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NATIONAL CO_2 AND NON-CO_2 EMISSION FACTORS FOR KEY SECTORS UNDER IPCC AND CORINAIR METHODOLOGIES

-FINAL REPORT-

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List of abrevations:

AR	Activity Rate
CDK	Cement Dust Kiln
CLRTAP	Convention on Long-range Transboundary Air Pollution
CORINAIR	Co-ordination of Information on AIR Emissions
CO_2	Carbon Dioxide
CH_4	Methane
CO	Carbon monoxide
EEA	European Environmental Agency
EFDB	Emission Factor Database
EMEP	European Monitoring and Evaluation Programme
EF	Emission Factor
EU	European Union
EAFs	Eelectric Arc Furnaces
FOD	First Order Decay
GHG	Greenhouse gasses
GPG	Good Practice Guidance
IPCC	Intergovernmental Panel on Climate Change
LDVs	Light Duty Vehicles
LPG	Liquid Petroleum Gas
MOEPP	Ministry of Environment and Physical Planning
N_2O	Nitrous Oxide
NO_x	Nitrogen Oxide
NCV	Net Caloric Value
NMVOC	Non-Methane Volatile Organic Compounds
NEV	Net Energetic Value
PCs	Passenger cars
RM	Republic of Macedonia
SO_2	Sulphur dioxide
SOx	Sulphur oxides
TNC	Third National Communication
UNDP	United Nation Development Program
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nation Framework Convention on Climate Changes

INTRODUCTION

In order to improve the quality of future national air emissions inventories, our Country as an EU candidate country takes steps for improving the access to input data and to emission factors necessary for preparing the Inventories.

In accordance with the signed and ratified Convention on Long-range Transboundary Air Pollution (LRTAP) and United Nations Framework Convention on Climate Change (UNFCCC) for reporting air pollutant emissions, the following Inventories have been developed in our Country through the Ministry of Environment and Physical Planning (MOEPP): Greenhouse Gas Inventory, under the 1996 Revised Guidelines of the Intergovernmental Panel on Climate Change (IPCC), and Air Pollutant Emission Inventory under the CORINAIR methodology. In both Inventories, the air pollutant emissions have been calculated by applying the appropriate standard methods, emerging as a product of the activity rate (AR) and the emission factors (EF) for the respective pollutants.

The activity rate refers to the intensity of processes, which is a data obtained from the official statistical data in the country and refers to the quantity of raw materials used, quantity of fuel consumed, products obtained etc., from the specific processes which produce emissions. In case of lack of statistical data, data obtained directly from the industrial/ energy or other facilities have been used which account for the key categories holding significant share in GHG emissions.

Selection of appropriate Emission Factors is the basis for comprehensive and accurate emission calculations, especially for the key emission sectors.

Despite the fact that for both Inventories the emissions have been estimated by applying default methods and procedures based on the IPCC Guidelines for National Greenhouse Gas Inventories and respective Technical Guidelines; the Emission Factor Database (EFDB) which contains a EF library from different source categories; the EMEP/EEA air pollutant emission inventory guidebook; the Technical Guidelines to prepare national emission inventories; the Good Practice for CLRTAP Emission Inventories, there are certain differences in the estimated air emissions. Reasons for such deviations are principally the differences between the two inventory development systems, but also the selection and use of emission factors which are mainly obtained from the simple tier methods or the so-called Default Emission Factors, what creates differences in the reported emissions. Also, the use of different emission factors in reporting under IPCC and CORINAIR methodologies creates differences in emissions calculated, but at the same time it is reflected in many related national documents and studies.

In order to harmonise the two air emission inventory development systems, as well as to improve the quality and accuracy of emissions being reported in accordance with UNFCCC and LRTAP, it is recommended that a database of national emission factors be developed and introduced, which will take into consideration the national conditions specific for each country.

European practices have shown that the development and introduction of national emission factors leads to improvement of the accuracy and reliability of inventories in terms of using higher tier by applying specific emission factors which reflect the specific national conditions and which are based on using country-specific information (knowledge of the type of processes and specific conditions under which they take place, the quality of fuels being used, etc.). This will help the country to better harmonise its obligations with the United Nations Framework Convention on Climate Change (UNFCCC) and also to be better prepared for climate change negotiations with the EU.

In this regard, the MOEPP as a competent institution for reporting in accordance with the United Nations Framework Convention on Climate Change (UNFCCC), as well as in accordance with the Geneva Convention on Long-range Transboundary Air Pollution (LRTAP), stresses the importance of developing and introducing a Database of National Specific Emission Factors necessary for common reporting according to the abovementioned conventions.

The Company TEHNOLAB DOO from Skopje was commissioned by the United Nations Development Programme – UNDP the task of developing and introducing national emission factors for the needs of the Project 00075206 – Third National Report to the UNFCCC.

This Report provides a summary factsheet of the emission factors for the three main greenhouse gases: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in the key sectors/ sources given in the Greenhouse Gas Inventory according to IPCC Guidelines within the Second National Communication [1]. Also, the Report includes emission factors for carbon monoxide (CO), nitrogen oxides (NOx), sulphur dioxide, as well as SOx and non-methane volatile compounds, such as NMVOCs, as indirect greenhouse gases which are present in the key sectors/ sources in the Inventory prepared in accordance with the CORINAIR methodology [2].

The Report is drafted in accordance with the scope of work reflected within the terms of reference, the proposed methodology for implementation of project activities, as well as the recommendations given in the Roadmap for Adoption of National Emission Factors and Recommendations for Harmonisation of Emission Factors between UNFCCC and CORINAIR Methodologies and Reporting Guidance in our Country [3] (Table 1 and Table 2).

Table 1: Key source categories in the Greenhouse Gas Inventory from the Third National Communication - TNC

SOURCE CATEGORIES	CO_2	CH_4	N_2O
1. ENERGY			
1.A.1 Energy Industries			
1.A.1.a Electricity and Heat Production	YES	YES	YES
1.A.2 Manufacturing Industries and Construction			
1.A.2 Manufacturing Industries and Construction	YES		YES
1.A.3 Transport			
1.A.3.b Road Transportation	YES	YES	YES
1.A.4 Other sectors			
1.A.4.b Residential	YES	YES	YES
1.B Fugitive Emissions from Fuels			
1.B.1.a ii Coal Mining and Handling – Open Cast Mining		YES	
2. INDUSTRIAL PROCESSES			
2.A Mineral Products			
2.A.1 Cement Production	YES		
2.C Metal Production			
2.C.1 Iron and Steel Production	YES		
2.C.2 Ferroalloys Production	YES		
4. AGRICULTURE			
4.A. Enteric Fermentation			
4.A.1 Livestock (dairy cattle and non-dairy cattle)		YES	
4.A.2 Buffalos		YES	
4.A.3 Sheep		YES	
4.A.4 Goats		YES	
4.A.6 Horses		YES	
4.A.8 Swine		YES	
4.A.9 Poultry		YES	
4.A.10 Other livestock *(as given in 4.A) Rabbits*			
4.B Manure Management			
4.A.1 Livestock (dairy cattle and non-dairy cattle)		YES	YES
4.A.2 Buffalos		YES	YES
4.A.3 Sheep		YES	YES
4.A.4 Goats		YES	YES
4.A.6 Horses		YES	YES
4.A.8 Swine		YES	YES
4.A.9 Poultry		YES	YES
4.A.10 Other livestock (as given in 4.A) Rabbits		YES	YES
4.A.12 Flowing Systems		YES	YES
4.A.13 Compact and solid storage and dry parcels		YES	YES
4.A.14 Other Agricultural Waste Management System - AWMS		YES	YES
4.D Agricultural soils			
4.D.1 Direct Soil Emissions		YES	YES
4.D.2 Pastures, range and fertilization of enclosed pasture		YES	YES
4.D.3 Indirect Emissions		YES	YES
6. WASTE			
6.A. Solid Waste Disposal on Land		YES	
6.B. Waste Water Handling			YES
6.B.2 Domestic Waste Water and Commercial Waste Water			YES

Table 2: Key source categories of emissions in the Inventory according to the CORINAIR methodology

SOURCE CATEGORIES	SOx	CO	NOx	NMVOC	TSP
1. ENERGY					
1.A.1 Energy industries					
1.A.1.a Electricity and Heat Production	YES		YES		YES
1.A.2 Manufacturing Industries and Construction					
1.A.2.a Iron and Steel	YES				
1.A.3 Transport					
1.A.3.b I Road Transportation: Passenger cars		YES	YES	YES	
1.A.3.b ii Road Transportation: Light Duty Vehicles			YES		
1.A.3.b iii Road Transportation: Heavy Duty Vehicles			YES		
1.A.3.b v Road Transportation: Evaporative emissions from vehicles				YES	
1.A.4 Other sectors					
1.A.4.b I Residential: Stationary Plants		YES	YES	YES	YES
1.B Fugitive Emissions from Fuels					
1.B.1.a: Coal Mining and Handling – Open Cast Mining				YES	
2. INDUSTRIAL PROCESSES					
2.A.6 Road Paving with Asphalt					YES
2.D.2 Food and Drinks				YES	

In general, the Emission Factor Database included in this Report is improved in terms of use of a higher methodological tier for all sectors in accordance with the Roadmap for Adoption of National Emission Factors, except for the source category of Agriculture and for several sub-categories in which the officially available national data necessary for development/ preparation of NEF (National Emission Factors) are not segregated enough to enable the use of a higher methodological tier (Tier 2), therefore, the basic Tier 1 Emission Factors as National Emission Factors for the abovementioned sectors shall be used until the national statistical authorities produce properly segregated data necessary for deriving EF (Emission Factors) by applying a higher methodological tier.

ANNEX 2 includes summary comparison tables which show the Emission Factors by sectors according to the project task, and for comparison purposes, it also includes a summary of the Emission Factors which have been used until now in the Inventories according to IPCC and CORINAIR Guidelines, as well as the default Emission Factors according to the respective Reference Manuals.

However, having regard to the nature and multidisciplinarity of the subject matter related to the development of national emission factors, this emission factors database should not be treated as final, but more as a basis for having it further supplemented and upgraded with the purpose of improving future national inventories, what, by its nature, is a continuous process.

METHODOLOGICAL APPROACH FOR OBTAINING/ADOPTING EMISSION FACTORS

The Emission Factors Database is developed by taking into consideration the methodological recommendations given in the following documents:

- IPCC Guidelines for National Greenhouse Gas Inventories and respective Technical Guidelines, 1996/2006;
- EMEP/EEA air pollutant emission inventory guidebook 2009;
- IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC GPG);
- Good Practice for CLRTAP Emission Inventories;
- Roadmap for Adoption of National Emission Factors and Recommendations for Harmonisation of Emissions Factors between UNFCCC and CORINAIR Methodologies and Reporting Guidance in the Country.

The selection/estimation of appropriate Emission Factors was preceded by a detailed review and analysis of the following documents:

- Greenhouse Gas Inventory developed within the Second National Communication on Climate Change and the respective accompanying documents (procedures and analyses);
- Shortcomings in data and recommendations for improving the Second Greenhouse Gas Inventory;
- Latest preparations for greenhouse gas inventories for the period 2003-2009;
- National CORINAR Inventory and relevant accompanying documentation (Information Report on the Inventory for 2010).

After making comparison of the Emission Factors given in the Inventories according to IPCC and CORINAIR Guidelines, review was made on the availability of data necessary for developing National Emission Factors as follows:

- Official documents drafted by national institutions (statistical yearbooks, area-segregated reports produced by the State Statistical Office, energy balances, reports by respective ministries, local self-government units, relevant studies, plans and programmes, IPPC (Integrated Pollution Prevention and Control) applications, etc.);

- Manufacturers/ importers of fuels that are used in the country (Thermal Power Plant REK Bitola, Thermal Power Plant REK Oslomej, OKTA AD Skopje, Makpetrol AD Skopje, GA-MA AD Skopje) regarding data related to the features and quality of fuels used nationally;

- Companies engaged in production and service activities (Titan Cement Production Plant Skopje, Skopski leguri – Skopje, Makstil – Skopje, Feni Industry – Kavadarci, Jugohrom – Jegunovce, etc., and which are sources of CO_2 emissions) regarding data related to their working technologies and techniques, the used raw materials, semi-finished products, products and energy sources.

The knowledge and data obtained by means of direct contact with the abovementioned companies from the industrial sector have contributed significantly in increasing the accuracy of the estimations necessary for developing appropriate National Emission Factors (NEF), especially for the source category of Industrial Processes.

All these information were the basis on which decisions were made on the selection of the tier method (Tier 1, Tier 2, Tier 3), as well as on the final selection and the determination of emission factors.

In order to enable the use of a higher tier method in the estimation of indirect GHG (SOx, NOx, CO, TSP) emissions which are present in the key source categories in the Inventory according to the CORINAIR Guidelines), comparison analyses and estimations were made for developing National Emission Factors based on real measurement data recorded in the Cadastre of Air Polluters and Pollutants of the Republic of Macedonia prepared by Tehnolab DOO for the year 2008 [4], as well as measurement of air pollutant emissions at larger power plants in the country over the course of several years made by the accredited laboratory of TEHNOLAB. This has contributed significantly towards raising the level of certainty in the process of making decisions on the development/estimations of National Emission Factors for the abovementioned gases, especially for the energy sector. A more detailed description of the methodological approach on determining the Emission Factors for SOx, NOx, CO, TSP based on data obtained from emission measurements made in the course of several years is given in Chapter 1.0 of the Energy Sector.

Effort was made to improve the emission estimates in the Waste Sector as well, by introducing the so-called FOD (First Order Decay) method. The trial estimations that were made by using historic data of waste produced in the country have given satisfying results. It was a great encouragement for and support to the intention of introducing this method for future emission estimations in the National Inventories, what would be a promotion and improvement compared to the inventories that were used until now.

For some sectors, that is, some sub-sectors in which the availability of the type of national data did not allow the use of higher tier method (Tier 2 or Tier 3) for development/ determination of Emission Factors (especially for the Agricultural Sector), default emission factors have been used from the respective Reference Manuals by carefully reviewing the compatibility of the aforementioned factors with the specific national conditions.

The process of selection of methods for determining/developing Emission Factors has been described for each source category and for each gas (CO2, that is, non-CO2) individually in the following Chapters.

Nonetheless, the emission factors database is developed by taking into consideration the methodological recommendations given in the IPCC Guidelines for National Greenhouse Gas Inventories and the respective Technical Guidelines, EMEP/EEA Air Pollutant Emissions Inventory Guidebook “Technical guidance to prepare national emission inventories” and EMEP/CORINAIR GPG, Good practice for CLRTAP emission inventories and by following the concept of Good Practice which implies using a systematic and objective analysis of the key source categories in each country as a basis for selection of a method for estimation of emissions. This type of process leads to improvement in the quality of the inventories, as well as to greater accuracy of the results obtained in the process of estimation of emissions.

1.0. ENERGY

1.1. ENERGY INDUSTRIES – Source Category 1.A.1

This source category is a key source of the following emissions: **CO_2 ; CH_4 ; N_2O ; SOx ; NOx and TSP.**

Key sources within this source category are the following sub-categories:

- 1.A.1.a i Electricity Production;
- 1.A.1.a ii – Combined Electricity and Heat Production;
- 1.A.1.a iii – Heating plants.
-

The emissions of the aforementioned gases come as a result of fuel combustion:

- Coal – Lignite,
- Residual Fuel Oil,
- Natural gas.

Lignite

Lignite is extracted from open cast mining at Suvodol and is used for the needs of the Thermal Power Plant Bitola and from the open cast mining at Oslomej for the needs of the Thermal Power Plant Oslomej. Having regard to the fact that the CO_2 emissions factor depends on the fuel's carbon content, it should be mentioned that carbon C (%) content in lignite from Thermal Power Plant REK (Mining and Energy Combine) Bitola and Thermal Power Plant REK (Mining and Energy Combine) Oslomej is inconsistent, therefore, it is recommended for future estimations to use the latest data on their content in coal.

This is especially important when it comes to the coal from Thermal Power Plant REK Bitola, having in mind the fact that apart from the coal mining activities in the main layer, coal mining operations have also began in deeper layers of the coalfield Suvodol. Also, coal extracted from open cast mining at Brod-Gneotino began to be used, whereby these coals are being mixed in order to have coal with satisfying average quality equal to ca. 7.300 kJ/kg.

Data about the lignite composition and characteristics provided by Thermal Power Plant REK Bitola [16] and Thermal Power Plant REK Oslomej [18] were used for determining the CO_2 emission factor.

Residual Fuel Oil

In this source category, Residual Fuel Oil is mainly used for heat production (sub-category 1.A.1.a iii) in the boiler rooms of Toplifikacija AD Skopje (district heating company). In addition, this fuel is used in small quantities in the Thermal Power Plant Bitola and the Thermal Power Plant Oslomej (for the starting the boiler rooms). Also, TEC (Thermoelectric Power Plant) Negotino has been using small quantities necessary for maintaining the "cold reserve" mode over the course of several years.

