the values of all subgroups in order to obtain the total emissions.

The emission factors for enteric fermentation are taken from the revised IPCC Guidebooks.

Table 12. Methane emissions from etheric fermentation for Municipalities in Bulgaria

Municipality		BLAGOEVGRAD		SIMITLI		KRESNA		STRUMIANI		SANDANSKI		TOTAL	
Type of animal	Emission factor for enteric fermentatio	Number of animals	Methane emissions from enteric	Number of animals	Methane emissions from enteric	Number of animals	Methane emissions from enteric	Number of animals	Methane emissions from enteric	Number of animals	Methane emissions from enteric	Number of animals	Methane emissions from enteric fermentatio
Unit	kg/head/y	No.	(tons/y)	No.	(tons/y)	No.	(tons/y)	No.	(tons/y)			No.	(tons/y)
Dairy cattle Cows	109,85	0	0,00	911	100,07	20	2,20	0	0,00	0	0,00	931	102,27
Cattle that does not produce milk	62,35	3639	226,89	1794	111,86	1321	82,36	1401	87,35	10583	659,85	18738	1.168,31
Sheep	7,11	7113	50,57	8186	58,20	6100	43,37	4442	31,58	12834	91,25	38675	274,98
Goats	5,00	2632	13,16	4659	23,30	3000	15,00	2684	13,42	4800	24,00	17775	88,88
Horses	18,00	76	1,37	76	1,37	120	2,16	27	0,49	319	5,74	618	11,12
Mules and donkeys	18,00	0	0,00	0	0,00	700	12,60	0	0,00	0	0,00	700	12,60
Pigs	1,50	388	0,58	22	0,03	30	0,05	28	0,04	288	0,43	756	1,13
Poultry	0,01	0	0,00	911	0,01	20	0,00	0	0,00	0	0,00	931	0,01
Total emmisions CH4 (t/y):			292,58		294,84		157,74		132,88		781,27		1.659,31
TOTAL eq CO2 (t/y)			**6.144,08**		**6.191,59**		**3.312,49**		**2.790,54**		**16.406,75**		**34.845,45**

Etheric emissions of CH4 for 2016 calculated based on the answers in the questionaries' are 1.659,31 t CH4/year, which is **34.845,45 t CO2eq/year**



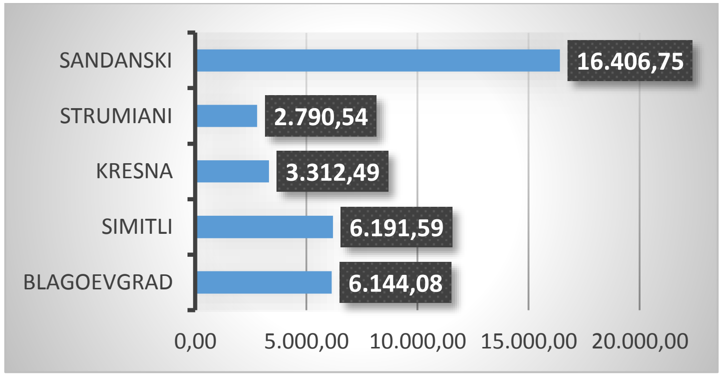
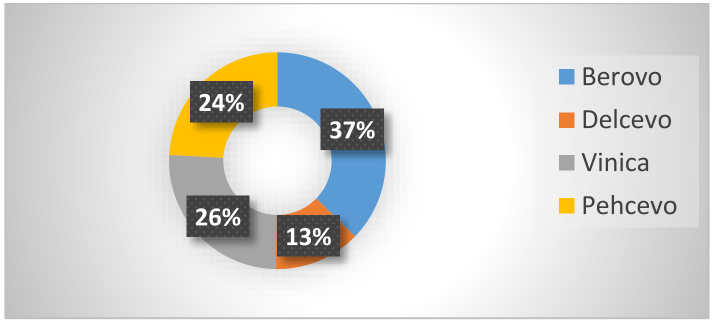
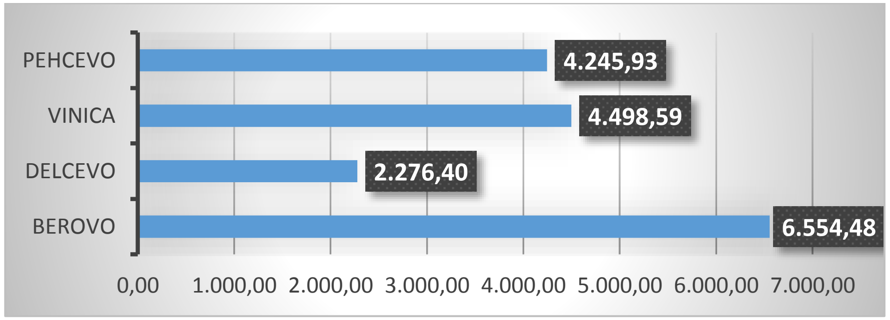


Table 13. Methane emissions from enteric fermentation for Municipalities in Macedonia

Municipality		BEROVO		DELCEVO		VINICA		PEHCEVO		TOTAL	
Type of animal	Emission factor for enteric fermentation	Number of animals	Methane emissions from enteric fermentation	Number of animals	Methane emissions from enteric fermentation	Number of animals	Methane emissions from enteric fermentation	Number of animals	Methane emissions from enteric fermentation	Number of animals	Methane emissions from enteric fermentation
Unit	kg/head/y	No.	(tons/y)	No.	(tons/y)	No.	(tons/y)	No.	(tons/y)	No.	(tons/y)
Dairy cattle Cows	81	1063	86,103	1200	97,2	560	45,36	1500	121,5	4323	350,163
Cattle that does not produce milk	56	1127	63,112	200	11,2	1320	73,92	500	28	3147	176,232
Sheep	5	26226	131,13	0	0	9560	47,8	9900	49,5	45686	228,43
Goats	5	3379	16,895	0	0	3800	19	150	0,75	7329	36,645
Horses	18	617	11,106	0	0	530	9,54	35	0,63	1182	21,276
Mules and donkeys	18	0	0	0	0	950	17,1	50	0,9	1000	18
Pigs	1	3623	3,623	0	0	1280	1,28	900	0,9	5803	5,803
Poultry	0	12422	0	0	0	18200	0	600	0	31222	0
Total CH4 emmisions (t/y):			311,969		108,4		214		202,18		836,55
Total CO2 eq (t/y):			**6551,35**		**2276,4**		**4494**		**4245,78**		**17567,53**

Etheric emissions of CH_4 for 2016 calculated based on the answers in the questionaries' are 836,55 t CH_4/year, which Is **17.567,53 t CO_2eq/year**





3.2. METHANE EMISSIONS FROM FERTILIZER MANAGEMENT

The term “fertilizer” is jointly used for feces and urine (solid and liquid matters) derived from animals. The breakdown of fertilizers under anaerobic conditions (in absence of oxygen), during storage and processing, produces methane. These conditions are most common when many animals are in a small closed space (farms for dairy cows, facilities for cattle fattening, poultry and pig farms) and in case of liquid system of fertilization. The main factors that have an impact on methane emissions are the quantity of produced fertilizer and the part of the fertilizer that breaks down anaerobically. The quantity of fertilizer depends on the rate of fertilizer production per animal and on the number of animals, and the anaerobic breakdown depends on the system of fertilizer management. When the fertilizer is stored and processed as liquid (lagoons, ponds, pit etc.), anaerobic breakdown occurs, and formation of significant quantities of methane. The temperature and the time period of storage of the fertilizer have considerable influence on the produced quantity of methane. When the fertilizer is processed in solid state (piles) or when it is spread in pastures, it is prone to aerobic breakdown and produces much smaller quantities of methane.

For the purpose of calculation of the emissions, a simple method was used, that requires data about the population of domestic animals according to animal type/category and the climate region or temperature in combination with standard emission factors according to IPCC. Considering that some of the emissions that originate from fertilizers are especially sensitive to temperature differences, what is considered as a good practice is the performance of an assessment of average annual temperature at the locations of the fertilizer.

The calculation of the emissions from fertilizer management is performed in the following steps: Step 1: Collection of data about the population from the characterization of the population of domestic animals;

Step 2: Application of standard values or development of emission factors specific for the country for each subcategory of animals expressed in kilograms of methane per animal per year;

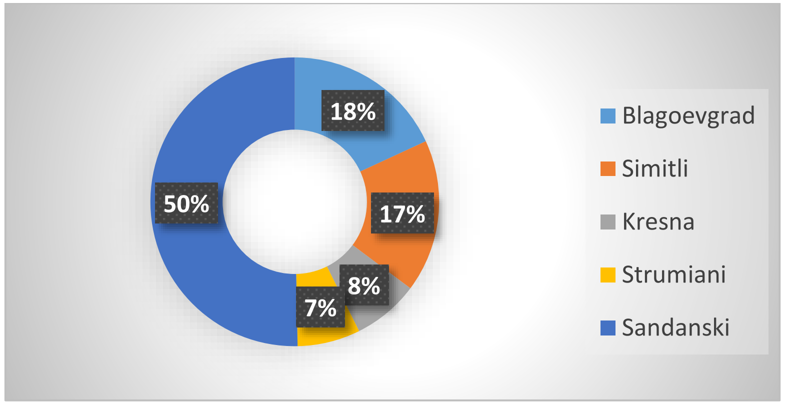
Step 3: Multiplication of the emission factors from the subcategories of animals with the population of the same subcategory of animals;

Step 4: Collection of all emissions from all subcategories of animals in order to obtain the total value of emissions from all types of domestic animals.

Table 14. Methane emissions from fertilizer management in the Municipalities in Bulgaria

Municipality		BLAGOEVGRAD		SIMITLI		KRESNA		STRUMIANI		SANDANSKI		TOTAL	
Type of animal	Emission factor for enteric fermentatio	Number of animals	Methane emissions	Number of animals	Methane emissions	Number of animals	Methane emissions	Number of animals	Methane emissions	Number of animals	Methane emissions	Number of animals	Methane emissions
Unit	kg/head/y	No.	(tons/y)	No.	(tons/y)	No.	(tons/y)	No.	(tons/y)	No	(tons/y)	No.	(tons/y)
Dairy cattle Cows	15,00	0	0,00	911	13,67	20	0,30	0	0,00	0	0,00	931	13,97
Cattle that does not produce milk	8,00	3.639	29,11	1.794	14,35	1.321	10,57	1.401	11,21	10.583	84,66	18.738	149,90
Sheep	0,19	7.113	1,35	8.186	1,56	6.100	1,16	4.442	0,84	12.834	2,44	38.675	7,35
Goats	0,10	2.632	0,26	4.659	0,47	3.000	0,30	2.684	0,27	4.800	0,48	17.775	1,78
Horses	1,56	76	0,12	76	0,12	120	0,19	27	0,04	319	0,50	618	0,96
Mules and donkeys	0,76	0	0,00	0	0,00	700	0,53	0	0,00	0	0,00	700	0,53
Pigs	3,00	388	1,16	22	0,07	30	0,09	28	0,08	288	0,86	756	2,27
Poultry	0,03	0	0,00	911	0,03	20	0,00	0	0,00	0	0,00	931	0,03
Total emmisions:			32,01		30,25		13,14		12,45		88,94		176,79
Total CO2 eq (t/y):			672,19		635,25		275,87		261,38		1.867,83		3.712,52

Manure management emissions of CH_4 for 2016 calculated based on the answers in the questionaries' are 176,79 t CH_4/year, or 3.172,52 t CO_2e/year



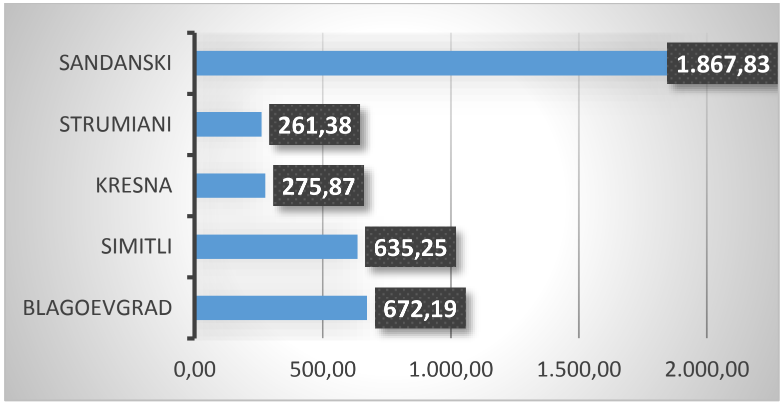
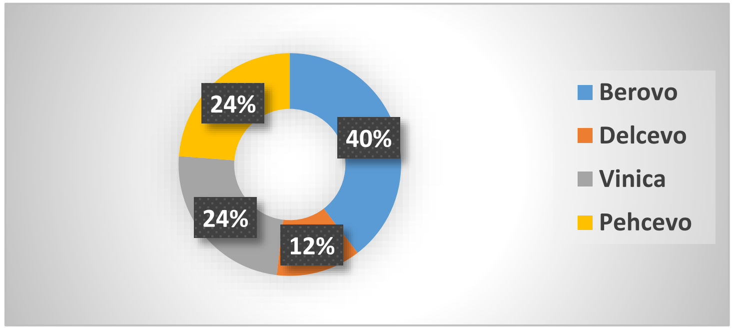
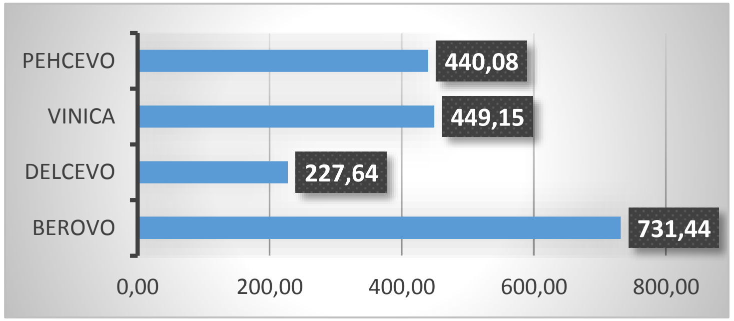


Table 15. Methane emissions from fertilizer management in the Municipalities in Macedonia

Municipality		**BEROVO**		**DELCEVO**		**VINICA**		**PEHCEVO**		**TOTAL**	
Type of animal	Emission factor for enteric fermentatio	Number of animals	Methane emissions	Number of animals	Methane emissions	Number of animals	Methane emissions	Number of animals	Methane emissions	Number of animals	Methane emissions
Unit	kg/head/y	No.	(tons/y)	No.	(tons/y)	No.	(tons/y)	No.	(tons/y)	No.	(tons/y)
Dairy cattle Cows	8,10	1.063	8,61	1.200	9,72	560	4,54	1.500	12,15	4.323	35,02
Cattle that does not produce milk	5,60	1.127	6,31	200	1,12	1.320	7,39	500	2,80	3.147	17,62
Sheep	0,50	26.226	13,11	0	0,00	9.560	4,78	9.900	4,95	45.686	22,84
Goats	0,50	3.379	1,69	0	0,00	3.800	1,90	150	0,08	7.329	3,66
Horses	1,80	617	1,11	0	0,00	530	0,95	35	0,06	1.182	2,13
Mules and donkeys	0,76	0	0,00	0	0,00	0	0,00	0	0,00	0	0,00
Pigs	1,00	3.623	3,62	0	0,00	1.280	1,28	900	0,90	5.803	5,80
Poultry	0,03	12.422	0,37	0	0,00	18.200	0,55	600	0,02	31.222	0,94
Total emmisions:			34,83		10,84		21,39		20,96		88,01
Total CO2 eq (t/y):			**731,44**		**227,64**		**449,15**		**440,08**		**1.848,30**

Methane emissions from fertilizer management for 2016 in the Municipalities in Macedonia are 88,01 tons, or **1.848,30 tons of CO2-eq.**





3.3. GREENHOUSE GAS EMISSIONS FROM BURNING OF CROPS

The burning of the remaining biomass from agricultural activities leads to emissions of CO2. These practices are common in the rural areas in Macedonia. However, these emissions of CO2 will be again absorbed during growth of crops in the next season, for this reason these emissions are not included in the net emissions in the municipal greenhouse gas inventory. However, during this burning process, due to the incomplete combustion, also other direct and indirect gasses are emitted: CO, N2O, CH4 and NOx.

The activity rate has been obtained in cooperation with Municipalities that are partner & beneficiaries in this project. The emission factors of the crops are taken from the Revised IPCC guidebooks, while the assumptions for the fraction of burned residues from the total number of residues have been made according to the IPCC Guidebook for good practices.