Data about the characteristics of this fuel are obtained from the Refinery Okta A.D. Skopje and Makpetrol A.D. Skopje. [34], [35].

Natural gas.

In this sector, natural gas is being used in the plants for combined electricity and heat generation of CCPP TE-TO AD Skopje (sub-category 1.A.1.a ii) and in the boiler rooms of Toplifikacija AD Skopje for heat production (sub-category 1.A.1.a iii).

For the purpose of determining the emission factor for this fuel, data were used about the composition of the Russian natural gas used in the country which have been used from the Table obtained from Violeta Hristova as an appendix to the Roadmap for Adoption of National Emission Factors [3].

- **Methodological approach**

According to 2006 IPCC Guidelines for National Greenhouse Gas Inventories and EMEP/EEA air pollutant emission inventory guidebook 2009, there are three methodological tiers for determining the emissions from this sector. They are as follows:

Tier 1 method which is based on fuel quantity as it implies that the emissions from all combustion sources can be estimated on basis of the quantities of fuels used for combustion (data from the national energy statistics) and the default emission factors.

Tier 2 method which takes into account similar data about fuels, like in Tier 1 method, and country-specific emission factors (as a result of fuel specifics, combustion technologies, etc.).

Tier 3 method which uses thorough emission models or data obtained from measurements made at individual energy plants.

It is a good practice to use Tier 2 and Tier 3 method depending on the availability of the necessary data.

In the process of determining the emission factors for the abovementioned gases, the recommendations given in Tier 1, Tier 2 and Tier 3 have been applied depending on the availability of obtainable data.

- **Determination of emission factors**

The determination of emission factors was made on the basis of:

- Data about the characteristics of the fuels used in the combustion processes (carbon content in lignite, Residual Fuel Oil and natural gas, as well as sulphur content in lignite and Residual Fuel Oil);
- Information about the combustion technologies used, that is, information about the type of combustion plant (steam generator, gas turbine, dry bottom boiler etc.);
- Information about fitted/non-fitted equipment for flue gas cleaning, improvement in combustion;
- Data obtained from measurements made on the emission of air polluters; and
- Selection of default emission factors recommended in 2006 IPCC Guidelines for National Greenhouse Gas Inventories and EMEP/EEA air pollutant emission inventory guidebook 2009.

1. Determination of CO_2 and SO_2 emission factors was made on the basis of data about the characteristics of fuels consumed in combustion processes.

a) In the process of determining the CO_2 emission factor for lignite and Residual Fuel Oil, the following Equation 1 was applied:

Equation 1

$$EF_{CO2}\ [t/TJ] = (C\ [\%] \bullet\ 44 \bullet\ O_x)/(NCV\ [TJ/t] \bullet 12 \bullet 100)$$

where:

C - % of carbon content
Ox – oxidation factor
NCV – net calorific value in TJ/t

b) In the process of determining the CO_2 emission factor for natural gas the Equation 1 has been used, however one needs to have in mind that the content of C [%] contains all components of the Russian natural gas (methane, ethane, propane, butane etc.), as they are presented in the following table:

Table 3: Content of Russian natural gas

Component	%
CH_4	97.8876
C_2H_6	0.8559
C_3H_8	0.2743
i-C_4H_{10}	0.0455
n-C_4H_{10}	0.0443
i-C_5H_{12}	0.0094
n-C_5H_{12}	0.0062
i-C_6H_{14}	0.0050
N_2	0.6868
CO_2	0.1849

a) In the process of determining the SO_2 emission factor for Residual Fuel Oil, the following Equation 2 was applied:

Equation 2

$$EF_{SO2}\ [g/GJ] = (S\ [\%] \bullet 20000) / (NCV\ [GJ/t])$$

where:

S - % of sulphur content
NCV – net calorific value in GJ/t

The NCV (net calorific value in TJ/t) for fuels are obtained from the Energy Balance of the Republic of Macedonia for the period 2013 – 2017 (Official Gazette of the Republic of Macedonia No. 170/2012). The table with net calorific values is given in ANNEX 1.

The oxidation (Ox) factor values are obtained from IPCC Guidelines for National Greenhouse Gas Inventories, 1996, v. 2, p.1.8, Table I-4 and amount to:

- for coal = 0.98
- for Residual Fuel Oil = 0.99, and
- for natural gas = 0.995.

The data on carbon and sulphur content in lignite were obtained from Thermal Power Plant REK Bitola and Thermal Power Plant REK Oslomej, whereas for the Residual Fuel Oil, they were provided by the Refinery OKTA AD Skopje and AD Makpetrol Skopje.

2. Determination of the SO_2, NO_2 and TSP emission factors for lignite was made on the basis of data obtained from measurements of atmospheric emissions. Measurement of emissions was performed at Thermal Power Plant REK Bitola and Thermal Power Plant REK Oslomej by TEHNOLAB Skopje. Namely, TEHNOLAB Skopje as an accredited laboratory performs regular periodical measurement of air pollutant emissions at all three blocks of the Thermal Power Plant Bitola and at one block of the Thermal Power Plant Oslomej. Measurements are performed on monthly basis and relevant laboratory reports are being drafted and delivered to the clients, and through them, to the Ministry of Environment and Physical Planning.

In the course of one year, a total of 66 measurements are being performed at TE Bitola on all three blocks which have two channels each (except during the months when regular overhaul is done on each of the blocks). With the purpose of determining the emission factors data obtained from the measurements performed during a period of 5 years, i.e. data obtained from around 330 measurements has been used. In the case of TE Oslomej which has 4 channels on one of its blocks, data obtained from around 220 measurements have been used.

Measurement of individual air pollutant emissions is performed according to the following standards: ISO 9096:2008, ISO 10780:2008, ISO 7935:2008, ISO 12039:2008 and ISO 10849:2008. In compliance with these standards, the measurements comprise of isokinetic sampling which covers the following processes:

- Determination of the temperature in waste gases [^oC];
- Determination of the static pressure and the dynamic pressure [kPa];
- Determination of the flow rate [m/s];
- Determination of volume flow rate [m^3/h and Nm^3/h];
- Determination of the concentration of CO, SO_2, NO_x in the exhaust gases [mg/Nm^3]; and
- Gravimetric extraction of solid particles (TSP) from gases and determination by applying a gravimetric method (mg/Nm3).

Apart from these measurements, data of consumption of fuel at the time of the measuring are also being recorded.

By using the measured concentrations calculated under normal conditions and the volume flow for flue gas, the hourly emission rate for each air pollutant can be determined, and by multiplying it with the number of annual working hours of the release on which the measurement is performed the annual quantity of emissions can be obtained. The amount of fuel consumed (hourly or annually), expressed in kilograms, i.e. tonnes, is converted in the measurement unit GJ through the net calorific value. The NCV value for lignite is given in ANNEX 1.

The ratio between the quantity of air pollutant emission (on hourly or annual basis) and the amount of fuel consumed (on hourly or annual basis), expressed in GJ, shows the emission factor for that pollutant (g/GJ).

When making calculations for each air pollutant, the emission factors for each measurement individually and for each block individually, in the course of every year have been determined. Then the mean value is calculated for each block individually for all five years, and in the end the mean value for the whole TE Bitola is obtained. The procedure for determining the emission factors at TE Oslomej is exactly the same as the procedure applied at TE Bitola.

1.1.1. CO_2 emission factors

In the process of determining the CO_2 emission factor for lignite and Residual Fuel Oil, Equation 1 is applied for making the calculation. The following result is obtained:

Lignite

For the coal from Thermal Power Plant REK Bitola the following **CO_2 emission factor** has been obtained:
C [%] = 21.26 [%]
Ox = 0.98
NCV = 0.007338 [TJ/t]
EF_{CO2} = 104.11 [t/TJ]

For the coal from Thermal Power Plant REK Oslomej the following **CO_2 emission factor** has been obtained:
C [%] = 21.70 [%]
Ox = 0.98
NCV = 0.007338 [TJ/t]
EF_{CO2} = 106.26 [t/TJ]

Residual Fuel Oil
C [%] = 85.60 [%]
Ox = 0.99
NCV = 0.04 [TJ/t]
EF_{CO2} = 77.68 [t/TJ]

Natural gas.
For the natural gas the following **CO_2 emission factor** has been obtained:
C[%] = 68.78
Ox = 0.995
NCV = 0.033588 [TJ/t]
EF_{CO2} = 54.802 [t/TJ]

The CO_2 emission factors for the fuels relevant for the source category 1.A.1. – Energy Industries are shown in Table 4.

Table 4: CO_2 emission factors for the source category 1.A.1. – Energy Industries

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.1.a i	Electricity production	**104.11**	t/TJ	Lignite (REK Bitola)	TJ
		106.26	t/TJ	Lignite (REK Oslomej)	TJ
		77.68	t/TJ	Residual Fuel Oil	TJ
1.A.1.a ii	Combined electricity and heat production	**54.802**	t/TJ	Natural gas	TJ
1.A.1.a iii	Heating plants	**77.68**	t/TJ	Residual Fuel Oil	TJ
		54.802	t/TJ	Natural gas.	TJ

1.1.2. CH_4 emission factors

The determination of CH_4 emission factors for lignite, Residual Fuel Oil and natural gas is made by selecting the default emission factors recommended in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 2.2 Volume 2, Chapter 2, page 2.16. This decision is based on the fact that in the country there are no direct measurements of methane in the gases emitted by the power plants which could be used for estimating/developing the values of the national emission factor of CH_4, so the application of default emission factors for this gas gives values which are accurate enough, having in mind the fact that methane has a very small share in the total non-CO_2 gas emissions.

The CH_4 emission factors for the fuels relevant for the source category 1.A.1. – Energy Industries are shown in Table 5.

Table 5: CH_4 emission factors for the source category 1.A.1. – Energy Industries

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.1.a i	Electricity production	**1.0**	Kg/TJ	Lignite	TJ
		3.0	Kg/TJ	Residual Fuel Oil	TJ
1.A.1.a ii	Combined electricity and heat production	**1.0**	Kg/TJ	Natural gas	TJ
1.A.1.a iii	Heating plants	**3.0**	Kg/TJ	Residual Fuel Oil	TJ
		1.0	Kg/TJ	Natural gas.	TJ

1.1.3. N_2O emission factors

The determination of N_2O emission factors for lignite, Residual Fuel Oil and natural gas is made by selecting the default emission factors recommended in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 2.2 Volume 2, Chapter 2, page 2.16. This decision is based on the fact that in the country there are no direct measurements of N_2O in the gases emitted by the power plants which could be used for estimating/developing the values of the national emission factor of N_2O, so the application of default emission factors for this gas gives values which are accurate enough, having in mind the fact that N_2O has a very small share in the total non-CO2 gas emissions.

The N_2O emission factors for the fuels relevant for the source category 1.A.1. – Energy Industries are shown in Table 6.

Table 6: N_2O emission factors for the source category 1.A.1. – Energy Industries

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.1.a i	Electricity production	**1.5**	Kg/TJ	Lignite	TJ
		0.6	Kg/TJ	Residual Fuel Oil	TJ
1.A.1.a ii	Combined electricity and heat production	**0.1**	Kg/TJ	Natural gas.	TJ
1.A.1.a iii	Heating plants	**0.6**	Kg/TJ	Residual Fuel Oil	TJ
		0.1	Kg/TJ	Natural gas.	TJ

1.1.4. SOx emission factors

The determination of **SOx** (expressed as SO_2) **emission factor** for lignite is made on the basis of data obtained from direct measurements of air pollutant emissions performed by TEHNOLAB Skopje at the two largest energy installations: the Thermal Power Plant of REK Bitola and the Thermal Power Plant of REK Oslomej, which use lignite as fuel. The procedure for obtaining the SOx emission factor is described on page 11 above.

Thereby, the following SOx emission factors for lignite were obtained: for REK Bitola **1599** [g/GJ], and for REK Oslomej **1628** [g/GJ].

The determination of the SOx (expressed as SO_2) emission factor for Residual Fuel Oil is made by doing a calculation in which Equation 2 is applied:

Thereby, the following SO_2 emission factor has been obtained:
S [%] = 1 [%]
NCV = 0.04 [TJ/t]
EF_{SO2} = 500.0 [g/GJ]

The reasons for having the determination of this emission factor being done by calculation are the following:

The largest Thermal Power Plant which use Residual Fuel Oil - TEC Negotino has not been operational for a longer time period and no measurements of these air pollutant emissions were performed. The amount of relevant data obtained from measurements is not sufficient and is outdated, since they have been made in a period when Residual Fuel Oil was consumed that had a sulphur content higher than 1%. There have been no recent measurements. Regarding the measurements, there is a similar situation with Toplifikacija AD Skopje where the amount of data obtained from measurements performed when Residual Fuel Oil was used that had a sulphur content higher than 1% is not sufficient to determine the relevant emission factor.

The determination of SO_2 emission factor for natural gas is made by selecting the value of the default SO_2 emission factors recommended in Table 3-14, page 27 (for sub-category 1.A.1.a iii – Heating Plants) and in Table 3-20, page 33 (for sub-category 1.A.1.a ii – Combined Heat and Power Generation), EMEP/EEA guidebook 2009.

The reason for deciding to take the default SO_2 emission factors is the fact that there is no available data on the content of sulphur in natural gas for this type of fuel (see Table 3). However, when selecting the factors, the combustion technology specificity, that is, the

information about the type of combustion plants (gas turbine, type of boiler) has been taken into consideration, which unequivocally points to the use of Tier 2 method.

The SO_2 emission factors for the fuels relevant for the source category 1.A.1 – Energy Industries are given in Table 7.

Table 7: SO_2 emission factors for the source category 1.A.1. – Energy Industries

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.1.a i	Electricity production	**1599.0**	g/GJ	Lignite (REK Bitola)	GJ
		1628.0	g/GJ	Lignite (REK Oslomej)	GJ
		500.0	g/GJ	Residual Fuel Oil	GJ
1.A.1.a ii	Combined electricity and heat production	**0.281**	g/GJ	Natural gas	GJ
1.A.1.a iii	Heating plants	**500.0**	g/GJ	Residual Fuel Oil	GJ
		0.3	g/GJ	Natural gas	GJ

1.1.5. NOx emission factors

The determination of **NOx** (expressed as NO_2) **emission factor** for lignite is made on the basis of data obtained from direct measurements of NOx emissions in the air performed by TEHNOLAB Skopje at the two largest energy installations: the Thermal Power Plant REK Bitola and the Thermal Power Plant REK Oslomej, which use lignite as fuel. The procedure for obtaining the NOx emission factor is described on page 11 above.

Thereby, the following **NOx emission factors** for lignite were obtained:
for REK Bitola **265** [g/GJ], and for REK Oslomej **318.0** [g/GJ].

For Residual Fuel Oil and natural gas in this sector, the default NOx emission factors given in Table 3-13, page 26, Table 3-14, page 27 and Table 3-20, page 33, EMEP/EEA Guidebook 2009 have been taken. When selecting the factors, the combustion technology specificity, that is, the information about the type of combustion plants (gas turbine, type of gas boiler or Residual Fuel Oil boiler) have been taken into consideration, which unequivocally points to the use of Tier 2 method.

Reasons for deciding to take the default NOx emission factors is the fact that the largest electricity generation Residual Fuel Oil-fired power plant – TEC Negotino has not been operational for a longer period of time and no measurements of these air pollutant emissions were performed. The amount of relevant data obtained from measurements is not sufficient and is outdated. Regarding the measurements, there is a similar situation with Toplifikacija AD Skopje where the amount of data obtained from measurements performed when gas was used is not sufficient to determine the relevant emission factor.

The NO_2 emission factors for the fuels relevant for the source category 1.A.1 – Energy Industries are given in Table 8.

Table 8: NO_2 emission factors for the source category 1.A.1. – Energy Industries

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.1.a i	Electricity production	**265.0**	g/GJ	Lignite (REK Bitola)	GJ
		318.0	g/GJ	Lignite (REK Oslomej)	GJ
		210.0	g/GJ	Residual Fuel Oil	GJ
1.A.1.a ii	Combined electricity and heat production	**153.0**	g/GJ	Natural gas.	GJ
1.A.1.a iii	Heating plants	**210.0**	g/GJ	Residual Fuel Oil	GJ
		89.0	g/GJ	Natural gas.	GJ

1.1.6. TSP emission factors

The determination of the **TSP emission factor** for lignite is made on the basis of data obtained from direct measurements of air pollutant emissions performed by TEHNOLAB Skopje at the two largest energy installations: the Thermal Power Plant REK Bitola and the Thermal Power Plant REK Oslomej, which are lignite-fired. The procedure for obtaining the TSP emission factor is described on page 11 above.

Thereby, the following **TSP emission factors** for lignite were obtained:
for Thermal Power Plant REK Bitola **101.0** [g/GJ], and for Thermal Power Plant REK Oslomej **108.0** [g/GJ].

For Residual Fuel Oil and natural gas in this sector, the default **TSP emission factors** given in Table 3-13, page 26, Table 3-14, page 27 and Table 3-20, page 33, EMEP/EEA guidebook 2009 have been taken. When selecting the factors, the combustion technology specificity, that is, the information about the type of combustion plants (gas turbine, type of gas boiler or Residual Fuel Oil boiler) have been taken into consideration, which unequivocally points to the use of Tier 2 method.

Reasons for deciding to take the default TSP emission factors is the fact that the largest electricity generation Residual Fuel Oil-fired power plant – TEC Negotino is has not been operating for a longer period and no measurements of these air pollutant emissions were performed. The amount of relevant data obtained from measurements is not sufficient and is outdated. Regarding the measurements, there is a similar situation with Toplifikacija AD Skopje where the amount of data obtained from measurements performed when gas was used is not sufficient to determine the relevant emission factor.

The TSP emission factors for the fuels relevant for the source category 1.A.1 – Energy Industries are given in Table 9.

Table 9: TSP emission factors for the source category 1.A.1. – Energy Industries

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.1.a i	Electricity production	**101,0**	g/GJ	Lignite (REK Bitola)	GJ
		108,0	g/GJ	Lignite (REK Oslomej)	GJ
		20,0	g/GJ	Residual Fuel Oil	GJ
1.A.1.a ii	Combined electricity and heat production	**0,908**	g/GJ	Natural gas.	GJ
1.A.1.a iii	Heating plants	**20,0**	g/GJ	Residual Fuel Oil	GJ
		0,90	g/GJ	Natural gas.	GJ

1.2. Source Category 1.A.2 - MANUFACTURING INDUSTRIES AND CONSTRUCTION

Source category 1.A.2 is a key source of the following pollutants: **CO_2, N_2O,** whereas, for **SOx,** key source is sub-category 1.A.2 a – Iron and Steel.

Source category **1.A.2** comprises the following sub-categories:

- 1.A.2 a – Iron and Steel;
- 1.A.2 b – Non-ferrous Metals;
- 1.A.2 c – Chemicals;
- 1.A.2 d – Pulp, Paper and Print;
- 1.A.2 e—Food processing, Beverages and Tobacco
- 1.A.2 f – Non-metallic Minerals;
- 1.A.2 g – Transport Equipment;
- 1.a.2 h – Machinery;
- 1.A.2 j – Mining (except for fuels) and Extraction of Stone;
- 1.A.2 k – Construction;
- 1.A.2 l – Textile and Leather;
- 1.A.2 m – Unspecified Industry.

The following fuels are being used:

- Gas Diesel Oil
- Residual Fuel Oil
- Liquefied Petroleum Gas (LPG)
- Coal – Lignite,
- Natural gas
- Wood/wood waste.

This list of fuels is made on the basis of what kind of fuel is used in each of the abovementioned sub-sectors. This is shown in the Statistical Yearbooks of the Republic of Macedonia in section 11. Industry, Construction and Energy, Chapter 11.03 – Energy.

- **Methodological approach**

Similar to source category 1.A.1 Energy Industries, this source category also has a three-tier method for determination of emissions. Tier 1 and Tier 2 method are based on the type and quantity of fuel consumed in the production processes, whereas Tier 3 also includes data from direct measurements of combustion processes' emissions within the production plants.

Characteristic about this source category is the fact that in some of its sub-categories double counting of emissions can occur (in this source category and in the non-energy source category 2. Industrial Processes, having in mind the fact that certain fuels (for example: coke, natural gas) are consumed in combustion as reducing agents in the production process (for example: production of iron and steel, cement production). Therefore, when using Tier 1 and Tier 2 it is necessary to make clear distinction between the intended use of fuels, and in certain cases only use of Tier 3 method is relevant.

When determining the emission factors for the abovementioned gasses, the recommendations given for Tier 1, and partially for Tier 2 have been used, in accordance with the availability of the data.

- **Determination of emission factors**

The determination of emission factors was made on the basis of:

1. Data about the characteristics of the fuels used in the combustion processes (carbon content in lignite, Residual Fuel Oil and natural gas, as well as sulphur content in Residual Fuel Oil);
2. Information about the combustion technologies applied, that is, information about the type of combustion plant (combustion processes with contact, combustion processes without contact, intended use of fuel, etc.);
3. Selection of default emission factors recommended in 2006 IPCC Guidelines for National Greenhouse Gas Inventories and EMEP/EEA air pollutant emission inventory guidebook 2009.

1.2.1. CO_2 emission factors

The determination of CO_2 emission factors for Residual Fuel Oil and lignite is made by doing a calculation for which Equation 1 is applied. Data obtained from the Refinery OKTA were used for calculating the emission factor for these liquid fuels, whereas for the lignite, the data was provided by Thermal Power Plant REK Bitola.

For the purpose of determining the emission factor for natural gas, data were used about the composition of the Russian natural gas consumed in the country (see Table 3).

For the other fuels (Liquefied petroleum gas, coke, Gas/Diesel Oil and wood/wood waste) the default CO_2 emission factors which are given in Table 2.3 Volume 2, Chapter 2, Guidelines for National GHG Inventories, page 2.18 and page 2.19 have been taken.

The CO_2 emission factors for the fuels relevant for the source category 1.A.2 – Manufacturing Industries and Construction, are given in Table 10.

Table 10: CO_2 emission factors for the source category 1.A.2. – Manufacturing Industries and Construction

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.2	a,b,c,d,e,f, g,h,j,k,l,m	**74.4**	t/TJ	Gas/Diesel Oil	TJ
		77.68	t/TJ	Residual Fuel Oil	TJ
		63.1	t/TJ	Liquefied Petroleum Gas (LPG)	TJ
		104.11	t/TJ	Lignite	TJ
		54.802	t/TJ	Natural gas	TJ
		112.0	t/TJ	Wood /wood waste	TJ

1.2.2. N_2O emission factors

For all types of fuels used in this Category the default N_2O emission factors shown in Table 2.3 Volume 2, Chapter 2, Guidelines for National GHG Inventories, page 2.18 and page 2.19 have been taken.

This decision is based on the fact that on one hand, in our Country there are no direct measurements of N_2O in the gases emitted by the energy plants that could be used for estimating/calculating the values of the national emission factor, and on the other hand, the use of default emission factors for this gas gives emission values which are accurate enough, having in mind the fact that N_2O has a very small share in the total non-CO_2 gas emissions.

The NO_2 emission factors for the fuels relevant for the source category 1.A.2 – Manufacturing Industries and Construction, are given in Table 11.

Table 11: N_2O emission factors for the source category 1.A.2. – Manufacturing Industries and Construction

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.2	a,b,c,d,e,f, g,h,j,k,l,m	**0.6**	Kg/TJ	Gas/Diesel Oil	TJ
		0.6	Kg/TJ	Residual Fuel Oil	TJ
		0.1	Kg/TJ	Liquefied Petroleum Gas (LPG)	TJ
		1.5	Kg/TJ	Lignite	TJ
		0.1	Kg/TJ	Natural gas	TJ
		4.0	Kg/TJ	Wood / wood waste.	TJ

1.2.3. SOx emission factors

Sub-category 1.A.2.a – Iron and Steel is a key source of SOx (expressed as SO_2).

The following fuels are being consumed in this sub-sector:

- Gas/Diesel Oil and heating oil
- Residual Fuel Oil
- Liquefied Petroleum Gas (LPG)
- Natural gas

whereas the coals are used as reducing agents in the production process or for electrode forming which are part of the electric arc furnaces or ladle furnaces.

The determination of the SOx (expressed as SO_2) emission factor for Residual Fuel Oil is made by doing a calculation in which Equation 2 is applied:

For the other fuels, the default SO_2 emission factors which are shown in Table 3-3 и Table 3-4, page 16, EMEP/EEA Guidebook 2009 have been used, because other reference data from relevant institutions necessary for calculation of SO_2 emission factors are not available.

The SO_2 emission factors for the fuels relevant for the source category 1.A.2 – Manufacturing Industries and Construction, are given in Table 12.

Table 12: SO_2 emission factors for the source category 1.A.2.–Manufacturing Industries and Construction

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.2.a	Iron and steel	**500.0**	g/GJ	Residual Fuel Oil	GJ
		140.0	g/GJ	Other liquid fuels	GJ
		0.5	g/GJ	Natural gas and Liquefied petroleum gas (LPG)	GJ

1.3. Source Category 1.A.3 - TRANSPORT

This source category is a key source of **CO_2 ; CH_4 ; N_2O ; CO ; NOx and NMVOC** emissions.

Key sources within this source category are the following sub-categories:

- 1.A.3.b.i – Passenger cars;
- 1.A.3.b.ii – Light duty vehicles;
- 1.A.3.b.iii – Heavy duty vehicles and buses;
- 1.A.3.b.iv – Motorcycles;
- 1.A.3.b.v – Evaporative emissions from vehicles (for NMVOC).

The emissions of the aforementioned gases come as a result of consumption of the following fuels:

- Motor Gasoline
- Gas/Diesel Oil
- Liquefied Petroleum Gas (LPG)

Nationally, main manufacturers, importers and distributors of these fuels are OKTA A.D. Skopje, MAKPETROL A.D. Skopje and LUKOIL MAKEDONIJA DOOEL, Skopje. Data about the quality of liquid fuels of these companies are officially published on their web-sites, according to which these types of fuels are standardised and compliant with the Rulebook on Quality of Liquid Fuels (Official Gazette of the RM No. 88/2007, 91/2007, 97/2007, 105/2007, 157/2007, 15/2008, 78/2008, 156/2008 and 81/2009) and the respective standards (MKS EN 228; MKS EN 590; MKS EN 14214; MKS 1001 and MKS B.H2 430).

- **Methodological approach**

According to 2006 IPCC Guidelines for National Greenhouse Gas Inventories and EMEP/EEA air pollutant emission inventory Guidebook 2009, there are three methodological tier for determining the emissions from this sector. They are as follows:

Tier 1 method based on the consumption of fuels which are used in this source category and default emission factors for each type of fuel. That qualifies for the “top-down” approach, without taking into consideration the combustion technologies (for example: the types of vehicles).

Tier 2 method which is “bottom-up” estimates the emissions in two steps. In the first step the quantity of fuel consumed has been estimated, segregating it by type of fuel and by type of vehicle, whereby data on the number of vehicles of each type, number of kilometres driven per vehicle on annual basis and average number of litres consumed per kilometre driven have been used. In the second step the total emissions by multiplying the quantities of fuel consumed (in the first step) and the respective emission factors for that type of fuel and that type of vehicle have been determined.

Tier 3 method estimates the emissions just like Tier 2 method, however, this method takes into consideration additional parameters which define in detail the combustion technology (cold start and warm start, how old is the vehicle) and road conditions (driving in rural areas and driving in urban areas, driving on motorway, road slope, etc.).

It is a good practice to use Tier 2 and Tier 3 method depending on the availability of the necessary data.

In the process of determining the emission factors for the abovementioned gases, the recommendations given in Tier 1 and Tier 2 have been applied according to the availability of obtainable data. Due to lack of relevant data necessary for Tier 3, this method cannot be applied in this phase.

- **Determination of emission factors**

The determination of emission factors was made on the basis of:

- Data on the total quantities of fuel consumed in this sector, segregated by the type of fuel, included in the Energy Balance of the Republic of Macedonia for the period 2013 - 2017 (Table 2.6, page 113, Official Gazette of the Republic of Macedonia 170/2012).
- Data on the number of vehicles by type, included in the Statistical Yearbooks of the Republic of Macedonia, Chapter 14, Transport and respective Statistical Reviews on Transport (Number of vehicles by vehicle type, number of vehicles by fuel type).

Unfortunately, there are no national data on per-vehicle kilometres driven annually and type of fuel, no data on average litres consumed per kilometre by vehicle type and by fuel type, no data on the overall distance driven by all vehicles shown by category and by technologies and no data on the mean annual distance driven by vehicle shown by category and by technology. Therefore, the determination of CO_2 emissions shall be based on data showing the quantity of annual consumption of each type of fuel. In order to determine the emissions of CH_4; N_2O; CO; NOx and NMVOC, a percentage allocation of the annual consumption for each type of fuel and for each type of vehicle covered with the abovementioned sub-sectors is made. This approach will enable the application of Tier 2 method and use of emission factors which are appropriate to the type of fuel and type of vehicle.

The determination of CO_2 emission factors is done by selecting the default CO_2 emission factors for each type of fuel. In respect of CH_4 ; N_2O, the emission factors which are relevant to the type of fuel and type of vehicle have been taken.

For the purpose of determining the CO; NOx and NMVOC emission factors, the default emission factors (expressed in g/kg of fuel) by type of fuel and type of vehicle have been obtained and developed into national emission factors (expressed in g/Gg of fuel) and at the same time the national conditions, that is, the specific features of the fuels consumed in the country determined through their net calorific value (NCV) shown in ANNEX 1 have been taken into consideration.

1.3.1. CO_2 emission factors

The estimations of CO_2 emissions in this source category can be made by applying Equation 3, whereby all types of consumed fuel would be covered:

Equation 3

$$\text{Emission} = \Sigma (\text{Fuel}_a \bullet \text{EF}_a)$$

where:

Emission = CO_2 emission (kg)
$Fuel_a$ = consumed fuel type **a** (TJ)
EFa = Emission factor for fuel type **a** (kg/TJ)
a = fuel type (Motor Gasoline, Gas/Diesel Oil, LPG)

For CO_2 the default CO_2 emission factors shown in Table 3.2.1 Volume 2, Chapter 3, Guidelines for National GHG Inventories, page 3.16 have been taken.

The CO_2 emission factors for the fuels relevant for the source category 1.A.3.b – Transport – Road Transportation, are given in Table 13.

Table 13: CO2 Emission factors for source category 1.A.3.b - Transport – Road Transportation

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.3.b.	Road Transportation	**69300.0**	kg/TJ	Motor Gasoline	TJ
		74100.0	kg/TJ	Diesel Oil	TJ
		63100.0	kg/TJ	Liquefied Petroleum Gas (LPG)	TJ

1.3.2. CH_4 emission factors

The estimations of CH_4 emissions in this source category can be made by applying Equation 4, whereby all types of consumed fuel would be covered by type of vehicle and type of technology:

Equation 4

$$\text{Emission} = \Sigma (\text{Fuel}_{a,b,c} \bullet EF_{a,b,c})$$

where:

Emission = CH_4 emission (kg)
$\text{Fuel}_{a,b,c}$ = consumed fuel type **a**, for vehicle type **b** and for technology type **c** (TJ)
$EF_{a,b,c}$ = emission factor (kg/TJ).
a = fuel type (Motor Gasoline, Gas/Diesel Oil, LPG)
b = vehicle type
c = emission control technology (for example: vehicles with catalyst or vehicles without catalyst)

For CH_4 the default CH_4 emission factors shown in Table 3.2.2 Volume 2, Chapter 3, Guidelines for National GHG Inventories, page 3.21 have been taken.

The CH_4 emission factors for the fuels relevant for the source category 1.A.3.b – Transport – Road Transportation, are given in Table 14.

Table 14: CH_4 Emission factors for source category 1.A.3. – Transport – Road Transportation

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.3.b.i	Passenger cars without catalyst	**33.0**	kg/TJ	Motor Gasoline	TJ
	Passenger cars with catalyst	**25.0**	kg/TJ	Motor Gasoline	
	Passenger cars	**3.9**	kg/TJ	Diesel Oil	TJ
		62.0	kg/TJ	Liquefied Petroleum Gas (LPG)	TJ
1.A.3.b.ii	Light duty vehicles	**3.8**	kg/TJ	Motor Gasoline	TJ
		3.9	kg/TJ	Diesel Oil	TJ
1.A.3.b.iii	Heavy duty vehicles and buses	**3.9**	kg/TJ	Diesel Oil	TJ
1.A.3.b.iv	Motorcycles	**33.0**	kg/TJ	Motor Gasoline	TJ

1.3.3. N_2O emission factors

The estimations of N_2O emissions in this source category can be made by applying Equation 4, whereby all types of consumed fuel would be covered by type of vehicle and type of technology:

For N_2O the default N_2O emission factors shown in Table 3.2.2 Volume 2, Chapter 3, Guidelines for National GHG Inventories, page 3.21 have been taken.

The N_2O emission factors for the fuels relevant for the source category 1.A.3.b – Transport – Road Transportation, are given in Table 15.