Table 16. Agricultural areas in the Municipalities in Bulgaria

Grains	Blagoevgrad	Simitli	Kresna	Strumiani	Sandanski	Total
Wheat (ha)	4200	90	8255	380	4000	**16925**
Maize (ha)	400	50	1450	330	200	**2430**
Barley (ha)	300	n/a	4184	165	150	**4799**
Rice (ha)	n/a	n/a	0	170	0	**170**
Other grains (ha)	2700	n/a	2870	430	650	**6650**
Total	7600		**16 759**	**1475**	**5000**	**14075**

Area of industrial crops	Blagoevgrad	Simitli	Kresna	Strumiani	Sandanski	Total
Soybean (ha)	/	/	/	/	/	**/**
Sunflower (ha)	/	/	/	/	/	**/**
Oilseed rape (ha)	2200	/	/	/	150	**2350**
Tobacco (ha)	/	50	35	90	25,5	**200,5**
Sugar beet (ha)	/	/	/	/	/	**/**
Other industrial crops (ha)	/	/	165	6	/	**171**
Total (ha)	2200	50	**200**	**96**	**25,5**	**2571,5**

Area of forage crops	Blagoevgrad	Simitli	Kresna	Strumiani	Sandanski	Total
Fodder beet (ha)	/	/	9	/	4	**13**
Alfalfa (ha)	/	/	257	15	148	**420**
Clover (ha)	/	/	/	/	0	**0**
Maize for green mass (ha)	/	/	/	/	0	**0**
forage mixtures (ha)	/	/	/	/	13	**13**
Other forage crops (ha)	/	/	274	10	17	**301**
Total:	/	/	**540**	**25**	**165**	**730**

Table 17. Quantity of direct and indirect greenhouse gas emission in incomplete combustion of the residues from the agricultural crops in Municipalities in Bulgaria

Greenhouse gas (tons)	Blagoevgrad	Simitli	Kresna	Strumiani	Sandanski	TOTAL
CH_4 in CO2e	1.02	0.21	1.8	0.21	0,42	**3,66**
CO	588	11.4	1049	95	311	**2.054,40**
N_2O in CO2e	21.7	3.1	3.1	3.1	9.3	**40,30**
Total	**610.72**	**14.71**	**1053.9**	**98.31**	**320.7**	**2.098,36**

Total emissions from incomplete combustion of the residues are **2.098,36 tCO2eq/y**

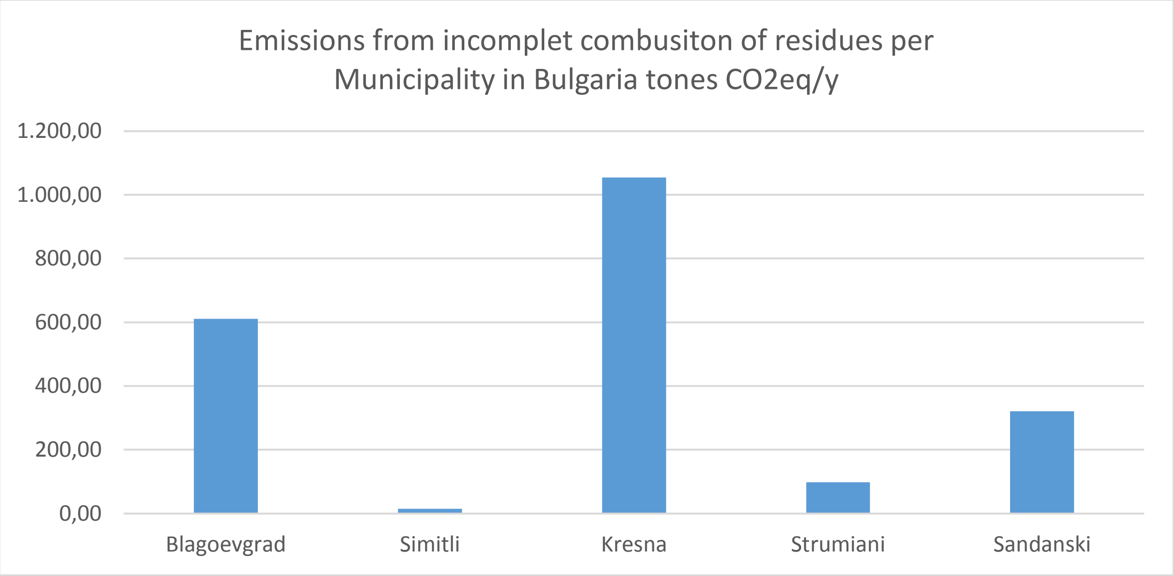


Table 18. Agricultural areas in the Municipalities in Macedonia

Grains	Berovo	Delcevo	Vinica	Pehcevo	Total
Wheat (ha)	385	8255	380	2650	**11670**
Maize (ha)	106	1450	330	20	**1906**
Barley (ha)	135	4184	165	150	**4634**
Rice (ha)	0	0	170	0	**170**
Other grains (ha)	1190	2870	430	340	**4830**
Total	1816	**16 759**	**1475**	**3160**	**23210**

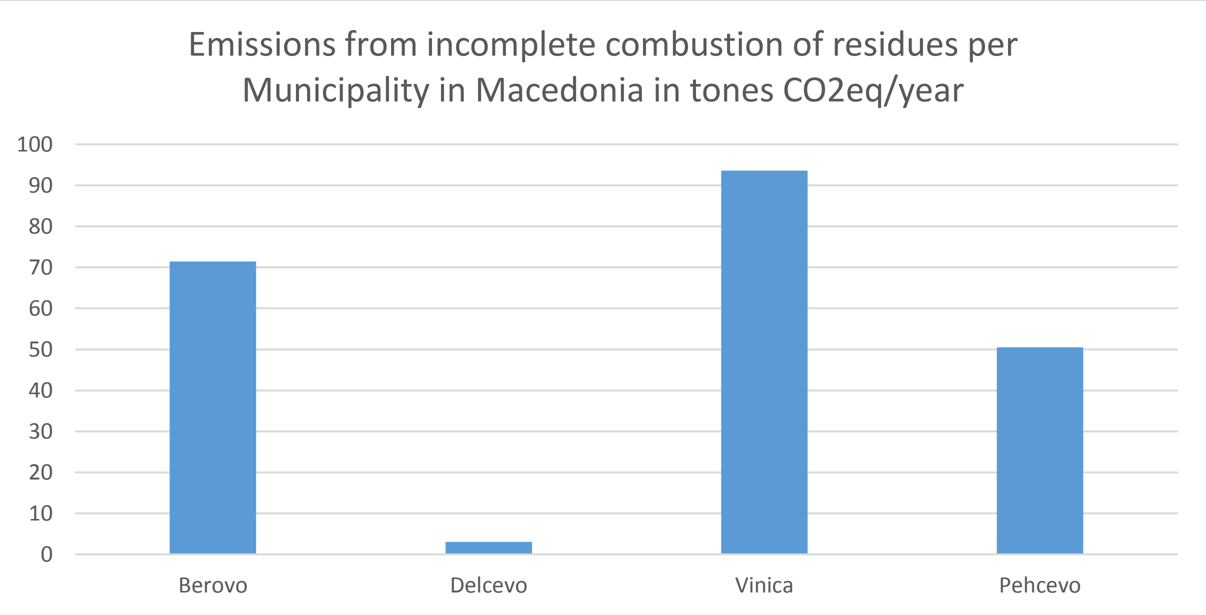
Area of industrial crops	Berovo	Delcevo	Vinica	Pehcevo	Total
Soybean (ha)	0	/	/	/	**0**
Sunflower (ha)	0	/	/	/	**0**
Oilseed rape (ha)	0	/	/	/	**0**
Tobacco (ha)	51	35	90	25,5	**201,5**
Potato (ha)	1050	/	/	/	**1050**
Other industrial crops (ha)	0	165	6	/	**171**
Total (ha)	1101	**200**	**96**	**25,5**	**1422,5**

Area of forage crops	Berovo	Delcevo	Vinica	Pehcevo	Total
Fodder beet (ha)	6	9	/	4	**19**
Alfalfa (ha)	178	257	15	148	**598**
Clover (ha)	0	/	/	0	**0**
Maize for green mass (ha)	0	/	/	0	**0**
forage mixtures (ha)	5	/	/	13	**18**
Other forage crops (ha)	0	274	10	17	**301**
Total:	189	**540**	**25**	**165**	**919**

Table 19. Quantity of direct and indirect greenhouse gas emission in incomplete combustion of the residues from the agricultural crops in Municipalities in Macedonia

Greenhouse gas (tons)	Berovo	Delcevo	Vinica	Pehcevo	TOTAL
CH_4	0,85	0,04	1,32	0,71	2,92
CO	70,56	3,03	92,23	49,76	215,58
N_2O	0,06	0	0,09	0,05	0,2
Total	71,47	3,07	93,64	50,52	218,7

Total emissions from incomplete combustion of the residues are **218.72 tCO2eq/y**



4. SECTOR: WASTE

4.1. METHANE EMISSIONS FROM SOLID WASTE LANDFILLS

The values of the correction factor for calculation of the methane emissions are taken from the Revised IPCC guidebooks for inventory preparation and they comply with the methodology which is used for calculation of the national greenhouse gas emissions.