Table 15: N_2O Emission factors for source category 1.A.3. – Transport – Road Transportation

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.3.b.i	Passenger cars without catalyst	**3.2**	kg/TJ	Motor Gasoline	TJ
	Passenger cars with catalyst	**8.0**	kg/TJ	Motor Gasoline	
	Passenger cars	**3.9**	kg/TJ	Diesel Oil	TJ
		0.2	kg/TJ	Liquefied Petroleum Gas (LPG)	TJ
1.A.3.b.ii	Light duty vehicles	**5.7**	kg/TJ	Motor Gasoline	TJ
		3.9	kg/TJ	Diesel Oil	TJ
1.A.3.b.iii	Heavy duty vehicles and buses	**3.9**	kg/TJ	Diesel Oil	TJ
1.A.3.b.iv	Motorcycles	**3.2**	kg/TJ	Motor Gasoline	TJ

1.3.4. CO emission factors

The estimations of CO emissions in this source category can be made by applying Equation 5, whereby all types of consumed fuel would be covered for every type of vehicle:

Equation 5

$$\text{Emission} = \Sigma (\text{Fuel}_{a,b} \bullet EF_{a,b})$$

where:

Emission = CO emission (kg)
Fuel $_{a,b}$ = consumed fuel type **a**, for vehicle type **b** (GJ)
EF $_{a,b}$ = Emission factor (g/GJ).
a = fuel type (Motor Gasoline, Gas/Diesel Oil, LPG)
b = vehicle type

For CO the default CO emission factors given in Table 3-5 и Table 3-6, 1.A.3.b Road Transportation, page 20, EMEP/EEA Guidebook 2009 have been taken. These emission factors expressed in g/kg of fuel, are converted into g/Gg of fuel by applying the net calorific values (NCV) specific for the fuels consumed in the country. Thus, the CO emission factors for the abovementioned fuels have been obtained, as they are shown in Table 16.

Table 16: CO Emission factors for source category 1.A.3. – Transport – Road Transportation

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.3.b.i	Passenger cars	**3069.76**	g/GJ	Motor Gasoline	GJ
		109.30	g/GJ	Diesel Oil	GJ
		1478.26	g/GJ	Liquefied Petroleum Gas (LPG)	GJ
1.A.3.b.ii	Light duty vehicles	**3604.65**	g/GJ	Motor Gasoline	GJ
		255.81	g/GJ	Diesel Oil	GJ
1.A.3.b.iii	Heavy duty vehicles and buses	**186.04**	g/GJ	Diesel Oil	GJ
1.A.3.b.iv	Motorcycles	**11395.34**	g/GJ	Motor Gasoline	GJ

1.3.5. NOx emission factors

The estimations of NOx (expressed as NO_2) emissions in this source category can be made by applying Equation 5, whereby all types of consumed fuel would be covered for every type of vehicle:

For NOx the default NOx emission factors given in Table 3-5 and Table 3-6, 1.A.3.b Road Transportation, page 20, EMEP/EEA guidebook 2009 have been taken. These emission factors expressed in g/kg of fuel, are converted into g/Gg of fuel by applying the net calorific values (NCV) specific for the fuels used in the country. In this way, the NO_2 emission factors for the abovementioned fuels have been obtained, as they are shown in Table 17.

Table 17: NO_2 Emission factors for source category 1.A.3. – Transport – Road Transportation

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.3.b.i	Passenger cars	**360.46**	g/GJ	Motor Gasoline	GJ
		255.81	g/GJ	Diesel Oil	GJ
		336.95	g/GJ	Liquefied Petroleum Gas (LPG)	GJ
1.A.3.b.ii	Light duty vehicles	**558.14**	g/GJ	Motor Gasoline	GJ
		348.84	g/GJ	Diesel Oil	GJ
1.A.3.b.iii	Heavy duty vehicles and buses	**860.47**	g/GJ	Diesel Oil	GJ
1.A.3.b.iv	Motorcycles	**220.93**	g/GJ	Motor Gasoline	GJ

1.3.6. NMVOC emission factors

The estimations of NMVOC emissions in this source category can be made by applying Equation 5, whereby all types of consumed fuel would be covered for every type of vehicle:

For NMVOC the default NMVOC emission factors given in Table 3-5 and Table 3-6, 1.A.3.b Road Transportation, page 20, EMEP/EEA Guidebook 2009 have been taken. These emission factors expressed in g/kg of fuel, are converted into g/Gg of fuel by applying the net calorific values (NCV) specific for the fuels consumed in the country. In this way, the MNVOC emission factors for the abovementioned fuels have been obtained, as they are shown in Table 18.

Table 18: NMVOC Emission factors for source category 1.A.3. – Transport – Road transportation

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.3.b.i	Passenger cars	**325.58**	g/GJ	Motor Gasoline	GJ
		25.58	g/GJ	Diesel Oil	GJ
		217.39	g/GJ	Liquefied Petroleum Gas (LPG)	GJ
1.A.3.b.ii	Light duty vehicles	**325.58**	g/GJ	Motor Gasoline	GJ
		41.86	g/GJ	Diesel Oil	GJ
1.A.3.b.iii	Heavy duty vehicles and buses	**37.21**	g/GJ	Diesel Oil	GJ
1.A.3.b.iv	Motorcycles	**2651.16**	g/GJ	Motor Gasoline	GJ

In respect of the sub-category **1.A.3.b.v – Evaporative emissions from vehicles** which refers only to NMVOC, the default emission factors for different average temperatures in course of the year have been taken. These factors are given in Table 3-1, page 8, Table 3-2, Table 3-3 и Table 3-1, page 9, EMEP/EEA Guidebook 2009.

Data about the number of days with certain average temperature in course of the year are obtained from the Statistical Yearbooks of the Republic of Macedonia, Chapter 02, Section – Environment.

The proposed NMVOC emission factors for evaporation at different daily temperature intervals are shown in Table 19.

Table 19: NMVOC Emission factors for source category 1.A.3. – Transport – Evaporative emissions from vehicles

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Vehicle type	Measurement unit	Daily temperature interval
1.A.3.b.v	Evaporative emissions from vehicles	**24.9**	g/ vehicle/ day	Motor Gasoline PCs	Vehicle/ day	When daily temperature is within the range of 20 and 35 °C
		37.9	g/ vehicle/ day	Motor Gasoline LDVs	Vehicle/ day	
		5.0	g/ vehicle/ day	Two-stroke vehicles	Vehicle/ day	
		14.8	g/ vehicle/ day	Motor Gasoline PCs	Vehicle/ day	When daily temperature is within the range of 10 and 25 °C
		22.6	g/ vehicle/ day	Motor Gasoline LDVs	Vehicle/ day	
		3.0	g/ vehicle/ day	Two-stroke vehicles	Vehicle/ day	
		10.8	g/ vehicle/ day	Motor Gasoline PCs	Vehicle/ day	When daily temperature is within the range of 0 and 15 °C
		16.6	g/ vehicle/ day	Motor Gasoline LDVs	Vehicle/ day	
		2.3	g/ vehicle/ day	Two-stroke vehicles	Vehicle/ day	
		7.7	g/ vehicle/ day	Motor Gasoline PCs	Vehicle/ day	When daily temperature is within the range of 10 and 5 °C
		11.7	g/ vehicle/ day	Motor Gasoline LDVs	Vehicle/ day	
		1.6	g/ vehicle/ day	Two-stroke vehicles	Vehicle/ day	

1.4. Source Category 1.A.4 – OTHER SECTORS

Sub-category 1.A.4.b – Residential sector is key source of: **CO_2; CH_4; N_2O; CO; NOx; NMVOC and TSP**

Thereby, the following fuels are being consumed:

- Gas/Diesel Oil
- Liquefied Petroleum Gas (LPG)
- Other petroleum products
- Coal – Lignite
- Wood / wood waste.

This list of fuels is made on the basis of what kind of fuel is consumed in this sub-sector. This is shown in the Statistical Yearbooks of the Republic of Macedonia in section 11. Industry, Construction and Energy, Chapter 11.03. – Energy.

- **Methodological approach (or selection of method)**

According to 2006 IPCC Guidelines for National Greenhouse Gas Inventories and EMEP/EEA Air Pollutant Emission Inventory Guidebook 2009, there are three tier methods for determining the emissions from this sector. They are as follows:

Tier 1 method is based on the quantities of fuel consumed by type and the default emission factors for those fuels.

Tier 2 method takes into consideration the quantities of fuel consumed by type and the country-specific emission factors, when possible, obtained from the national characteristics of fuels;

Tier 3 method takes into consideration the quantities of fuel consumed by type and the data on combustion technologies, that is, the data on the way of combustion (housing heating installations, smaller boilers, domestic boilers, ovens, cookers, etc.), as well as thorough emission models or measurement data.

In the process of determining the emission factors for the abovementioned gases, the recommendations given in Tier 1 and partially in Tier 2 have been applied depending on to the availability of obtainable data.

- **Determination of emission factors**

The determination of emission factors was made on the basis of:

- Data on the quantities of fuel consumed in this sector;
- Data on the characteristics of fuels consumed (carbon content in lignite);
- Selection of default emission factors recommended in 2006 IPCC Guidelines for National Greenhouse Gas Inventories and EMEP/EEA Air Pollutant Emission Inventory Guidebook 2009.

1.4.1. CO_2 emission factors

The determination of the CO_2 emission factor for lignite is made by applying Equation 1. Data obtained from REK Bitola have been used for that purpose.

For lignite, the determination of the CO_2 emission factors is made by doing a calculation and applying the Equation [1].

For the other fuels (Gas/Diesel Oil, liquefied petroleum gas, other petroleum products and wood / wood waste) the default CO_2 emission factors which are given in Table 2.5 Volume 2, Chapter 2, 2006 Guidelines for National GHG Inventories, page 2.22 and page 2.23 have been taken.

The CO_2 emission factors for the fuels relevant for the sub-category 1.A.4.b - Residential Sources are shown in Table 20.

Table 20: CO_2 emission factors for sub-category 1.A.4.b - Residential Sources

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.4.b	Residential	**74.1**	t/TJ	Gas/Diesel Oil	TJ
		63.1	t/TJ	Liquefied Petroleum Gas (LPG)	TJ
		73.3	t/TJ	Other petroleum products	TJ
		104.11	t/TJ	Lignite	TJ
		112.0	t/TJ	Wood / Wood waste.	TJ

1.4.2. CH_4 emission factors

For all types of fuels consumed in this source category the default CH_4 emission factors shown in Table 2.5 Volume 2, Chapter 2, 2006 Guidelines for National GHG Inventories, page 2.22 and page 2.23 have been used.

The CH_4 emission factors for the fuels relevant for the sub-category 1.A.4.b - Residential Sources are shown in Table 21.

Table 21: CH_4 emission factors for sub-category 1.A.4.b - Residential Sources

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.4.b	Residential	**10.0**	kg/TJ	Gas/Diesel Oil	TJ
		5.0	kg/TJ	Liquefied Petroleum Gas (LPG)	TJ
		10.0	kg/TJ	Other petroleum products	TJ
		300.0	kg/TJ	Lignite	TJ
		300.0	kg/TJ	Wood / Wood waste.	TJ

1.4.3. N_2O emission factors

For all types of fuels consumed in this source category the default N_2O emission factors shown in Table 2.5 Volume 2, Chapter 2, 2006 Guidelines for National GHG Inventories, page 2.22 and page 2.23 have been taken.

The N_2O emission factors for the fuels relevant for the sub-category 1.A.4.b - Residential Sources are shown in Table 22.

Table 22: N_2O emission factors for sub-category 1.A.4.b. - Residential Sources

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.4.b	Residential	**0.6**	kg/TJ	Gas/Diesel Oil	TJ
		0.1	kg/TJ	Liquefied Petroleum Gas (LPG)	TJ
		0.6	kg/TJ	Other petroleum products	TJ
		1.5	kg/TJ	Lignite	TJ
		4.0	kg/TJ	Wood / wood waste.	TJ

1.4.4. CO emission factors

For all types of fuels consumed in this sector, the default CO emission factors given in Table 3-3, page 21, Table 3-5, page 23, and Table 3-6, page 24, 1.A.4 Small Combustion, EMEP/EEA Guidebook 2009 have been taken.

The CO emission factors for the fuels relevant for the sub-category 1.A.4.b - Residential Sources are shown in Table 23.

Table 23: CO emission factors for sub-category 1.A.4.b - Residential Sources

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.4.b	Residential	**46.0**	g/GJ	Gas/Diesel Oil	GJ
		31.0	g/GJ	Liquefied Petroleum Gas (LPG)	GJ
		46.0	g/GJ	Other petroleum products	GJ
		4600.0	g/GJ	Lignite	GJ
		5300.0	g/GJ	Wood / wood waste.	GJ

1.4.5. NOx emission factors

For all types of fuels consumed in this sector, the default NO_2 emission factors given in Table 3-3, page 21, Table 3-5, page 23, и Table 3-6, page 24, 1.A.4 Small combustion, EMEP/EEA Guidebook 2009 have been taken.

The NO_2 emission factors for the fuels relevant for the sub-category 1.A.4.b - Residential Sources are shown in Table 24.

Table 24: NO_2 emission factors for sub-category 1.A.4.b - Residential Sources

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.4.b	Residential	**68.0**	g/GJ	Gas/Diesel Oil	GJ
		57.0	g/GJ	Liquefied Petroleum Gas (LPG)	GJ
		68.0	g/GJ	Other petroleum products	GJ
		110.0	g/GJ	Lignite	GJ
		74.5	g/GJ	Wood / wood waste	GJ

1.4.6. NMVOC emission factors

For all types of fuels consumed in this sector, the default NMVOC emission factors given in Table 3-3, page 21, Table 3-5, page 23, and Table 3-6, page 24, EMEP/EEA Guidebook 2009 have been taken.

The NMVOC emission factors for the fuels relevant for the sub-category 1.A.4.b - Residential Sources are shown in Table 25.

Table 25: NMVOC emission factors for sub-category 1.A.4.b - Residential Sources

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.4.b	Residential	**15.5**	g/GJ	Gas/Diesel Oil	GJ
		10.5	g/GJ	Liquefied Petroleum Gas (LPG)	GJ
		15.5	g/GJ	Other petroleum products	GJ
		484.0	g/GJ	Lignite	GJ
		925.0	g/GJ	Wood / wood waste.	GJ

1.4.7. TSP emission factors

For all types of fuels consumed in this sector, the default TSP emission factors given in Table 3-3, page 21, Table 3-5, page 23, and Table 3-6, page 24, EMEP/EEA Guidebook 2009 have been taken.

The TSP emission factors for the fuels relevant for the sub-category 1.A.4.b - Residential Sources are shown in Table 26.

Table 26: TSP emission factors for sub-category 1.A.4.b - Residential Sources

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.A.4.b	Residential	**6.0**	g/GJ	Gas/Diesel Oil	GJ
		0.5	g/GJ	Liquefied Petroleum Gas (LPG)	GJ
		6.0	g/GJ	Other petroleum products	GJ
		444.0	g/GJ	Lignite	GJ
		730.0	g/GJ	Wood / wood waste.	GJ

1.5. Source Category 1.B FUGITIVE EMISSIONS FROM FUELS

This sub-category 1.B.1.a ii Coal Mining and Handling – Open Cast Mining is a key source of **CH_4** and **NMVOC**.

All lignite mines in the country are surface mines. The geological process of coal formation produces methane (CH_4), part of which remains trapped within the coal bed until the coal is being extracted. According to Tier 2 method a country-specific emission factors or basin-specific emission factors should be used which reflect the average methane content in the coal that is being extracted.

It is being assumed that CH_4 emissions in open cast mining come from two sources:

- from the coal itself that is being extracted and
- from surrounding layers which open during the mining process.

According to Tier 1 method, the separation of these sources is ignored and one emission factor is used.

According to Tier 2 method, emission factors are necessary for each source individually.

If there is additional information on the content of methane in-situ and on other characteristics of the coal that is being extracted from the surface of the land, methane emission estimates for Tier 2 called “Method for determining country-specific and basin-specific emissions” can be used. When determining the methane emission factor the recommendations given in Tier 1 have been applied.

1.5.1. CH_4 emission factors

When determining CH_4 emission factor the recommendations given in Volume 2; Chapter 4; Guidelines for National GHG Inventories, page 4.18 have been applied, according to which the emission factor value equals to the range between 0.3 and 2.0 m^3 CH_4/t lignite. In absence of more recent data, the same value which was used in the Inventory of the Second National Communication has been used, that is, 1.5 m^3 CH_4/t lignite.

The **CH_4** emission factor is presented in Table 27.

Table 27: CH_4 emission factor for sub-category 1.B.1.a ii – Open Cast Coal Mining

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.B.1.a ii	Coal mining and handling – open cast mining	**1.5**	m^3 CH_4 / t	Lignite	t of coal produced

1.5.2. NMVOC emission factor

For NMVOC the default NMVOC emission factors shown in Table 3-2, 1.B.1.a, page 10, Coal-mining-and-handling EMEP/EEA Guidebook 2009 have been taken. The NMVOC emission factor is given in table 28.

Table 28: NMVOC emission factor for sub-category 1.B.1.a – Open Cast Coal Mining

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
1.B.1.a	Coal mining and handling – open cast mining	**0.2**	kg/Mg of coal produced	Lignite	Mg of coal produced

2.0. INDUSTRIAL PROCESSES

2.1. Source Category 2.A. - MINERAL INDUSTRY

In the source category of Mineral Industry, key source of carbon dioxide (CO2) emission is the Sub-category **2.A.1 – Cement Production**.

In the cement production process, CO_2 emissions appear as a result of the use of dolomite (CaCO3) or other carbonate raw material, which when heated breaks down to form CaO and CO_2 as by-product. In fact, main CO_2 emissions emerge in the course of production of clinker which is an indirect component in the process of cement production.

There is one cement production factory in the country – Titan Cementarnica Usje A.D. Skopje. Marlstone is used as basic mineral raw material and it is obtained from the open cast mine Usje located within the factory. Marlstone, as a non-metallic mineral raw material is a basic component in the production of clinker, that is, cement. Other components are used, apart from marlstone, in order to form fly ash, from which the semi-finished product – clinker is obtained.

- **Methodological approach**

Three tier method for determination of CO_2 emissions is being used in this sector.

Tier 1 method is based on the quantities of clinker used (data obtained on the basis of the quantities of cement produced), adjusted to the quantities of clinker imported and exported, multiplied by the default emission factor.

Tier 2 method uses the data for direct production of clinker and applies the national emission factor.

Tier 3 method takes into consideration broken down data on all input carbonate components consumed in the process of clinker production, as well as their respective emission factors.

The recommendations given in Tier 2 were used in the process of determining the CO_2 emission factor.

- **Determination of emission factors**

Determination of the emission factor was made on the basis of:

- Data on the total annual cement production;
- Data on the total annual clinker production;
- Percentage share of clinker in the cement;
- Data on the quantity of imported clinker;
- CaO share in clinker (mean annual value);
- MgO share in clinker (mean annual value);
- Percentage share in cement kiln dust (CKD) which is recycled.

The above data were obtained from Titan Cementarnica Usje Skopje.

2.1.1. CO_2 emission factors

For the purpose of determining CO_2 emissions, IPCC Good Practice Guidance recommends Tier 2 method and application of the national data on production of clinker, national emission factor for clinker and corrective emission factor for Cement Kiln Dust (CKD) by applying Equation 6.

Equation 6

$$CO_{2\ \mathbf{Emissions}} = M_{\mathbf{cl}} \bullet EF_{\mathbf{clinker}} \bullet CF_{\mathbf{ckd}}$$

where:

$CO_{2\ \mathbf{Emissions}}$ = CO_2 emissions from production of cement, (tonnes);
Mcl = mass of produced clinker, (tonnes);
EFclinker = emission factor for clinker, (tones of CO_2/ tones of clinker);
CFckd = corrective emission factor for CKD (Cement Kiln Dust).

Emission factor for clinker (EFclinker)

The emission factor for clinker is determined by applying Equation 7:

Equation 7

EFclinker = CaO content (mass share) in clinker • (44,01 g/mole CO_2 / 56,08 g/mole CaO) + MgO Content (mass share) in clinker • (44,01 g/mole CO_2 / 40 g/mole CaO)

that is:

Equation 7a

EFclinker = CaO content in clinker • 0,785 + MgO content in clinker • 1,1

According to the data received from Titan Cementarnica Usje Skopje (CaO share in the clinker amounts to 0.65, and MgO share in the clinker amounts to 0.029) relevant value for the CO_2 emission factor which amounts to 0.54215 (tonnes of CO_2/ tonnes of clinker) has been obtained.

Corrective emission factor for Cement Kiln Dust (CFckd).

According to Tier 2 method, the value of the corrective emission factor CFckd is determined by applying Equation 8.

Equation 8

$$CFckd = 1 + (Md / Mcl) \bullet Cd \bullet Fd \bullet (EFc / EFcl)$$

where:

CFckd = corrective emission factor CKD, (non-dimensional);
Md = CKD (Cement Kiln Dust) mass – Cement kiln dust which is not recycled in the kiln, (tonnes);
Mcl = mass of produced clinker, (tonnes);
Cd = fraction of original carbonate in CKD (i.e. before calcination), (fraction);
Fd = fraction of calcined carbonate in CKD, (fraction);

EFc = emission factor for carbonate, (tonnes of CO_2/ tonnes of carbonate);
EFcl = emission factor for clinker without corrections to the CKD, (tonnes of CO_2/ tonnes of clinker).

According to the information received from Titan Cementarnica Usje Skopje, the total CKD content is being returned again in the kiln and is being recycled. It means that Md = 0, i.e. by applying Equation 8 the following is obtained:

CFckd = 1+ 0 = **1**

The CO_2 emission factors for clinker and the corrective emission factor CFckd are shown in Table 29.

Table 29: CO_2 emission factor and corrective emission factor for 2.A.1 – Cement Production.

Code	Factor	Value	Measurement unit (EF)	Activity rate	Measurement unit (for the activity rate)
1.A.1.a Cement Production	EFclinker	**0.54215**	tonnes of CO_2/ tonnes of clinker	Clinker	tonnes of clinker
	CFckd	**1**	-	-	-

2.2. Source Category 2.C – METAL PRODUCTION

In the source category of the Metal Production, key sources of carbon dioxide (CO_2) emissions are the following sub-sectors:

- Iron and Steel Production (2.C.1) and
- Ferroalloy Production (2.C.2)

2.2.1. Iron and Steel Production (2.C.1)

Nationally, iron and steel are being produced in the factory Makstil AD Skopje. To be more precise, the economic activity of this factory covers steel and hot rolled plate production. 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: Steel Mill – production of steel in slabs and Rolling Mill for thick plates – production of hot rolled plates.

The production process of the Steel Mill involves preparation and processing of scrap iron which is being melted in an electric arc furnace, thus, producing liquid steel. This liquid steel is then further processed in ladle furnace (which is an electric furnace) and afterwards continuously cast into slabs. The process in the Rolling Mill for thick plates includes heating of slabs in pre-heating furnace and hot rolling of slabs in rolling mills.

In the process of production of slabs, apart from scrap iron as main input raw material, other materials are used as well, which act as reducing agents, melting agents and electrodes for the electric furnaces (anthracite, coke, lime, dolomite, electrode mass).

- **Methodological approach**

Three-tier method for determination of CO_2 emissions is being used in this sector.

Tier 1 is based on data about the total quantity of iron and steel produced on national level and use of default emission factors.

Tier 2 method implies the use of data about consumed raw materials, including the quantities of reducing agents in the production of iron and steel. This method is based on tracking carbon in the production process through the mass balance and carbon content in the respective materials that have been used. Emission estimates are based on specific data about each plant. This method provides much more accurate emission estimations compared to Tier 1 method because it takes into consideration current quantities of input raw materials and their impact on CO_2 emissions.

Tier 3 method takes into account specific data about the installation, as well as CO_2 emission measurements.

IPCC Good Practice Guidance recommends calculating plant emissions. In the process of determining the CO_2 emission factor the recommendations given in Tier 2 were used.

- **Determination of emission factors**

The determination of emission factors was made on the basis of:

- Data on the annual steel production;
- Data on the annual consumption of anthracite;
- Data on the annual consumption of coke;

- Data on the annual consumption of lime;
- Data on the annual consumption of dolomite;
- Data on the annual consumption of a carbon electrode;
- Carbon content in these materials.

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

The data on carbon content in the aforementioned materials have been obtained from Table 4.3 Volume 3, Chapter 4, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 4.27.

CO_2 emission factors

According to the proposed Tier 2 method, the following Equation 9 is applied for the purpose of making an estimation of CO_2 emissions:

Equation 9

$$E_{CO2,non-energy} = \left[PC \bullet C_{PC} + \sum_a (COB_a \bullet C_a) + CI \bullet C_{CI} + L \bullet C_L + D \bullet C_D + CE \bullet C_{CE} + \sum_b (O_b \bullet C_b) + COG \bullet C_{COG} - S \bullet C_S - IP \bullet C_{IP} - BG \bullet C_{BG} \right] \bullet \frac{44}{12}$$

where:

E_{CO2}, non-energy = CO_2 emissions, tonnes;
PC = quantities of coke consumed in the process of iron and steel production (not including the production of sinter), tonnes;
COBa = quantity of by-product from a furnace which is used in blast furnaces, tonnes;
CI = quantity of coal directly injected into blast furnaces, tonnes
L = quantity of limestone used in the process of iron and steel production, tonnes;
D = quantity of dolomite used in the process of iron and steel production, tonnes;
CE = quantity of carbon electrodes used in electric arc furnaces, tonnes;
Ob = quantity of other carbonates and the process material b which is used in the process of iron and steel production, like for example, sinter or plastic waste, tonnes;
COG= quantity of gas from a coke furnace which is consumed at the blast furnace in the process of iron and steel production, m3 (or other measurement units, like for example, tonnes or GJ). Unit conversion should be compliant with Volume 2: Energy)
S = quantity of steel produced, tonnes;
IP = quantity of produced iron which is not converted into steel, tonnes;
BG = quantity of gas from blast furnaces transferred outside the location;
Cx = carbon content in material x, tonnes of C/ tonne of material x.

Having in mind the fact that ore is not used for producing liquid steel, and that scrap iron is used for that purpose, and also having in mind that the process takes place in electric furnaces only, some units in Equation 9 will be equal to zero and the Equation takes the following formation:

Equation 9a

$$E_{CO2,\ non\text{-}energy} = [PC \bullet C_{PC} + L \bullet C_L + D \bullet C_D + CE \bullet C_{CE} - S \bullet C_S] \bullet 44 / 12$$

Based on the calculations that have been made and by applying the data that were mentioned previously the respective value of the CO_2 emission factor is obtained which amounts to 0.0899 (tonnes of CO_2/ tonnes of steel).

The CO_2 emission factor for the sub-category Iron and Steel Production is shown in Table 30.

Table 30: CO_2 emission factor for the sub-category 2.C.1 – Iron and Steel Production.

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
2.C.1	Iron and Steel Production	**0.0899**	t / t of steel produced	Steel	t of steel produced

2.2.2 Ferroalloy Production (2.C.2)

This sub-category is one of the key sources of carbon dioxide (CO_2) emissions.

Ferroalloy producers in the country are the following companies:

- JAGUNOVCE FERROALLOYS DOO village of Jagunovce, which produces FeSi 75% and Si – metal. The technology enables production of FeSi 75%, but according to the demands of the clients, lower percentage FeSi is being produced;
- SKOPSKI LEGURI DOOEL Skopje, which produces FeMn and SiMn;
- FENI INDUSTRY Kavadarci, which produces FeNi.

- **Methodological approach**

Three tiers for determination of CO_2 emissions are being used in this sector.

Tier 1 method is based on data about the total quantity of ferroalloys produced on national level and use of default emission factors. This method is simple, but less accurate.

Tier 2 method for emissions estimation uses data about the input raw material, as well as about the consumption of reducing agents which are used in ferroalloy production. This method is based on tracking carbon in the production process through the mass balance and carbon content in the respective materials that have been used. Emission estimates are based on specific data about each plant. This method provides much more accurate emission estimations compared to Tier 1 method because it takes into consideration current quantities of input raw materials and their impact on CO_2 emissions.

Tier 3 method takes into account specific data about the installation, as well as CO_2 emission measurements.

IPCC Good Practice Guidance recommends plant emission estimates. Therefore, the ferroalloy producers have provided the necessary information and data for each ferroalloy individually (FeSi, FeMn, SiMn and FeNi). When determining the CO_2 emission factor the recommendations given in Tier 2 have been applied.

- **Determination of emission factors**

The determination of emission factors is done on the basis of received data necessary for the production of each ferroalloy individually. These data refer to:

- Annual manufacture of finished products;
- Annual ore consumption:
- Annual consumption of reducing agents (coke, lignite, limestone);
- Data on the annual consumption of carbon electrodes;
- Carbon content in these materials.

CO_2 emission factors

The following Equation 10 is applied with the purpose of making an estimation of CO_2 emissions:

Equation 10

$$E_{CO2,} = [\ \Sigma(RAj \bullet C_{RA\,i}) + \ OR \bullet C_{ORE} + CE \bullet C_{CE} - FA \bullet C_{FA}] \bullet 44 / 12$$

where:

E_{CO2} = CO_2 emissions, tonnes;
Raj = quantity of type **j** reducing agents, tonnes;
OR = ore quantity, tonnes;
CE = quantity of carbon electrode, tonnes;
FA = quantity of finished ferroalloy product, tonnes;
$C_{RA}i$; C_{ORE}; C_{CE}; C_{FA} = carbon content in the materials, tonnes of C/ tonne of material

Based on the calculations made by applying the aforementioned data, respective values of CO_2 emission factors have been obtained for each ferroalloy individually. Those values are shown in Table 31.

Table 31: CO_2 emission factors for source category 2.C.2. – Ferroalloy Production.

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity	Measurement unit (activity)
2.C.2	Ferroalloy Production	**4.1782**	t / t ferroalloy	Ferrosilicon FeSi 75%	t
		1.3457	t / t ferroalloy	Ferromanganese	t
		1.5511	t / t ferroalloy	Silicon manganese	t
		4.0158	t / t ferroalloy	Ferronickel	t

2.3. Source Category 2.D – OTHER INDUSTRY

Sub-category **2.D.2 – Food and drinks** is the key source of NMVOC emissions within source category 2.D - OTHER INDUSTRY.

- **Methodological approach**

Three tiers for determination of NMVOC emissions are being used in this sector.

Tier 1 is based on data about the total quantity of food and drinks produced on national level and use of single default emission factor.

Tier 2 is based on providing data on the total quantities of each type of product (or a group of similar products) and use of respective emission factor for each type of product.

Tier 3 method takes into consideration the data from the installations themselves, if they can be provided and if they cover the total annual production of that type of food or product.

Good Practice Guidance advises to apply the recommendations given in the Tier 2 method when determining NMVOC emissions.

- **Determination of emission factors**

The determination of emission factors was made on the basis of:

- Selection of default emission factors recommended in EMEP/EEA Air Pollutant Emission Inventory Guidebook 2009.

NMVOC emission factors

According to the proposed Tier 2 method, the following Equation is applied for the purpose of making an estimation of NMVOC emissions:

Equation 11

$$E_{NMVOC} = \Sigma \left(AR_{production,\ technology} \bullet EF_{tecnology,\ NMVOC} \right)$$

where:

AR production, technology = quantity of product in the source category by applying a specific technology;
EF technology, $_{NMVOC}$ = emission factor for this technology and for this pollutant.

Data on the activity rate can be obtained from the Statistical Yearbooks of the Republic of Macedonia or from the relevant separate statistical reports.

The values of NMVOC emission factors are shown in Table 3-11, from Table 3-18 to Table 3-28 and Table 3-32, page 13 – page 21. 2.D.2 Food and drinks, EMEP/EEA Air Pollutant Emission Inventory Guidebook 2009.

The NMVOC emission factors for specific technologies for food and drinks are shown in Table 32.

Table 32: Summary of NMVOC emission factors for specific technologies for food and drinks.

Code	Sub-sector	Value (EF)	Measurement unit (EF)	Activity rate	Measurement unit (for the activity rate)
2.D.2	Bread	**4.5**	kg/Mg bread	Bread	Mg of bread
	Cookies, biscuits, cereals	**1.0**	kg/Mg product	Cookies, biscuits, cereals	Mg of product
	Meat, fish and poultry	**0.3**	kg/Mg product	Meat, fish and poultry	Mg of product
	Sugar	**10.0**	kg/Mg sugar	Sugar	Mg of sugar
	Margarine and solid fats for cooking	**10.0**	kg/Mg product	Margarine and solid fats for cooking	Mg of product
	Fodder	**1**	kg/Mg food	Fodder	Mg of food
	Roasting coffee	**0.55**	kg/Mg beans	Coffee beans	Mg of beans
	Wine with undetermined colour	**0.08**	kg/hl wine	Wine	hl wine
	Red wine	**0.08**	kg/hl wine	Wine	hl wine
	White wine	**0.035**	kg/hl wine	Wine	hl wine
	Beer (including alcohol free)	**0.035**	kg/hl wine	Wine	hl of wine
	Alcoholic drinks	**15.0**	kg/hl alcohol	alcohol	hl of alcohol

2.4. Source Category 2.A.6 – ROAD PAVING WITH ASPHALT

This source category is one of the key sources of TSP emissions.

- **Methodological approach**

Three tier method for determination of NMVOC emissions is being used in this sector.

Tier 1 method is based on data about the total quantity of asphalt for paving produced on national level and use of default emission factor.
Tier 2 method is based on providing data on the quantities of asphalt produced on national level by applying a specific production technology and a relevant emission factor for each phase of the technological process (heating, mixing, paving with asphalt etc.).
The Tier 3 method takes into consideration the data provided by the production facilities themselves, if they can be provided and if they cover the total annual production activity.

The Good Practice Guidance advise to apply the recommendations given in Tier 2 method when determining NMVOC emissions; however, having regard to the fact that no relevant data necessary for this field are available, the recommendations given in the Tier 1 method have been applied.

- **Determination of emission factors**

Determination of the emission factor was made on the basis of:
- Selection of default emission factors recommended in EMEP/EEA Air Pollutant Emission Inventory Guidebook 2009.

NMVOC emission factor
According to the proposed Tier 1 methodology, the following Equation is applied for the purpose of making an estimation of TSP emissions:

Equation 12

$$E_{TSP} = AR_{production} \bullet EF_{TSP}$$

where:

E_{TSP} = specified pollutant emission (TSP)
AR production = activity rate for paving with asphalt
EF_{TSP} = emission factor for this pollutant

For this sector, the default TSP emission factor shown in Table 3-1, 2.A Mineral industry, 2.A.6 page 8, EMEP/EEA Guidebook 2009 has been taken. The TSP emission factor is shown in Table 33.