Table 21. Values of the correction factor for calculation of the methane emissions

Landfill type	Waste ratio (by weight) in a landfill	Correction factor for methane	Measured average correction factor for each type of landfill
Managed Landfill	0,283	1	0,28
Unmanaged deep >=5m waste	0,318	0,8	0,26
Unmanaged deep < 5m waste	0,4	0,4	0,16
Total	***1***	***0,6***	***0,70***

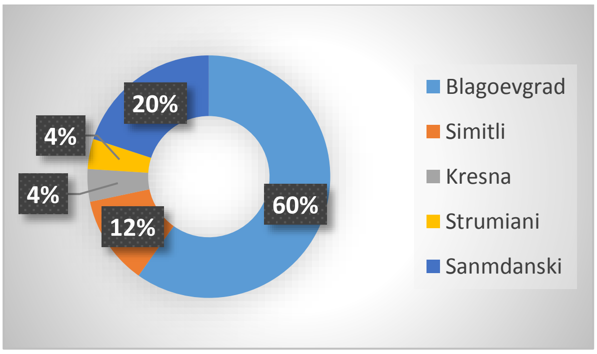
The key parameter in the determination of the total methane emissions from the landfills, is the value of the degradable organic carbon and it directly depends on the different fractions of waste that is being disposed on the landfills. The values of these fractions are taken from the revised IPCC guidebooks, whereby this value is calculated and it is equal to 19,23%. The methane emissions in one year are calculated according to the equation: CH_4 emitted in the year (kt/year) = [CH_4 generated in the year – R(ton)] •(1-OX) Where: R – methane that has been reused, OX – oxidation factor. In these calculations, R and OX are taken with a value of 0.

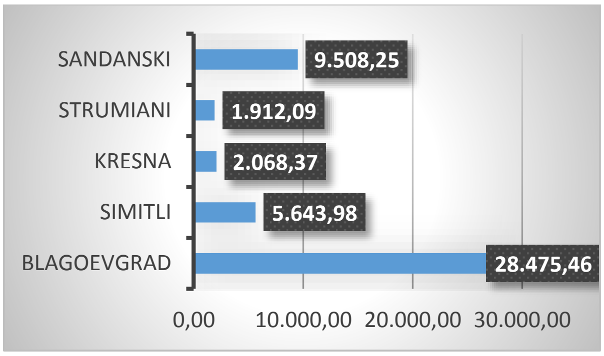
Treatment like disposal of municipal, industrial and other solid waste produces significant amounts of methane (CH4). CH4 produced at SWDS contributes approximately 3 to 4 percent to the annual global anthropogenic greenhouse gas emissions (IPCC 2001). The major greenhouse gas emissions from Waste sector are CH4, CO2 and N2O. The methodology used to estimate emissions from waste management activities requires country-specific knowledge on waste generation, composition and management practice. The main parameters that influence the estimation of the emissions from landfills, apart from the amount of the disposed waste, are: the waste composition, fraction of methane in landfill gas and amount of landfill gas that is collected and treated. These parameters are strictly dependent on the waste management policies throughout the waste streams which start from waste generation through collection and transportation, separation for resource recovery, recycling and energy recovery and terminate at landfill sites. The improvements of quality and quantity of data are visible in last couple of years. Effort was done in order to evaluate and compile data coming from different sources and adjust them to recommended IPCC methodology which is used for GHGs emissions estimation. At present in this enventarization are used country specific data like amount of waste generated per capita, where they are available. Default values are used when such data are not available. Emissions from solid waste disposal on land have been calculated using the First Order Decay (FOD) method, the IPCC Tier 2 method given in the 2006 IPCC Guidelines.

Table 20. Methane emission from solid waste landfills in the Municipalities from Bulgaria

Municipality	Population	Waste generation rate kg/person/day	Annual quantity of generated communal waste (kilotons of municipal waste	Fraction of MSW disposed	Waste disposed at landfills	Emission factor per capita/annually kg CH4	Emission of CH4 in t/y	Emission in t CO2eq/yearly
Blagoevgrad	77440	1,21	34.201,38	0,694	19.616,33	17,51	1.355,97	28.475,46
Simitli	15349	1,21	6.778,89	0,694	3.888,06	17,51	268,76	5.643,98
Kresna	5625	1,21	2.484,28	0,694	1.424,87	17,51	98,49	2.068,37
Strumiani	5200	1,21	2.296,58	0,694	1.317,21	17,51	91,05	1.912,09
Sanmdanski	25858	1,21	11.420,19	0,694	6.550,09	17,51	452,77	9.508,25
Total	**129472**		**57.181,31**		**32.796,55**		**2.267,05**	**47.608,15**

The total emissions from landfills in the five municipalities in the project area are 2.267,05 CH4 t/year or **47.608,15 t CO2eq/year**



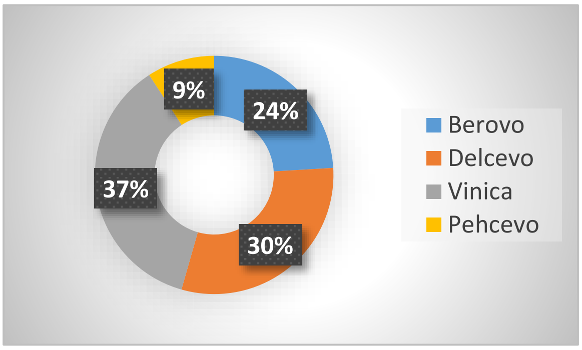


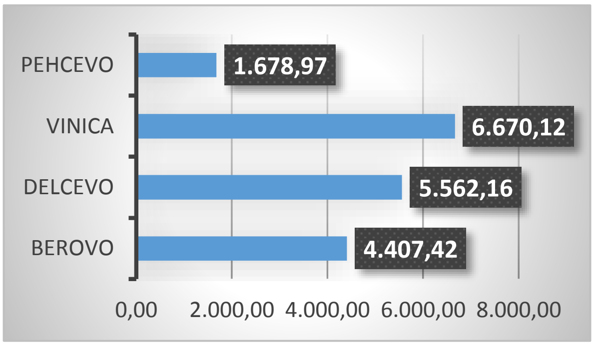
In Republic of Macedonia it is very difficult to find historical data about the quantity of solid waste at local level. In the absence of such data, in order to calculate the emissions of waste generated in the municipality, it is necessary to use indicators (population, economic growth etc.). The most important data for this calculation is the number of population in the municipalities.

Table 21. Methane emission from solid waste landfills in the Municipalities from Macedonia

Municipality	Population	Waste generation rate kg/person/day	Annual quantity of generated communal waste (kilotons of municipal waste	Fraction of MSW disposed	Waste disposed at landfills	Emission factor per capita/annually kg CH4	Emission of CH4 in t/y	Emission in t CO2eq/yearly
Berovo	12813	0,86	4.022,00	0,93	4.349,37	16,38	209,88	4.407,42
Delcevo	16170	0,86	5.075,76	0,93	5.488,91	16,38	264,86	5.562,16
Vinica	19391	0,86	6.086,83	0,93	6.582,27	16,38	317,62	6.670,12
Pehcevo	4881	0,86	1.532,15	0,93	1.656,86	16,38	79,95	1.678,97
Total	53255		16.716,74		18.077,41		872,32	18.318,65

The methane emission from the landfills in the project municipalities in Macedonia is 872,32 tones/y CH4, or that is 18.318,65 tons of CO_2-eq/y, if it is multiplied with the appropriate potential for global warming.