Table 33: TSP emission factor for sub-category 2.A.6. – Road Paving with Asphalt

Code	Sector	Value (EF)	Measurement unit (EF)	Activity rate	Measurement unit (for the activity rate)
2.A.6	Road paving with asphalt	**14**	kg/Mg asphalt	asphalt	Mg

Data on the quantity of asphalt used on annual level for road paving can be obtained from the separate reports of the State Statistical Office.

3.0. AGRICULTURE

This is key sector concerning methan (CH_4) and nitrous oxide (N_2O) emissions.

Key source sub-sectors covered by this sector are:

- 4.A Enteric Fermentation
- 4.B Manure Management and
- 4.D Agricultural Soils

Text below gives general descriptions related to selection of relevant emission factors for this sector.

- **Emissions from livestock and manure management**

➢ **Livestock Population and Feed Characterisation**

Steps to define categories and subcategories of livestock

Methodological choice for individual source categories is important in managing overall inventory quality and minimising uncertainty. Generally, inventory uncertainty is lower when emissions are estimated using the most rigorous, higher tiered, methods provided for each category or subcategory. However, these methods generally require more extensive resources for data collection and calculation, so it may not be feasible to use most rigorous method for every category of emissions. It is, therefore, good practice to identify and prioritise the effort on those categories which make the greatest contribution to the overall inventory estimates. A key category is one that is prioritised within the national inventory system because it is significantly important for one or a number of air pollutants in a country's national inventory of air pollutants in terms of the absolute level, the trend, or the uncertainty in emissions. It is good practice for each country to use key category analysis systematically and objectively as a basis for choosing methods of emission calculation. Such a process will lead to improved inventory quality as well as greater confidence in the resulting estimates.

Selection of method

Basic characterization of livestock population

Emissions can be estimated at different levels of complexity. Within the IPCC Guidelines these are expressed in three tiers of increasing complexity.

The Tier 1 method is a 'simple' method using default emission factors only. This method uses readily available statistical data on the intensity of processes (activity rates) and default emission factors. These emission factors assume a linear relation between the intensity of the process and the resulting emissions. The Tier 1 default emission factors also assume an average or typical process description. It has the highest level of uncertainty and should not be used to estimate emissions from key categories.

More complex method Tier 2 is similar to Tier 1 but uses more specific emission factors developed on the basis of knowledge of the types of processes and specific process conditions that apply in the country for which the inventory is being developed. Tier 2 methods are more complex, will reduce the level of uncertainty, and are considered adequate for estimating emissions for key categories.

To upgrade a Tier 1 to a Tier 2 method, the default emission factors should be replaced by country-specific or technology-specific emission factors. This might also require a further split of the activity data over a range of different technologies.

A Tier 3 method could be regarded as a method that uses the latest scientific knowledge in more sophisticated approaches and models. The key criterion to be met before a Tier 3 methodology can replace a Tier 2 methodology is a more accurate estimation of the relevant emissions, reducing the following common sources of error.

Enhanced characterization of livestock population (Tier 2 methodology)

In contrast to the Tier 1 characterization which relies on "basic" characterization principles to estimate emission factors, Tier 2 is based around the more detailed principles of 'enhanced" characterization.

The use of "enhanced" characterization requires detailed information on:

- Definitions for livestock subcategories (Table 10.1,2006 IPCC Guidelines for National Greenhouse Gas Inventories);
- Livestock population by subcategory, with consideration for estimation of annual population as per Tier 1; and
- Feed intake estimates for the typical animal in each subcategory..
- Definition of livestock categories and livestock population by subcategories according to age, type of production and sex is considered to be good practice and essential in applying Tier 2 methodology.

Tier 2 methodology goes even further by adding the possibility of additional division into more specific subcategories with the purpose of acquiring more detailed information. These additional subcategories offer very specific classification possibilities:

- Cattle and buffalo populations should be classified into at least three main subcategories: mature dairy, other mature, and growing cattle. Depending on the level of detail in the emissions estimation method, subcategories can be further classified based on animal or feed characteristics. For example, growing /fattening cattle could be further subdivided into those cattle that are fed a high-grain diet and housed in dry lot vs. those cattle that are grown and finished solely on pasture.
- Subdivisions similar to those used for cattle and buffalo can be used to further segregate the sheep population
- Subcategories of swine could be further segregated based on production conditions. For example, growing swine could be further subdivided into growing swine housed in intensive production facilities vs. swine that are grown under free-range conditions.
- Subcategories of poultry could be further segregated based on production conditions. For example, poultry could be divided on the basis of production under confined or free-range conditions.

In our Country, all usable data comes from Statistical Yearbook, and Operative data from Farm Animals Identification System. In regard of the first Tier 2 methodology requirement for "enhanced" characterization which is the definition of livestock population and further classification into subcategories, there is insufficient data to fulfill even the basic parameters necessary to successfully calculate the desired emission factors. Statistical data offers information on only the basic categories of livestock thus rendering the mathematical methods of estimation according to Tier 2 useless due to the lack of crucial parameters within the equations.

The only presently available data in our country offers the total number of animals per animal specie, with emphasis being placed on dairy animals and sheep and lacking in even round, let alone precise numbers for crucial subcategories like age, sex, level of production, housing type etc.

Feed intake estimates – Tier 2 emissions estimates require feed intakes for a representative animal in each subcategory. Feed intake is typically measured in terms of gross energy (e.g., megajoules (MJ) per day) or dry matter (e.g., kilograms (kg) per day). Dry matter is the amount of feed consumed (kg) after it has been corrected for the water content in the complete diet.

For all estimates of feed intake, good practice is to:

- Collect data to describe the animal's typical diet and performance in each subcategory;
- Estimate feed intake from the animal performance and diet data for each subcategory.

The first problem encountered when trying to apply Tier 2 emission estimates to feed intake in the Country originates in the previously described lack of data needed to form the required subcategories of livestock population thus making the concept of choosing a representative animal practically impossible.

Even if we look past this obstacle for a moment, we come across another problem regarding the required animal performance data for each animal subcategory to estimate feed intake for the subcategory:

- **Weight (W), kg:** It is unrealistic to perform a complete census of live-weights, so live-weight data should be obtained from representative sample studies or statistical databases if these already exist. Unfortunately, the statistical databases available in the Country offer insufficient data and studies on the subject are virtually inexistent. Seeing that for cattle, buffalo and mature sheep, the yearly average weight for each animal category (e.g., mature beef cows) is needed, further exploration of this subject proves to be pointless.
- **Average weight gain per day (WG), kg day-1:** Data on average weight gain are generally collected for feedlot animals and young growing animals. The absence of these subcategories in the statistical databases of the Country is enough of a reason to stop any additional insight into this piece of animal performance data.
- **Feeding situation:** Although there are preexisting constants regarding the animals feeding situation the inability to divide the animals into the required subcategories in the first place renders this data useless. Since detailed information may be needed when calculating the enteric fermentation emissions, because interpolation between the feeding situations may be necessary to assign the most appropriate coefficient, this puts a stop to any chance of using use of Tier 2 methodology for the estimation of emissions, at least at the present, when it come to our Country.

Further animal performance data includes mature weight , average number of hours worked per day, mean winter temperature , average daily milk production , fat content , percent of females that give birth in a year, number of off spring produced per year, feed digestibility and average annual wool production per sheep , all of which are not within the realm of possibilities of statistical data collection in the Country, at least not at this time. Our Country's present failure to comply with the suggested detailed requirements, leaves us with the only option of using of the Tier 1 methodology, at least for the time being.

3.1. Sector 4.A Enteric Fermentation

➢ Methane Emissions from Enteric Fermentation

Selection of method

It is good practice to choose the method for estimating methane emissions from enteric fermentation according to the decision tree in Figure 10.2 (2006 IPCC Guidelines for National Greenhouse Gas Inventories).

The Tier 1 method is likely to be suitable for most animal species in the Country where enteric fermentation is not a key source category, and enhanced characterization data are not available. When approximate enteric emissions are derived by extrapolation from main livestock categories they should be considered to be a Tier 1 method.

The Tier 2 method is recommended for countries with large livestock populations and implementing the Tier 2 method for additional livestock subgroups may be desirable when the category emissions are a large portion of total methane emissions for the country (table 10.9 suggested emissions inventory methods for enteric fermentation, 2006 IPCC Guidelines for National Greenhouse Gas Inventories).

The method for estimating methane emission from enteric fermentation in accordance with Tier 2 requires three basic steps:

Step 1: Divide the livestock population into subgroups and characterize each subgroup. It is recommended that national experts use annual averages estimated with consideration for the impact of production cycles and seasonal influences on population numbers.

Step 2: Estimate emission factors for each subgroup in terms of kilograms of methane per animal per year.

Step 3: Multiply the subgroup emission factors by the subgroup populations to estimate subgroup emission, and sum across the subgroups to estimate total emission.

The process of integrating Tier 2 methodology for estimation of methane emissions from enteric fermentation in the Country is inevitably and abruptly stopped at the first of the above stated three basic steps. The unavailability of enhanced livestock characterization prevents us from attaining the required detailed data necessary for classification of the livestock population into the specific subcategories which are integral to successful implementation of the Tier 2 methodology. A more specific explanation as to why we are unable, at the present time, to progress to a higher Tier methodology is presented width in this chapter.

Selection of emission factors

Enteric fermentation emission factors were taken from table 10.10 - enteric fermentation emission factors for Tier 1 method (2006 IPCC Guidelines for National Greenhouse Gas Inventories), in order to estimate total emissions. The selected emission factors are multiplied by the associated animal population (Equation 10.19 and summed Equation 10.20, 2006 IPCC Guidelines for National Greenhouse Gas Inventories).

Tier 2 Approach for methane emissions from Enteric Fermentation

The Tier 2 method is applied to more disaggregated livestock population categories and used to calculate emission factors, as opposed to default values. The key considerations for the Tier 2 method are the development of emission factors and the collection of detailed activity data.

The lack of ability to obtain precisely this type of data due to a statistical database system that's far removed from the level of its peers in other countries makes the development of emission factors specific to our Country impossible for the time being.

Step 1: Livestock population
The animal population data and related activity data should be obtained using the enhanced characterization principles. No animal population data with the required Tier 2 of detail and specific to our Country is available at the given moment, from both statistical databases and studies

Step 2: Emission factors
When the Tier 2 method is used, emission factors are estimated for each animal category using the detailed data developed in Step 1. The emission factors for each category of livestock are estimated based on the gross energy intake and methane conversion factor for the category. The gross energy intake data should be obtained using the approach described previously.

Without this crucial data, using Tier 2 methodology is practically impossible. The following two sub-steps need to be completed to calculate the emission factor under the Tier 2 method, neither of which can be achieved at our Country current state:

1. Obtaining the methane conversion factor
2. Emission factor development

Step 3: Total emissions
To estimate total emissions, the selected emission factors are multiplied by the associated animal population and summed. As with Tier 1, the emissions estimates should be reported in gig grams.

Table 34 gives an overview of the methane Emission factors (CH_4)

Table 34: Methane Emission factors from Enteric fermentation

Cod	Sector	Value (EF)	Unit (EF)	Activity (Categories /subcategories)	Unit (Activity)
4.A.1	Cattle	**81**	kg/head/year	Dairy	Head
		56	kg/head/year	Non – Dairy	Head
4.A.2	Buffalo	**55**	kg/head/year	Buffalo	Head
4.A.3	Sheep	**5**	kg/head/year	Sheep	Head
4.A.4	Goats	**5**	kg/head/year	Goats	Head
4.A.5	Camels and lamas	**0**	kg/head/year	Camels and lamas	Head
4.A.6	Horses	**18**	kg/head/year	Horses	Head
4.A.7	Mules and Asses	**0**	kg/head/year	Mules and Asses	Head
4.A.8	Swine	**1**	kg/head/year	Swine	Head
4.A.9	Poultry	**0**	kg/head/year	Poultry	Head
4.A.10	Other	**0**	kg/head/year	Other	Head

Reference: Table 10.10, Volume 4, Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Page 10.28

3.2. 4.B Manure Management

- **Methane Emissions from Manure Management**

The term 'manure' is used here collectively to include both dung and urine (i.e., the solids and the liquids) produced by livestock. The decomposition of manure under anaerobic conditions (i.e., in the absence of oxygen), during storage and treatment, produces CH4. These conditions occur most readily when large numbers of animals are managed in a confined area (e.g., dairy farms, beef feedlots, and swine and poultry farms), and where manure is disposed of in liquid-based systems.

The main factors affecting CH4 emissions are the amount of manure produced and the portion of the manure that decomposes anaerobically. The former depends on the rate of waste production per animal and the number of animals, and the latter on how the manure is managed. When manure is stored or treated as a liquid (e.g., in lagoons, ponds, tanks, or pits), it decomposes anaerobically and can produce a significant quantity of CH4. The temperature and the retention time of the storage unit greatly affect the amount of methane produced. When manure is handled as a solid (e.g., in stacks or piles) or when it is deposited on pastures and rangelands, it tends to decompose under more aerobic conditions and less CH4 is produced.

Selection of method

Tier 1
A simplified method that only requires livestock population data by animal species/category and climate region or temperature, in combination with IPCC default emission factors, to estimate emissions. Because some emissions from manure management systems are highly temperature dependent, it is good practice to estimate the average annual temperature associated with the locations where manure is managed.

Tier 2
A more complex method for estimating CH4 emissions from manure management should be used where a particular livestock species/category represents a significant share of a country's emissions. This method requires detailed information on animal characteristics and manure management practices, which is used to develop emission factors specific to the conditions of the country.

Tier 3
Some countries for which livestock emissions are particularly important may wish to go beyond the Tier 2 method and develop models for country-specific methodologies or use measurement–based approaches to quantify emission factors.
Good practice in estimating CH4 emissions from manure management systems entails making every effort to use the Tier 2 method. After exhausting all possible avenues to use the Tier 2 method and determining that the source is not a key category or subcategory, the recommendation advises that the Tier 1 method remains the best option for our Country since methane emissions from manure management can only be calculated using default values given by this type of methodology. National circumstances in our Country force us away from any attempt of implementing more precise methodology, the likes of Tier 2, since the available data is far from the needed level of precision required for calculating emission factors using country-specific information.

Once again the first obstacle we encounter lies in the very foundation of the Tier 2 principles, which in our country is unable to fulfil at the present time. According to the 2006

IPCC Guidelines for National Greenhouse Gas Inventories, regardless of the method chosen, the animal population must first be divided into categories (as described in Section 10.2) that reflect the varying amounts of manure produced per animal. The inability to devise the adequate subcategories leaves our Country firmly dependant on default data which in turn reverts to the only possibility of calculating CH4 emissions from manure which is the Tier 1 methodology.

There are four steps which are commonly used to estimate CH4 emissions from manure management. Our County's failure to comply with the very first step of this list renders all further exploration of the latter steps useless. These steps are as follows:

Step 1: Collect population data from the Livestock Population Characterization

Step 2: Use default values or develop country-specific emission factors for each livestock subcategory in terms of kilograms of methane per animal per year.

Step 3: Multiply the livestock subcategory emission factors by the subcategory populations to estimate subcategory emissions, and sum across the subcategories to estimate total emissions by primary livestock species.

Step 4: Sum emissions from all defined livestock species to determine national emissions.

Selection *of emission factors*

The Tier 2 method is applicable when Manure Management is a key source or when the data used to develop the default values do not correspond well with the country's livestock and manure management conditions. Keeping in mind that in our Country manure management is not classified as a key source, along with the lack of data required to develop country specific values, we go back to the Tier 1 methodology as the only viable option at present.

Significant variations in key livestock species and manure management systems among different countries encourage the use of the Tier 2 method in order to obtain relevant country specific data.

With cattle and sheep being the most significant species for our Country, and in so attracting considerable expert interest lately, doors seem to open to a not so unlikely opportunity of implementation of Tier 2 methodology in the near future. Unfortunately, the lack of proper data collection on manure management systems further delays the recommended integration of a more advanced method then Tier 1.

Until such times when the afore mentioned problems are solved, and sufficiently detailed, country specific data can be repeatedly gathered, an updated version of the Tier 1 method is the only way of keeping a successful record of methane emissions from manure management in our Country.

The Tier 2 method relies on two primary types of inputs that affect the calculation of methane emission factors from manure:

Manure characteristics
Includes the amount of volatile solids produced in the manure and the maximum amount of methane able to be produced from that manure. Insufficient data on both values due to the scattered nature of manure management and lack of communication is more than a sound reason for sticking with the Tier 1 methodology.

Production of manure volatile solids can be estimated based on feed intake and digestibility, which are the variables also used to develop the Tier 2 enteric fermentation emission factors. The reasons which put our Country at the back of the queue of countries lacking the information required by these two variables. Alternatively, volatile solids production rates can be based on laboratory measurements of livestock manure which doesn't seem to be within our County's grasp in the foreseeable future.