4.2. METHANE EMISSIONS FROM RESIDENTIAL/ COMMERCIAL ORGANIC WASTEWATER AND SLUDGE

Wastewater can be an important source of methane. Sewers can be open or closed. Usually in urban areas they are closed and underground and they can have purification systems. These types of sewers are not important methane emitters unlike open systems which are present in rural areas. For this reason, it is important for municipal inventories to calculate the methane emission from organic wastewaters. Methane emissions directly depend on the degradable organic matter in water and they increase with the growth of temperature. The basic parameter for calculation of the content of organic matter is the biochemical oxygen demand (BOD). The concentration of BOD represents a quantity of carbon that is aerobically degradable. Standard measurement of BOD includes testing of the sample within 5 days. This value has been taken as a standard parameter from the Revised IPCC guidebooks.

This sector includes CH_4 emissions from wastewater when treated or disposed anaerobically and indirect N_2O emissions as the CO_2 emissions from wastewater are not considered in the 2006 IPCC Guidelines. For Bulgaria according to NSI data, domestic wastewater has been treated in centralized aerobic treatment plants, septic systems, latrines and discharged into water bodies (sea, river, lakes). In 2015 about 62.3 % of the population is connected to centralized aerobic treatment plants, 13.2 % is connected to the public sewerage, but without treatment (sea, river, lake) and 24.5 % of the country population use septic systems and latrines.

The methodology for the calculation of the methane emissions from domestic wastewater handling consists of three components: 1) definition of the total organically degradable material in domestic wastewater (TOW); 2) definition of emission factor for each domestic wastewater treatment/discharge pathway or system and 3) emission estimation. The first step in the calculations is to define the total organically degradable material in domestic wastewater (TOW), which is the AD for this source category. TOW is expressed in the term of biochemical oxygen demand (kg BOD/year). Based on the demographic data acquired by the National Statistical Institute for the respective inventory years, we calculate TOW with the following equation:

$TOW = P \bullet BOD \bullet 0.001 \bullet I \bullet 365$

Where:

- TOW – total organics in the wastewater in inventory year, kg BOD/yr
- P – Municipality population in inventory year
- BOD – country specific per capita BOD in inventory year, g/person/day
- Default value = 60 g/person/day
    - - conversion from grams BOD to kg BOD
- I - correction factor for additional industrial BOD discharged into sewers (for collected the default is 1.25, used in calculations)

The next step of the calculation is to define the Emission factor.

The emission factor for wastewater treatment and discharge pathway and system is a function of the maximum CH_4 producing potential (Bo) and methane correction factor (MCF) for wastewater treatment and discharge system.

The Equation for calculation of EF is: $\boldsymbol{EFj = B0 \bullet MCFj}$

Where:

- EFj – emission factor, kg CH_4/kg BOD
- j – each treatment/discharge pathway or system
- Bo – maximum CH_4 producing capacity, kg CH_4/kg BOD
- $MCFj$– methane correction factor (fraction)
- 2006 IPCC Guidelines provides the default value for domestic wastewater:
- Bo = 0,60 kg CH_4 /kg BOD

The first step for the definition of MCF is to characterize the systems for wastewater treatment in the municipality.

a) waters without treatment discharged in the water sources (sea, rivers and lakes) MCF = 0.1

b) waters discharged trough sewer system into centralized aerobic wastewater treatment plant – MCF = 0.3

c) waters treated in septic systems – MCF = 0.5

d) waters treated in latrines – MCF =0.1

After determination of TOW, wastewater treatment systems and discharge pathways and respective MCF, we can calculate the CH4 emissions from domestic wastewater as follows:

$CH4\ Emissions$= [Σ(Ui•Ti,j•EFj)i,j](TOW−S)−R

Where:

- CH4 emissions – CH4 emissions in inventory year, kg CH4/yr
- TOW – total organics in wastewater in inventory year, kg BOD/yr
- S – organic component removed as sludge in inventory year, kg BOD/yr
- R – amount of CH4 recovered in inventory year, kg CH4/yr
- Ui – fraction of population in income group i in inventory year
- Ti,j – degree of utilization of treatment/discharge pathway or system, j, for each income group fraction i in inventory year
- i – income group: rural, urban high income and urban low income
- j – each treatment/discharge pathway or system
- EF – emission factor, kg CH4/yr

Table 22. Methane emission from wastewater in the Municipalities from Bulgaria

Municipality	**Population**	**Average residential wastewater per capita (t/yr.)**	**TOW (t BOD/yr)**	**Emission factors (kg CH4/t BOD)**	**Emissions CH4 t/year**	**Emission in t CO2eq/yr.**
Blagoevgrad	77441	27,35	2118011,35	0,18	381,24	8.006,08
Simitli	15349	27,35	419795,15	0,06	25,19	528,94
Kresna	5625	27,35	153843,75	0,06	9,23	193,84
Strumiani	5200	27,35	142220	0,06	8,53	179,20
Sandanski	25585	27,35	699749,75	0,06	41,98	881,68
Total	**129200**		**3533620**		**466,18**	**9.789,75**

The total emissions CH4 from wastewaters in the project area are 466.18 CH4 t/yr or **9.789,75 CO2eq t/yr**

Table 23. Methane emission from wastewater in the Municipalities from Macedonia

Municipality	Population	Average residential wastewater per capita (t/yr.)	TOW (t BOD/yr)	Emission factors (kg CH4/t BOD)	Emission s CH4 t/year	Emission in t CO2eq/yr.
Berovo	12813	18,25	233837,25	0,06	14,61	306,91
Delcevo	16170	18,25	295102,5	0,06	18,44	387,32
Vinica	19391	18,25	353885,75	0,06	22,12	464,48
Pehcevo	4881	18,25	89078,25	0,06	5,57	116,92
Вкупно	**53255**		**971903,75**		**60,74**	**1.275,62**

The methane emission from wastewater for the municipalities in Macedonia is 60,74 tons/yr., that is, **1.275,62 tons of CO_2-eq/yr.** if it is multiplied with the appropriate potential for global warming.

4.3. NITROUS OXIDE EMISSIONS FROM SEWERS

The nitrous oxide (N2O) is a consequence of the breakdown of nitrous components in wastewater, such as urea, nitrates and proteins. The residential wastewater includes sewerage mixed with another type of wastewater such as water from washing machines, water that is used in agriculture etc. This water is mostly discharged in larger body of water (such as a river, a lake).

Direct emissions of nitrous oxide are generated by two processes: nitrification and denitrification of the nitrogen that is present in the compound where nitrous oxide is an intermediate product and in both processes. In order to calculate these emissions, the key data is the consumption of proteins per capita, which is taken from the database of FAOSAT for Macedonia and Bulgaria it has a value of 27,92 kg/resident/year.

For estimation of N2O from domestic wastewater effluent, 2006 IPCC Guidelines suggest a single methodology for calculations with no higher TIERS and decision tree provided. Nitrous oxide emissions can occur as direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into waterways, lakes or the sea. This section addresses indirect N2O emissions from wastewater treatment effluent that is discharged into aquatic environments. 2006 IPCC Guidelines suggests a methodology for calculation of N2O emissions.

The calculations of the emissions follow the general equation

Equation

N2O Emissions = *N Effuent* ● *EF Effluent* ●44/28,

Where:

- N2O emissions - N2O emissions in inventory year, kg N2O/yr
- N Effluent - nitrogen in the effluent discharged to aquatic environments, kg N/yr
- EF *Effluent* - emission factor for N2O emissions from discharged to wastewater, kg N2O-N/kg N
- The factor 44/28 is the conversion of kg N2O-N into kg N2O.

Choice of emission factors

The default IPCC emission factor for N2O emissions from domestic wastewater nitrogen effluent is 0.005 (0.0005-0.25) kg N2O-N/kg N.

Choice of Activity data

The activity data that are needed for estimating N2O emissions are nitrogen content in the wastewater effluent, country population and average annual per capita protein generation (kg/person/yr). Per capita protein generation consists of intake (consumption) of protein, available at FAO statistics, multiplied by factors to account for additional “non-consumed” protein and for industrial protein discharged into the sewer system. The total nitrogen in the effluent is estimated, using equation 6.8 (p. 6.25) :

Equation

N *Effluent* = (P ● Protein ● F *NPR* ● F *NON-CON* ● F *IND-COM*) - N sludge,

Where:

- N *Efflent* - total annual amount of nitrogen of the wastewater effluent, kg N/yr
- P- human population (municipality specific)
- Protein - annual per capita protein consumption, kg/person/yr
- F *NPR* – fraction of nitrogen in protein, default = 0.16 kg N/kg protein
- F *NON- CON – factor for none-consumed protein added to the wastewater (1.4)*
- *F IND-COM – factor for industrial and commercial co-discharged protein into the sewer system (1.26)*
- *N Sludge – nitrogen removed with sludge (default = zero), kg N/yr*

Based on this methodolgy are calculated the emissions of NO2 from wastewaters in the five municipalities that are in the project area.

Table 24. Nitrous oxide emissions from sewerage in the municipalities in Bulgaria

Municipality	Population	Protein consumed (protein kg/man/year)	FracNPR (kgN/kg protein)	N Efflent - total annual amount of nitrogen of the wastewater effluent, (kg N/yr)	Emission Factor EF6 (кг N2O-N/кг канал.-N)	Emissions N2O (t/y)	Emission in t CO2eq/ yr.
Blagoevgrad	77441	27,92	0,16	345.944,44	0,0157	5,43	1.683,71
Simitli	15349	27,92	0,16	68.567,05	0,0157	1,08	333,72
Kresna	5625	27,92	0,16	25.128,00	0,0157	0,39	122,30
Strumiani	5200	27,92	0,16	23.229,44	0,0157	0,36	113,06
Sandanski	25585	27,92	0,16	114.293,31	0,0157	1,79	556,27
Total	129200			577.162,24		9,06	2.809,05

The total emissions NO2 from wastewaters in the five municipalities in the project area are 9,06 N_2O t/year or **2.809,05 CO_2-eq t/year**

Table 25. Nitrous oxide emissions from sewerage in the municipalities in Macedonia

Municipality	Population	Protein consumed (protein kg/man/year)	FracNPR (kgN/kg protein)	N Efflent - total annual amount of nitrogen of the wastewater effluent, (kg N/yr)	Emission Factor EF6 (кг N2O-N/кг канал.-N)	Emissions N2O (t/y)	Emission in t CO2eq/ yr.
Berovo	12813	27,92	0,16	57.238,23	0,0157	0,90	278,58
Delcevo	16170	27,92	0,16	72.234,62	0,0157	1,13	351,57
Vinica	19391	27,92	0,16	86.623,48	0,0157	1,36	421,60
Pehcevo	4881	27,92	0,16	21.804,40	0,0157	0,34	106,12
Total	53255			237.900,74		3,74	1.157,86

The nitrous oxide emissions are 3,74 tons of N_2O yr. Taking into consideration the potential of global warming of nitrous oxide, it results that emissions calculated as CO_2-eq. are **1.157,86** tons of CO_2-eq/yr.

5. SECTOR: FORESTRY

Forests are natural dump of carbon dioxide, through the process of photosynthesis. The process of removal of carbon dioxide from the atmosphere is known as sequestration of carbon dioxide. In order to calculate the emissions, that is, the deposition of carbon dioxide in forests, it is necessary to perform measurements of many years of the annual changes in the forests (growth rate of the biomass, forest logging, diseases of the trees etc.)

For defining forest, Bulgaria uses the definition in the Bulgarian Forest Act (last amendment 07.08.2012, SG №60):

“***Area over 0.1 ha, covered with forest tree species higher than 5 meters and tree crown cover over 10% or with trees which can reach these parameters in natural environment***”.

Areas of natural forest regeneration outside urban areas with a size of more than 0.1 ha also represent “forest”. City parks with trees, forest shelter belts, and single row trees do not fall under the category “forests. According to their functions, forests are divided into: forests for timber production, protective and recreation forests and forests in protected areas.

Forests are also: areas which are in a process of recovering and are still under the parameters, but it is expected to reach forest crown cover over 10% and tree height 5 meters; areas, which as the result of anthropogenic factors or natural reasons are temporarily deforested, but will be reforested; protective forest belts, as well as tree lines with an area over 0.1 ha and width over 10 meters; cork oak stands. All forests in Bulgaria are managed.

The evaluation of the emissions/removals from Forest land is made In accordance with the IPCC Guidelines. The total area cover with forest in the area of interest is 119 318 ha. as the biggest area is occupied by Dediduous forest.

Table 26. Forestry in the municipalities in Bulgaria

	Total area in ha.	Deciduous forest in ha	Coniferous forest in ha.	Removals т CO2e
Blagoevgrad	23309	12897	10412	69338
Simitli	32400	19705	12695	96422
Kresna	20455	10817	9638	60837
Strumiani	21015	n/a	n/a	62505
Sandanski	22139	13486	8653	65842
Total	**119318**	**56905**	**41398**	**354944**

In total the project area has absorption capacity of **354.944 thousands CO2 t/year.**

Due to the non-existence of such research in the preparation of the municipal greenhouse gas inventory, an approximate calculation of the forest dumps has been made before 2016. The total coverage with forest in four municipalities is 84.815,37 ha high-quality forest wealth. The vegetation in the region is mostly represented by grassland and forest communities. In terms of vegetation, most of the area in four municipalities is covered with deciduous (71%), coniferous (10%) and mixed forests (19%). In the source area of Bregalnica River there are dense natural complexes of beech, pine and fir forests, which is a rarety for the Eastern part of Macedonia. The data about the surface and the type of forests are shown in Table 27.

Table 27. Review of the forest areas in the municipalities in Macedonia

	Total area in ha.	**Deciduous forest in ha**	**Coniferous forest in ha.**	**Mixed forest in ha.**	**Removals (sinks) t CO2e**
Berovo	27000	n/a	n/a	n/a	85224,47
Delcevo	27899	24200	3699	n/a	97276,67
Vinica	21702,5	12032	1255	8415	62538,21
Pehcevo	8255,88	4944	741	2570,88	26059,37
Total	**84857,38**	**43985,77**	**6410,91**	**11549,01**	**271098,7**

The values of the annual growth rate of forests and the factors of absorption are taken from the Revised IPCC guidebooks for inventory preparation. The absorption of carbon dioxide from the forests in the municipalities in Macedonia is **198.780,40 tons of CO_2/yr.**