Manure management system characteristics
There is insufficient data on the types of systems used to manage manure which, alongside the understandable absence of a system-specific methane conversion factor are the basic manure management system characteristics. Regional assessments of manure management systems are impossible to conduct at the moment with only the most basic, country wide data being available on the subject, which are not in accordance with Tier 2 methodology.

Table 35 gives an overview of methane emission factors (CH_4) from manure management.

Table 35: Methane emission factors (CH4) from manure management

Cod	Sector	Value (EF)	Unit (EF)	Activity (Categories /subcategories)	Unit (Activity)
4B1	Cattle	**6**	kg/head/year	Dairy	Head
		4	kg/head/year	Non – Dairy	Head
4B2	Buffalo	**3**	kg/head/year	Buffalo	Head
4B3	Sheep	**0,1**	kg/head/year	Sheep	Head
4B4	Goats	**0,11**	kg/head/year	Goats	Head
4B5	Camels and lamas	**0**	kg/head/year	Camels and lamas	Head
4B6	Horses	**1,1**	kg/head/year	Horses	Head
4B7	Mules and Asses	**0**	kg/head/year	Mules and Asses	Head
4B8	Swine	**4**	kg/head/year	Swine	Head
4B9	Poultry	**0,012**	kg/head/year	Poultry	Head

Reference: Table 10.14, Volume 4, Chapter 10, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Page 10.38

- **N_2O Emissions from Manure Management**

The N2O emissions generated by manure in the system 'pasture, range, and paddock' occur directly and indirectly from the soil, and are therefore reported under the category 'N2O Emissions from Managed Soils'.

Direct N2O emissions occur via combined nitrification and denitrification of nitrogen contained in the manure. The emission of N2O from manure during storage and treatment depends on the nitrogen and carbon content of manure, and on the duration of the storage and type of treatment. Nitrification is likely to occur in stored animal manures provided there is a sufficient supply of oxygen. Nitrification does not occur under anaerobic conditions. The production and emission of N2O from managed manures requires the presence of either nitrites or nitrates in an anaerobic environment preceded by aerobic conditions necessary for the formation of these oxidized forms of nitrogen. In addition, conditions preventing reduction of N2O to N2, such as a low pH or limited moisture, must be present.

Indirect emissions result from volatile nitrogen losses that occur primarily in the forms of ammonia and NOx. The fraction of excreted organic nitrogen that is mineralized to ammonia nitrogen during manure collection and storage depends primarily on time, and to a lesser degree temperature. Simple forms of organic nitrogen such as urea (mammals) and uric acid (poultry) are rapidly mineralized to ammonia nitrogen, which is highly volatile and easily diffused into the surrounding air (Asman et al., 1998; Monteny and Erisman, 1998). Nitrogen is also lost through runoff and leaching into soils from the solid storage of manure at outdoor areas, in feedlots and where animals are grazing in pastures.

Selection of method
Direct N2O emissions from Manure Management

Tier 1
The Tier 1 method entails multiplying the total amount of N excretion (from all livestock species/categories) in each type of manure management system by an emission factor for that type of manure management system. Emissions are then summed over all manure management systems. The Tier 1 method is applied using IPCC default N2O emission factors, default nitrogen excretion data, and default manure management system data. This method has been used in our Country, as stated in exploiting the default values available through IPCC.

Tier 2
A Tier 2 method follows the same calculation equation as Tier 1 but would include the use of country-specific data for some or all of these variables. To estimate emissions from manure management systems, the livestock population must first be divided into categories that reflect the varying amounts of manure produced per animal as well as the manner in which the manure is handled, which is the first and essential step when trying to upgrade the emission estimation methodology to a higher Tier variant. The inability to form such categories and subcategories at present in our Country prevents advancing to Tier 2 methodology when it comes to estimation of N2O emissions from manure management

The following five steps are used to estimate direct N2O emissions from Manure Management:

Step 1: Collect population data from the Livestock Population Characterization;
Step 2: Use default values or develop the annual average nitrogen excretion rate per head for each defined livestock species/category;
Step 3: Use default values or determine the fraction of total annual nitrogen excretion for each livestock species/category that is managed in each manure management system;
Step 4: Use default values or develop N2O emission factors for each manure management system; and
Step 5: For each manure management system type, multiply its emission factor by the total amount of nitrogen managed (from all livestock species/categories) in that system, to

estimate N2O emissions from that manure management system. Then sum over all manure management systems.

Having already presented the various issues concerning the collection of population data from the livestock population characterization, which as is mentioned above is the first step towards successful calculation of direct N2O emissions from manure management, it is safe to say that our Country is not yet ready to implement higher Tier methodology. Although according to the Tier 2 method, and as can be seen from steps 2-4, default values can be used for certain parameters, being unable to comply with the demands for enhanced characterization as required by Tier 2, and being far from developing a successful system for classification and continual observation of the manure management systems with the goal of continuously obtaining detailed data, the only viable option for calculation of the direct N2O emissions from manure management systems is the previously used, default values based, Tier 1 method.

Tier 1
The Tier 1 calculation of N volatilization in forms of NH3 and NOx from manure management systems is based on multiplication of the amount of nitrogen excreted (from all livestock categories, data which is readily available in our Country) and managed in each manure management system by a fraction of volatilized nitrogen. N losses are then summed over all manure management systems. The Tier 1 method has already been applied in our Country as shown in using default nitrogen excretion data, default manure management system data and default fractions of N losses from manure management systems due to volatilization. The fact that the Tier 1 methodology is based around previously set values for the key parameters needed when estimating in direct N2O emissions from manure management systems along with our Coutry's presently limited capabilities for useful data gathering make this type of methodology the perfect choice for calculation and estimation direct N2O emissions.

Tier 2
Countries may wish to develop a Tier 2 methodology for better consideration of national circumstances and to reduce uncertainty of estimates as much as possible. However in practice, as proven in our Country it is much more difficult to raise up to the challenge of devising and successfully implementing programs which in turn are going to result in acquisition of the desired data.

As for direct N2O emission from manure management, a Tier 2 method would follow the same calculation equation as Tier 1 but include the use of country-specific data for some or all of these variables, which is the primary road block to upgrading the present tier methodology to a higher one in our Country. One example states the use of country-specific nitrogen excretion rates for livestock categories as part of the Tier 2 method. Two problems arise at the very first glance of this example as far as our Country is considered. The first, and already much spoken of problem, is the improper characterization of the livestock population, leaving us with very large and even more basic categories of livestock which bounds the choice of tier method to the previously successfully used Tier 1. Even if for a brief moment we look past this obstacle and focus on the second problem, again with the presented example in mind, we can even more clearly see how the complete lack of any inventories on the subject of country-specific nitrogen excretion rates leads us back to the default values defined Tier 1 method. A Tier 2 method would require more detailed characterization of the flow of nitrogen throughout the animal housing and manure management systems used in the country, something to be considered for development and incorporation in order for our Country to successfully climb the tier ladder.

Selection of emission factors

Emission factors for direct N2O emissions from Manure Management

According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories the best estimate is obtained using country-specific emission factors that have been fully documented in peer reviewed publications. Good practice states the use of country-specific emission factors that reflect the actual duration of storage and type of treatment of animal manure in each management system that is used. However, in the absence of any active inventory activities concerning the development of country specific emission factors, not mentioning the complete lack of documentation on the subject, unavoidably forces our Country to use the default values presented by the Tier 1 method which in practice renders all attempts to upgrade to Tier 2 improbable at the given time. In order to comply with the principles of good practice our Country needs to place further efforts in obtaining the required data before attempting to implement Tier 2 methodology in the development of country specific emission factors for direct N2O emissions from manure management.

Good practice also involves the measurement of emissions from different management systems taking into account variability in duration of storage and types of treatment, something that is virtually inexistent in our Country at the moment and needs to be worked on in order of achieving success in future endeavours on the subject. Note that emissions from liquid/slurry systems without a natural crust cover, anaerobic lagoons, and anaerobic digesters are considered negligible based on the absence of oxidized forms of nitrogen entering these systems combined with the low potential for nitrification and denitrification to occur in the system.

Emission factors for indirect N2O emissions from Manure Management

In order to estimate indirect N2O emissions from Manure Management, two fractions of nitrogen losses (due to volatilization and leaching/runoff), and two indirect N2O emissions factors associated with these losses. Default values for volatilization N losses are presented in the Table 10.22. Values represent average rates for N loss in the forms of NH3 and NOx, with most of the loss in the form of NH3. The values represent conditions without any significant nitrogen control measures in place. Countries are encouraged to develop country-specific values, particularly related to ammonia losses where component emissions may be well characterized as part of larger air quality assessments and where emissions may be affected by nitrogen reduction strategies, but in the meantime, until such developments have been made possible, our Country is far removed from successfully obtaining data on the required fractions of nitrogen loses as well as developing country specific indirect N2O emissions factors.

As large as the desire is to upgrade to the Tier 2 methodology and raise it up to its peers level, the circumstances in our Country leave this country bound with the only applicable option for the estimation of GHG emissions from both enteric fermentation and manure management, which is estimation based on the given values by way of the Tier 1 methodology.

Table 36 gives and overview of (N_2O) Emission factors from manure management.

Table 36: N_2O Emission factors from manure management

Cod	Sector	Value (EF)	Unit (EF)	Activity (Categories /subcategories)	Unit (Activity)
4.B.11	Liquid systems	**0,001**	kgN_2O/ kg Nitrogen excreted	Swine	Head
4.B.12	Solid storage and drylot	**0.02**	kgN_2O/ kg Nitrogen excreted	Dairy cattle	Head
		0.02	kgN_2O/ kg Nitrogen excreted	Non – Dairy cattle	Head
		0.02	kgN_2O/ kg Nitrogen excreted	Poultry	Head
4.B.13	Anaerobe	**0,001**	kgN_2O/ kg Nitrogen excreted	Non – Dairy cattle	Head
	Other	**0,005**	kgN_2O/ kg Nitrogen excreted	Swine	Head

Reference: Table 10.21,Volume 4, Chapter 10, 2006 Guidelines for National Greenhouse Gas Inventories, page 10.62; 1996 IPCC Guidelines Workbook, Module 4, TABLE 4-8 Tentative default values for N2O emission factors from animal waste per animal waste management system

3.3 4.D Agricultural Soils

Table 37 gives an overview of methane (CH_4) Emission factors from rice cultivation, while in Table 38 N_2O Emission factors from agricultural soils are presented.

Table 37: Methane (CH4) Emission factors from Rice Cultivation

Cod	Sector	Value (EF)	Unit (EF)	Activity (Categories /subacategories)	Unit (Activity)
4.B.1.	Irrigated	**1,30** (од 1 до 1,5)	kg/ha/ day	Intermittently flooded	ha/year
4.B.2.	Rainfed	**0**	kg/ha/ day	/	/
4.B.3.	Deep water	**0**	kg/ha/ day	/	/
4.B.4.	Other	**0**	kg/ha/ day	/	/

Reference:Table 11.1, Volume 4, Chapter 11, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 11.11

Table 38: N2O Emission factors from agricultural soils

Cod	Sector	Value (EF)	Unit (EF)	Activity (Categories /subacategories)	Unit (Activity)
4.D.1	Type of N input to soil	**0.0125**	[kg N_2O–N (kg N)-1]	Synthetic fertilizer	kg
		0.0125	kg N_2O–N (kg N)-1]	N-fixing crops	kg
		0,0125	kg N_2O–N (kg N)-1]	Crop residue	kg

Reference: Table 11.1, Volume 4, Chapter 5 Cropland, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, page 5.49

4.0. WASTE

4.1. Source Category 6.A – Solid Waste Disposal on Land

This source category is one of the key sources of methane (CH_4) emissions in the air.

Methane (CH_4) is produced in the process of anaerobic digestion of organic waste on land, disposed of at solid waste disposal sites (SWDS). Organic waste decays according to the decay rate and many years will pass until it decays completely.

- **Methodological approach**

There are three tiers for estimation of CH_4 emissions from solid waste disposal on landfills:

Tier 1: The estimations of this method are based on IPCC FOD method (First Order Decay) by applying default input data and default parameters laid down in the Manual.

Tier 2: Tier 2 applies the IPCC FOD method and some of the default parameters, but good quality is demanded from the specific data on each country and data on the current historic waste on landfills. The historical waste should be based on specific data about each country (data for 10 or more years) from surveys or studies.

Tier 3: Tier 3 method is based on application of country-specific quality data (like in Tier 2) and application of FOD method with (a) key parameters developed on national level, or (b) measuring derived specific parameters for each country.

Good practice for all countries would be to apply the FOD method or some other approved country-specific method which provides data in longer time series.

Our Country has been keeping historical data on produced municipal solid waste (kg / persons / day) as of 2004 onwards and keeps data from population censuses conducted in 1953, 1961, 1971, 1981, 1991 and 2002. For the years during which no data was kept, 2006 IPCC Guidelines for National Greenhouse Gas Inventories advises to obtain the lacking data by interpolating or extrapolating the population and economic parameters (GDP).

In order to introduce the FOD method in the estimations of emissions for the source category of waste, some trial estimations have been done by using the historic data on waste produced nationally and they have provided satisfying results. It was a great encouragement for and support to the intention of introducing this method for future emission estimations in the National Inventories, what would be a promotion and improvement compared to the inventories that were used until now.

- **Establishment of the parameters necessary for making estimations**

The method of dissolvable organic carbon applies the following Equation for produced methane:

Equation 13

$$CH4 \text{ produced in the year } (\kappa t/yr) = \Sigma x \left[(A \bullet k \bullet MSWT(x) \bullet MSWF(x) \bullet L0(x)) \bullet e^{-k(t-x)}\right.$$

where:

t = year of inventory development
x = years for which input data should be added
A = (1 – e-k) / k; normalisation factor which corrects the collection
k = constant of methane formation rate (1/ annually)
MSWT (x) = total amount of municipal solid waste (MSW) produced in the year x (Gg/ year)
MSWF (x) = fraction of MSW disposed to solid waste disposal sites for the year x
L0 (x) = potential for methane formation (MCF (x) • DOC (x) • DOCF • F • 16 / 12 (Gg CH4/Gg waste))
MCF (x) = Methane corrective factor for the year x (fraction)
DOC (x) = Dissolving organic carbon (DOC) in the year x (fraction) (Gg C/Gg waste)
DOCF = Fraction of dissolving organic factor dissimilated
F = Fraction by volume of CH_4 in landfill gas
16 / 12 = Conversion from C to CH_4
Sum of the obtained results for all years (x).
MSW = municipal solid waste
SWDS = solid waste disposal sites.

For calculation purposes, the simplified model of FOD for waste disposed of at disposal sites and the estimated values as of 1950 onwards should be used.

Key parameter when determining total methane emissions from disposal sites is the value of the dissolving organic carbon and it directly depends on the various fractions of waste which are disposed of at the disposal sites. Its value can be obtained by applying the following equation:

Equation 14

$$DOC = (0,4 \bullet A) + (0,17 \bullet B) + (0,15 \bullet C) + (0,3 \bullet D)$$

where:

A = Fraction of MSW which is paper waste (value 21.8) and textile waste (value 4.7)
B = Fraction of MSW which is gardening waste, park waste and other degradable organic waste (value 10.99)
C = Fraction of MSW which is food waste (value 30.10)
D = Fraction of MSW which is wood or straw waste (value 7.5)

The referent regional values of fractions A, C and D are obtained from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Chapter 2, Table 2.3, page 2.12, whereas of B, the value is obtained from the National Waste Management Plan in our Country 2006-2012, page 21. The obtained value for DOC amounts to 19.23%, that is, **0.19**.

Methane emission values have been obtained by applying the following Equation:

Equation 15

CH4 emitted in the year (κt/yr) = [CH4 produced in the year – R(t)] • (1-OX)

where:

R – recovered methane (value 0);
OX – oxidation factor (fraction from the oxidised methane – value 0).

4.2. Source Category 6.B – Waste Water Handling – N_2O emissions from the sewerage

This source category is one of the key sources of nitrous oxide (N_2O) emissions in the air.

The following Equation is applied for calculating N_2O emissions from sewerage:

Equation 16

$$N_2O_{(S)} = Protein \bullet Frac_{NPR} \bullet NR_{PEOPLE} \bullet EF_6$$

where:

$N_2O_{(s)}$ = N_2O emission from the sewerage (kg N2O-N/yr);
Protein = annual protein intake per capita (kg/person/yr);
NR_{PEOPLE} = number of citizens in the country
EF_6 = emission factors
$Frac_{NPR}$ = fraction of nitrogen in protein.

The value of the annual protein intake per capita has been obtained from FAOSTAT (http://faostat.fao.org/site/609/DesktopDefault.aspx?PageID=609#ancor 2009) which is 75,50 gr/person/day, that is (75,50 gr/person/day ● 365 days / 1000) = 27,55 kg/person/yr.

With regard to the emission factor EF_6, the default value has been taken, which amounts to 0.01 kg N_2O-N/kg sewerage- N produced, as shown in Table 4-18, Chapter 4, page 4.89, Revised 1996 IPCC Guidelines for GHG Inventories.