OVERVIEW OF THE GHG EMISSIONS

Table 28. Overview of the GHG emission of the municipalities in Bulgaria

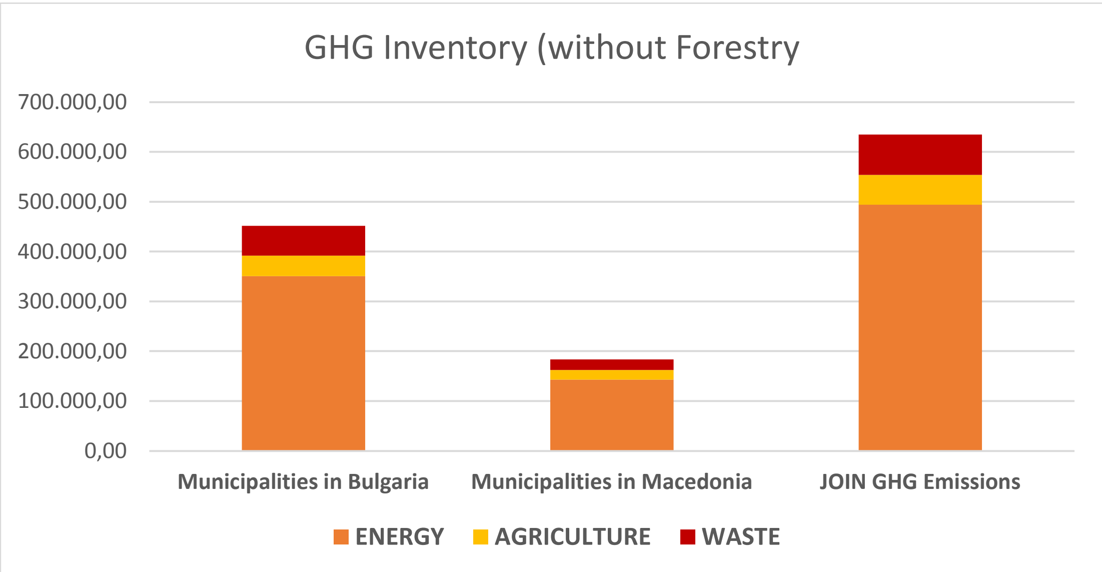
MUNICIPALITY	BLAGOEVGRAD		SIMITLI		KRESNA		STRUMIANI		SANDANSKI		TOTAL	
SECTOR	t CO_2 eq/yearly	%	t CO2 eq/yearly	%	t CO2 eq/yearly	%	t CO2 eq/yearly	%	t CO2 eq/yearly	%	**t CO2 eq/yearly**	**%**
ENERGY												
Electricity for households, public institutions, business entities	117.076,05	44,42%	n/a	n/a	n/a	n/a	n/a	n/a	57.633,03	46,85%	**174.709,08**	**38,67%**
Heating households, public Institution, business Entities	38.152,31	14,48%	11.606,82	28,60%	n/a	n/a	n/a	n/a	10.799,10	8,78%	**60.558,23**	**13,41%**
Transport and mobility	62.741,49	82,70%	15.628,73	38,51%	6.249,37	47,07%	5.960,19	52,68%	25.035,74	20,35%	**115.615,51**	**25,59%**
TOTAL ENERGY:	**217.969,85**	**82,70%**	**27.235,55**	**67,11%**	**6.249,37**	**47,07%**	**5.960,19**	**52,68%**	**93.467,87**	**75,98%**	**350.882,82**	**77,67%**
AGRICULTURE												
Methane emissions from enteric fermentation	6.144,08	2,33%	6.191,59	15,26%	3.312,49	24,95%	2.790,54	24,66%	16.406,75	13,34%	**34.845,45**	**7,71%**
Methane emissions from fertilizer management	672,19	0,26%	635,25	1,57%	275,87	2,08%	261,38	2,31%	1.867,83	1,52%	**3.712,52**	**0,82%**
Greenhouse gas emissions from burning of crops	610,72	0,23%	14,71	0,04%	1.053,90	7,94%	98,31	0,87%	320,70	0,26%	**2.098,34**	**0,46%**
TOTAL AGRICULTRE:	**7.426,99**	**2,82%**	**6.841,55**	**16,86%**	**4.642,26**	**34,97%**	**3.150,23**	**27,84%**	**18.595,28**	**15,12%**	**40.656,31**	**9,00%**
WASTE												
Methane emissions from solid waste landfills	28.475,46	10,80%	5.643,98	13,91%	2.068,37	15,58%	1.912,09	16,90%	9.508,25	7,73%	**47.608,15**	**10,54%**
Methane emissions from residential/ commercial organic wastewater and sludge	8.006,08	3,04%	528,94	1,30%	193,84	1,46%	179,20	1,58%	881,68	0,72%	**9.789,75**	**2,17%**
Nitrous oxide emissions from sewers	1.683,71	0,64%	333,72	0,82%	122,30	0,92%	113,06	1,00%	556,27	0,45%	**2.809,05**	**0,62%**
TOTAL WASTE:	**38.165,26**	**14,48%**	**6.506,64**	**16,03%**	**2.384,51**	**17,96%**	**2.204,35**	**19,48%**	**10.946,20**	**8,90%**	**60.206,95**	**13,33%**
FORESTRY	**69.338,00**		**96.422,00**		**60.837,00**		**62.505,00**		**65.842,00**		**354.944,00**	
TOTAL (without Forestry)	**263.562,10**	**100%**	**40.583,74**	**100%**	**13.276,14**	**100%**	**11.314,77**	**100%**	**123.009,34**	**100%**	**451.746,08**	**100%**
Per Capita t CO2-eq/yr.	3,40		2,64		2,36		2,18		4,81		3,50	
TOTAL (including Forestry)	**194.224,10**		**- 55.838,26**		**- 47.560,86**		**- 51.190,23**		**57.167,34**		**96.802,08**	

Table 29. Overview of the GHG emission of the municipalities in Macedonia

MUNICIPALITY	BEROVO		DELCHEVO		VINICA		PEHCEVO		TOTAL	
SECTOR	t CO_2 eq/yearly	%	t CO2 eq/yearly	%	t CO2 eq/yearly	%	t CO2 eq/yearly	%	**t CO2 eq/yearly**	**%**
ENERGY										
Electricity for households, public institutions, business entities	21.325,69	51,34%	27.507,09	54,47%	40.858,97	55,29%	9.245,82	53,36%	**98.937,57**	**53,99%**
Heating households, public Institution, business Entities	n/a		n/a		n/a		n/a		**n/a**	
Transport and mobility	7.867,83	18,94%	14.185,41	28,09%	20.439,98	27,66%	1.443,09	8,33%	**43.936,31**	**23,97%**
TOTAL ENERGY:	**29.193,52**	**70,28%**	**41.692,50**	**82,56%**	**61.298,95**	**82,95%**	**10.688,91**	**61,69%**	**142.873,88**	**77,96%**
AGRICULTURE										
Methane emissions from enteric fermentation	6.551,35	15,77%	2.276,40	4,51%	4.498,59	6,09%	4.245,93	24,50%	**17.572,27**	**9,59%**
Methane emissions from fertilizer management	731,44	1,76%	227,64	0,45%	449,15	0,61%	440,08	2,54%	**1.848,30**	**1,01%**
Greenhouse gas emissions from burning of crops	71,47	0,17%	3,07	0,01%	93,64	0,13%	50,52	0,29%	**218,70**	**0,12%**
TOTAL AGRICULTRE	**7.354,26**	**17,70%**	**2.507,11**	**4,96%**	**5.041,37**	**6,82%**	**4.736,53**	**27,34%**	**19.639,27**	**10,72%**
WASTE										
Methane emissions from solid waste landfills	4.407,42	10,61%	5.562,16	11,01%	6.670,12	9,03%	1.678,97	9,69%	**18.318,65**	**10,00%**
Methane emissions from residential/ commercial organic wastewater and sludge	306,91	0,74%	387,32	0,77%	464,48	0,63%	116,92	0,67%	**1.275,62**	**0,70%**
Nitrous oxide emissions from sewers	278,58	0,67%	351,57	0,70%	421,60	0,57%	106,12	0,61%	**1.157,86**	**0,63%**
TOTAL WASTE	**4.992,91**	**12,02%**	**6.301,04**	**12,48%**	**7.556,19**	**10,23%**	**1.902,00**	**10,98%**	**20.752,14**	**11,32%**
FORESTRY	**85.224,47**		**97.276,67**		**62.538,21**	**84,63%**	**26.059,37**		**271.098,72**	
TOTAL (without Forestry)	**41.540,68**	**100%**	**50.500,65**	**100%**	**73.896,51**	**100%**	**17.327,44**	**100%**	**183.265,29**	**100%**
Per Capita t CO2-eq/yr.	3,24		3,12		3,81		3,55		3,44	
TOTAL (including Forestry)	**-43.683,79**		**-46.776,02**		**11.358,30**		**-8.731,93**		**-87.833,43**	

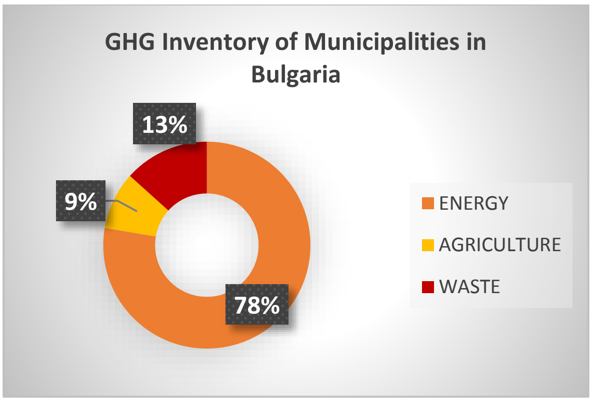
Table 30. Overview of the GHG emission of the municipalities in Macedonia

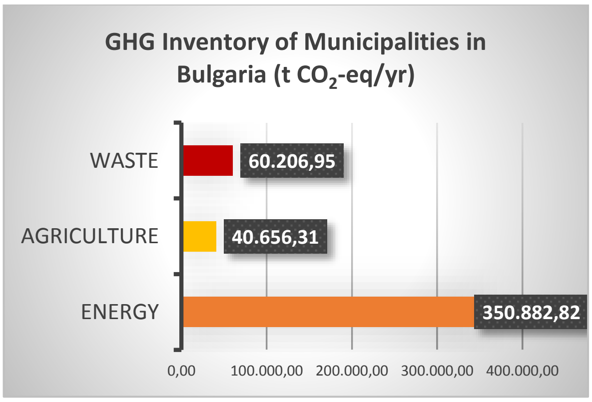
MUNICIPALITY	Municipalities in Bulgaria		Municipalities in Macedonia		JOIN GHG Emissions	
SECTOR	t CO2 eq/yearly	%	t CO2 eq/yearly	%	t CO2 eq/yearly	%
ENERGY						
Electricity for households, public institutions, business entities	174.709,08	38,67%	98.937,57	53,99%	273.646,65	43,09%
Heating households, public Institution, business Entities	60.558,23	13,41%	0,00		60.558,23	9,54%
Transport and mobility	115.615,51	25,59%	43.936,31	23,97%	159.551,82	25,13%
TOTAL ENERGY SECTOR:	350.882,82	77,67%	142.873,88	77,96%	493.756,70	77,76%
AGRICULTURE						
Methane emissions from enteric fermentation	34.845,45	7,71%	17.572,27	9,59%	52.417,72	8,25%
Methane emissions from fertilizer management	3.712,52	0,82%	1.848,30	1,01%	5.560,82	0,88%
Greenhouse gas emissions from burning of crops	2.098,34	0,46%	218,70	0,12%	2.317,04	0,36%
TOTAL AGRICULTRE	40.656,31	9,00%	19.639,27	10,72%	60.295,58	9,50%
						WASTE
Methane emissions from solid waste landfills	47.608,15	10,54%	18.318,65	10,00%	65.926,80	10,38%
Methane emissions from residential/ commercial organic wastewater and sludge	9.789,75	2,17%	1.275,62	0,70%	11.065,37	1,74%
Nitrous oxide emissions from sewers	2.809,05	0,62%	1.157,86	0,63%	3.966,91	0,62%
TOTAL WASTE	60.206,95	13,33%	20.752,14	11,32%	80.959,09	12,75%
FORESTRY	354.944,00		271.098,72		626.042,72	
TOTAL (without Forestry)	451.746,08	100,00%	183.265,29	100,00%	635.011,37	100,00%
TOTAL (including Forestry)	**96.802,08**		**-87.833,43**		**8.968,65**	



CONCLUSION

Over the past century, atmospheric concentrations of carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and hydrogenated hydrocarbons, i.e. greenhouse gases, have increased as a consequence of human activity. Greenhouse gases prevent the radiation of heat back to space and cause warming of the climate. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (AR4) (IPCC 2007)1, the atmospheric concentrations of CO2 have increased by 35%, CH4 concentrations have more than doubled and N2O concentration has risen by 18%, compared with the pre-industrial era. Changing climate has effects on both human and natural systems (e.g. human settlements, human health, water and food resources, ecosystem and biodiversity). Some of the effects on environmental and socio-economic systems will be beneficial, some damaging. The larger changes and the rate of changes in climate, the more adverse effects will predominate. In the examine area IN Bulgaria the adverse impacts are related, for example, the winter tourism, increased flooding and droughts and the prevalence of pests and diseases. Positive impacts could be possible growth of productivity in agriculture and forestry and decreased need for heating energy. According to the "Fifth National Communication of Bulgaria on Climate Change"2 from the year 2010 the average temperature in the country could rise. Extreme weather events, such as storms, droughts and heavy rains, are likely to increase. According to the HadCM33 model significant summer warming in the Western Balkan countries were projected for 2080. Air temperatures during this time of the year are expected to increase between 5°C and 8°C over most of the countries in the peninsula. Summer precipitation is projected to decrease in the region. Acknowledging the importance of the climate change issue is the reason for building of GHG inventories for local governments. The results from the Questionnaires and analyses of the data collected have shown the low level of information that the local governments possess about the sources of GHG emissions.

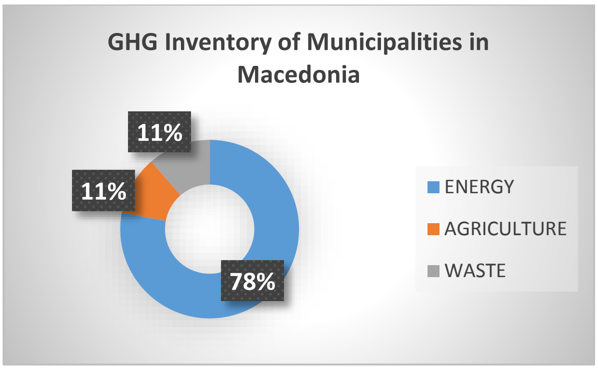


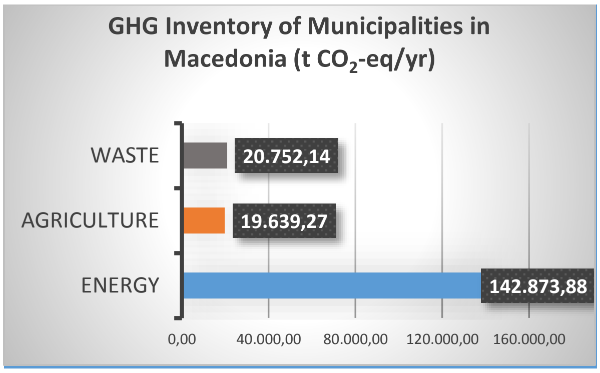


For Bulgarian Municipalities according the results of this research the total GHG emissions in CO2e are 451.746,08 tCO2eq/yr. The biggest source of GHG is the electricity consumption with total emissions of 174.709 tCO2eq/yr. As a second biggest source of GHG according the questionnaires are the emissions from road traffic which are 115.644 tCO2eq/yr., also substantial quantities of GHG are emitted by using coal for heating which produce 60.559 tCO2e.

Great source of GHG are the landfills in the five municipalities in the project area 2.251 CH4 t/year or 60.206 CO2eq t/year. The domestic wastewater handling is also a great source of GHG with the total emissions from wastewater in the project area equals 9.789 CO2e t/year. The sector of agriculture is also a contribute to the GHG emissions mainly due to etheric fermentation of the livestock. The Etheric emissions of CH4 for 2016 calculated based on the answers in the questionnaires are 40.565 t CO2e/year. Because of the absence of database about the electricity consumption and used fuel in the local communities, the municipality authorities did not filled this section of the questionnaires. This data were collected from local utilities providers. The data about the electricity consumption and the used fuels are associated only with the activities of the local authorities are also represented in this study but they have relatively small impact on the amount of the GHG. The average amount per capita **is 3,50 t CO2eq/yr.** for all five Municipalities.

Usually worldwide the sectors of electricity consumption's and road traffic are the biggest source of GHG, which turn out to be exactly the case in this research. Because of the local natural-geographic features like predominantly mountainous terrain in the area of interest the last one possess relatively good developed absorption capacity which is result of the broad area covered by forests. The total area cover with forest in the area of interest is 119 318 ha. As the biggest area is occupied by deciduous forest. They possess huge absorption capacity of 354.944 t CO2eq/year. Beside the great absorption capacity additional policy measures are highly needed to reduce the GHG emissions in the project area.





For Macedonian Municipalities according the results of this research the total GHG emissions in CO2e are 183.265,29 tCO2-eq/yr. The biggest source of GHG is coming from the Energy Sector (around 78%) and the main is the electricity consumption with total emissions of 98.937,57 t CO2eq/yr. As a second biggest source of GHG according the questionnaires are the emissions from road traffic which are 43.936,31 t CO2eq/yr., the GHG emissions from heating are not calculated because most of the objects (over 96%) use a biomass (wood) as an energy source.

The sector of agriculture is participating with 9,5% of total GHG Emissions, and that mainly due to etheric fermentation of the livestock. The Etheric emissions of CH4 for 2016 calculated based on the answers in the questionnaires are 19.639,27 t CO2eq/year.

Great source of GHG are also the landfills in the four municipalities in the project area with 12,75% share in all GHG Emissions of 20.752,14 t CO2-eq/year.

Same as in Bulgarian Mucipalities because of the local natural-geographic features like predominantly mountainous terrain in the area of interest the last one possess relatively good developed absorption capacity which is result of the broad area covered by forests. The total area cover with forest in the area of interest is 61.946,19 ha. As the biggest area is occupied by deciduous forest. They possess huge absorption capacity of 198.780,40 t CO2/yr, and causing negative rate of emission for all four municipalities for about -15.515,13 t CO2eq/yr., out of total GHG emission in amount of 183.265,29 t CO2-eq/yr. The average amount per capita for all four Municipalities is **3,44 t CO2eq/yr.**

LITERATURE AND REFERENCES

[1] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

[2] Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories

[3] National report on greenhouse gas inventory-Third national communication to UNFCCC of Republic of Macedonia

[4] National emission factors for CO2 and non-CO2 gases for the key Sectors of emissions in the air pursuant to the IPCC and CORINAIR methodologies for Republic of Macedonia, final report

[5] World Energy Outlook 2013, International Energy Agency

[6] IPCC, Second Assessment Report: Climate Change 1995 (SAR)