For the fractions of nitrogen in protein $Frac_{NPR}$ the default value has been taken, which amounts to 0.16 kg N/kg protein, as shown in Table 4-19 Chapter 4, page 4.94, Revised 1996 IPCC Guidelines for GHG Inventories.

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ANNEX 1

Table: Net calorific value (NCV) of certain types of energy sources

TYPE OF ENERGY SOURCE	NET ENERGY VALUE
Lignite and Coal	7.396 TJ/10^3t
Lignite for Thermal Power Plant	7.338 TJ/10^3t
Other Lignite types	8.718 TJ/10^3t
Imported Coal	18.043 TJ/10^3t
Coke	28.500 TJ/10^3t
Crude Oil	42.500 TJ/10^3t
Petrol Oil	43.000 TJ/10^3t
Diesel	43.000 TJ/10^3t
Extra Light Oil	43.000 TJ/10^3t
Residual Fuel Oil	40.000 TJ/10^3t
Liquid Petroleum Gas	46.000 TJ/10^3t
Jet Fuel	43.000 TJ/10^3t
Biodiesel	37.000 TJ/10^3t
Diesel and Biodiesel Mixture	42.491 TJ/10^3t
Natural Gas	33.688 TJ/10^6 Nm^3
Fuel Wood	10.902 TJ/10^3 m^3

Reference: Energy Balance of the RM for the period 2013 – 2017 (Official Gazette of the RM No. 170/2012)

ANNEX 2

1.0. ENERGY

1.1. Source Category 1.A.1. – ENERGY INDUSTRIES

Table A-4: Comparison of CO_2 Emission factors for the source category 1.A.1. – Energy Industries

Code	Sub- category	Activity (fuel) [TJ]	CO_2 Emission Factors [t/TJ]			Explanation about the NEF
			Default value of the EF (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.1.a i	Electricity production	Lignite (REK Bitola)	101	109.24	104.11	The NEF was obtained based on data on the content of S in the lignite, acquired from Thermal Power Plant REK Bitola
		Lignite (REK Oslomej)			106.26	The NEF was obtained based on data on the content of S in the lignite, acquired from Thermal Power Plant REK Oslomej
		Residual Fuel Oil	77.4	77.37	77.68	The NEF was obtained based on data on the content of S in the Residual Fuel Oil, acquired from OKTA Refinery
1.A.1.a ii	Combined heat and electricity production	Natural Gas	56.1	56.1	54.802	The NEF was obtained based on data on the content of S in the Russian natural gas
1.A.1.a iii	Heating plants	Residual Fuel Oil	77.4	77.36	77.68	The NEF was obtained based on data on the content of S in the Residual Fuel Oil, acquired from OKTA Refinery
		Natural Gas	56.1	56.1	54.802	The NEF was obtained based on data on the content of S in the Russian natural gas

Table A-5: Comparison of CH_4 Emission Factors for the source category 1.A.1. – Energy Industries

Code	Sub- category	Activity (fuel) [TJ]	CH_4 Emission Factors [kg/TJ]			Explanation about the NEF
			Default value of the EF (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.1.a i	Electricity production	Lignite	1	1	1	The Default value has been used
		Residual Fuel Oil	3	3	3	The Default value has been used
1.A.1.a ii	Combined heat and electricity production	Natural gas	1	1	1	The Default value has been used
1.A.1.a iii	Heating plants	Residual Fuel Oil	3	3	3	The Default value has been used
		Natural gas	1	1	1	The Default value has been used

Table A-6: Comparison of N_2O Emission Factors for the source category 1.A.1. – Energy Industries

Code	Sub- category	Activity (fuel) [TJ]	N2O Emission Factors [kg/TJ]			Explanation about the NEF
			Default value of the EF (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.1.a i	Electricity production	Lignite	1.5	1.4	1.5	The Default value has been used
		Residual Fuel Oil	0.6	0.6	0.6	The Default value has been used
1.A.1.a ii	Combined heat and electricity production	Natural gas	0.1	0.1	0.1	The Default value has been used
1.A.1.a iii	Heating plants	Residual Fuel Oil	0.6	0.6	0.6	The Default value has been used
		Natural gas	0.1	0.1	0.1	The default value has been used

Table A-7: Comparison of SO_2 Emission Factors for the source category 1.A.1. – Energy Industries

Code	Sub- category	Activity (fuel) [TJ]	SOx Emission Factors [kg/TJ]				Explanation about the NEF
			Default value of the EF (EMEP/EEA Guidebook 2009)	EF value used in the SNC (2000)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
1.A.1.a i	Electricity production	Lignite (REK Bitola)	820.0	2966.1	1419.0	1599.0	The NEF was obtained based on data on the content of S in the lignite, acquired from Thermal Power Plant REK Bitola
		Lignite (REK Oslomej)				1628.0	The NEF was obtained based on data on the content of S in the lignite acquired from Thermal Power Plant REK Oslomej
		Residual Fuel Oil	485.0	1463.5	485.0	500.0	The NEF was obtained based on data on the content of S in the Residual Fuel Oil, acquired from OKTA Refinery
1.A.1.a ii	Combined heat and electricity production	Natural gas	0.281	0.0	0.3	0.281	The Default value has been used
1.A.1.a iii	Heating plants	Residual Fuel Oil	485.0	1463.5	485.0	500.0	The NEF was obtained based on data on the content of S in the Residual Fuel Oil, acquired from OKTA Refinery
		Natural gas	0.3	0.0	0.3	0.3	The Default value has been used

Table A-8: Comparison of NO_2 Emission Factors for the source category 1.A.1. – Energy Industries

Code	Sub- category	Activity (fuel) [TJ]	N2O Emission Factors [kg/TJ]			Explanation about the NEF
			Default value of the EF (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.1.a i	Electricity production	Lignite	1.5	1.4	1.5	The Default value has been used
		Residual Fuel Oil	0.6	0.6	0.6	The Default value has been used
1.A.1.a ii	Combined heat and electricity production	Natural Gas	0.1	0.1	0.1	The Default value has been used
1.A.1.a iii	Heating plants	Residual Fuel Oil	0.6	0.6	0.6	The Default value has been used
		Natural Gas	0.1	0.1	0.1	The Default value has been used

Table A-9: Comparison of the TSP Emission Factors for the source category 1.A.1. – Energy Industries

Code	Sub-category	Activity (fuel) [GJ]	TSP Emission Factors [g/GJ]			Explanation about the NEF
			Default value of the EF (EMEP/EEA Guidebook 2009)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
1.A.1.a i	Electricity production	Lignite (REK Bitola)	40.0	82.3	101.0	The NEF was obtained based on data which have been taken from emission measuring made in Thermal Power Plant REK Bitola in a period of 5 years
		Lignite (REK Bitola)			108.0	The NEF was obtained based on data which have been taken from emission measuring made in Thermal Power Plant REK Oslomej in a period of 5 years
		Residual Fuel Oil	20.0	-	20.0	The Default value has been used
1.A.1.a ii	Combined heat and electricity production	Natural gas	0.908	-	0.908	The Default value has been used
1.A.1.a iii	Heating plants	Residual Fuel Oil	20.0	25.0	20.0	The Default value has been used
		Natural gas	0.9	0.9	0.9	The Default value has been used

Source Category 1.A.2 . – MANUFACTURING INDUSTRIES AND CONSTRUCTION

Table A-10: Comparison of CO_2 Emission Factors for the source category 1.A.2. – Manufacturing industries and construction

Code	Sub- category	Activity (fuel) [TJ]	CO_2 Emission Factors [t/TJ]			Explanation about the NEF
			Default value of the EF (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.2	a.b.c.d.e.f.g.h.j. k.l.m	Gas/Diesel Oil	74.1	74.1	74.1	The Default value has been used
		Residual Fuel Oil	77.4	77.4	77.68	The NEF has been calculated – data on the content of S in the Residual Fuel Oil have been used acquired from the OKTA Refinery
		Liquefied Petroleum Gas (LPG)	63.1	63.1	63.1	The Default value has been used
		Lignite	101.0	109.24	104.11	The NEF has been calculated – data on the content of S in the lignite have been used, acquired from Thermal Power Plant REK Bitola
		Natural gas	56.1	56.1	54.802	The NEF has been calculated – data on the content of S in the Russian natural gas
		Wood / Wood waste	112.0	109.6	112.0	The Default value has been used

Table A-11: Comparison of N_2O Emission factors for the source category 1.A.2. – Manufacturing Industries and Construction

Code	Sub- category	Activity (fuel) [TJ]	N2O Emission Factors [t/TJ]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.2	a.b.c.d.e.f.g.h.j. k.l.m	Gas/Diesel oil	0.6	0.6	0.6	The default value has been used
		Residual Fuel Oil	0.6	0.6	0.6	The default value has been used
		Liquefied Petroleum Gas (LPG)	0.1	-	0.1	The default value has been used
		Lignite	1.5	1.4	1.5	The default value has been used
		Natural gas	0.1	0.1	0.1	The default value has been used
		Wood / Wood waste	4.0	4.0	4.0	The default value has been used

Table A-12: Comparison of SO_2 Emission Factors for the source category 1.A.2. – Manufacturing Industries and Construction

Code	Sub- category	Activity (fuel) [TJ]	SOx Emission Factors [kg/TJ]				Explanation about the NEF
			EF Default value (EMEP/EEA Guidebook 2009)	EF value used in the SNC (2000)	EF value used in the CORINAIR (2010)	National Emission Factor (NEF)	
1.A.2.a	Iron and Steel	Residual Fuel Oil	-	1463.5	-	500.0	NEF has been obtained based on the data on the content of S in the Residual Fuel Oil, acquired from the OKTA Refinery
		Liquid fuels	140.0	-	140.0	140.0	The default value has been used
		Natural gas or Liquefied Petroleum Gas	0.5	0.0	0.5	0.5	The default value has been used

1.3. Source Category 1.A.3. – TRANSPORT

Table A-13: Comparison of CO_2 Emission Factors for the source category 1.A.3.b – Transport – Road Transportation

Code	Sub- category	Activity (fuel) [TJ]	CO_2 Emission Factors [t/TJ]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.3.b.i	Passenger cars	Motor Gasoline	69.3	69.3	69.3	The default value has been used
		Diesel oil	74.1	74.1	74.1	The default value has been used
		Liquefied Petroleum Gas (LPG)	63.1	63.1	63.1	The default value has been used
1.A.3.b.ii	Light duty vehicles	Motor Gasoline	69.3	69.3	69.3	The default value has been used
		Diesel oil	74.1	74.1	74.1	The default value has been used
1.A.3.b.iii	Heavy duty vehicles and buses	Diesel oil	74.1	74.1	74.1	The default value has been used
1.A.3.b.iv	Motorcycles	Motor Gasoline	69.3	69.3	69.3	The default value has been used

Table A-14: Comparison of CH_4 Emission Factors for the source category 1.A.3. – Transport – Road Trasnportation

Code	Sub- category	Activity (fuel) [TJ]	CH4 Emission Factors [kg/TJ]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.3.b.i	Passenger cars	Motor Gasoline without a catalyst	33.0	20.0	33.0	The default value has been used
		Motor Gasoline with a catalyst	25.0		25.0	The default value has been used
		Diesel oil	3.9	5.0	3.9	The default value has been used
		Liquefied Petroleum Gas (LPG)	62.0	-	62.0	The default value has been used
1.A.3.b.ii	Light duty vehicles	Motor Gasoline	3.8	20.0	3.8	The default value has been used
		Diesel oil	3.9	5.0	3.9	The default value has been used
1.A.3.b.iii	Heavy duty vehicles and buses	Diesel oil	3.9	5.0	3.9	The default value has been used
1.A.3.b.iv	Motorcycles	Motor Gasoline	33	20	33	The default value has been used

Table A-15: Comparison N_2O Emission Factors for the source category 1.A.3. – Transport – Road Transportation

Code	Sub- category	Activity (fuel) [TJ]	N2O Emission Factors [kg/TJ]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.3.b.i	Passenger cars	Motor Gasoline with a catalyst	3.2	0.6	3.2	The default value has been used
		Motor Gasoline without a catalyst	8.0		8.0	The default value has been used
		Diesel oil	3.9	0.6	3.9	The default value has been used
		Liquefied Petroleum Gas (LPG)	0.2	-	0.2	The default value has been used
1.A.3.b.ii	Light duty vehicles	Motor Gasoline	5.7	0.6	5.7	The default value has been used
		Diesel oil	3.9	0.6	3.9	The default value has been used
1.A.3.b.iii	Heavy duty vehicles and buses	Diesel oil	3.9	0.6	3.9	The default value has been used
1.A.3.b.iv	Motorcycles	Motor Gasoline	3.2	0.6	3.2	The default value has been used

Table A-16: CO Emission Factors for the source category 1.A.3. – Transport – Road Transportation

Code	Sub- category	Activity (fuel) [kg fuel]	CO Emission Factors [g/Gg]				Explanation about the NEF
			EF Default value (EMEP/EEA Guidebook 2009)	EF value used in the SNC (2000)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
1.A.3.b.i	Road transportation – Passenger cars	Motor Gasoline	2979.68	8000.0	3000.00	3069.76	NEF has been acquired based on data on the Net Energy Value of the fuels in the country, obtained from the National Energy Balance for 2012
		Diesel oil	109.30	1000.0	109.30	109.30	
		Liquefied Petroleum Gas (LPG)	1437.63	-	1478.26	1478.26	
1.A.3.b.ii	Road transportation – Light duty vehicles	Motor Gasoline	3498.87	8000.0	3522.73	3604.65	
		Diesel oil	255.81	1000.0	255.81	255.81	
1.A.3.b.iii	Road transportation - Heavy duty vehicles and buses	Diesel oil	186.05	1000.0	186.05	186.04	
1.A.3.b.iv	Road transportation – motorcycles	Motor Gasoline	11060.95	8000.0	11136.36	11395.34	

Table A-17: Comparison of NO_2 Emission Factors for the source category 1.A.3. – Transport– Road Transportation

Code	Sub- category	Activity (fuel) [kg of fuel]	NOx Emission Factors [g/Gg]				Explanation about the NEF
			EF Default Value (EMEP/EEA Guidebook 2009)	EF value used in the SNC (2000)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
1.A.3.b.i	Road transportation – Passenger cars	Motor Gasoline	349.89	600.0	329.55	360.46	NEF has been acquired based on data on the Net Energy Value of the fuels in the country, obtained from the National Energy Balance for 2012
		Diesel	255.81	800.0	255.81	255.81	
		Liquefied Petroleum Gas (LPG)	327.70	-	326.09	336.95	
1.A.3.b.ii	Road transportation – Light duty vehicles	Motor Gasoline	541.76	600.0	545.45	558.14	
		Diesel oil	348.84	800.0	348.84	348.84	
1.A.3.b.iii	Road transportation – Heavy duty vehicles and buses	Diesel oil	860.47	800.0	860.47	860.47	
1.A.3.b.iv	Road transportation – Motorcycles	Motor Gasoline	214.45	600.0	215.91	220.93	

Table A-18: Comparison of NMVOC Emission Factors for the source category 1.A.3. – Transport– Road Transportation

Code	Sub- category	Activity (fuel) [kg of fuel]	NMVOC Emission Factors [g/Gg]				Explanation about the NEF
			EF Default value (EMEP/EEA Guidebook)	EF value used in the SNC (2000)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
1.A.3.b.i	Road transportation – Passenger cars	Motor Gasoline	316.03	1500.0	318.18	325.58	NEF has been acquired based on data on the Net Energy Value of the fuels in the country, obtained from the National Energy Balance for 2012
		Diesel	25.58	200.0	25.58	25.58	
		Liquefied Petroleum Gas (LPG)	211.42	-	217.39	217.39	
1.A.3.b.ii	Road transportation – Light duty vehicles	Motor Gasoline	316.03	1500.0	318.18	325.58	
		Diesel oil	41.86	200.0	40.69	41.86	
1.A.3.b.iii	Road transportation – Heavy duty vehicles and buses	Diesel oil	37.21	200.0	37.21	37.21	
1.A.3.b.iv	Road transportation – Motorcycles	Motor Gasoline	2573.36	1500.0	2590.91	2651.16	

Table A-19: Comparison of NMVOC Emission Factors for the source category 1.A.3. – Transport – Evaporation of petrol

Code	Sub- category	Activity (fuel) [kg of fuel]	NMVOC Emission Factors [g/vehicle/day]				Explanation about the NEF
			EF Default value (EMEP/EEA Guidebook 2009)	EF value used in the SNC (2000)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
1.A.3.b.v	Evaporative emissions from vehicles (all temperature ranges)	Motor Gasoline	Default	-	Default	Default	For all temperature ranges, the default values have been used as National Emission Factors

1.4. Source Category 1.A.4. – OTHER SECTORS

Table A-20: Comparison of CO_2 Emission Factors for the sub-category1.A.4.b. – Residential Sources

Code	Sub- category	Activity (fuel) [TJ]	CO_2 Emission Factors [t/TJ]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.4.b	Residential	Gas/Diesel oil	74.1	74.1	74.1	The default value has been used
		Liquefied Petroleum Gas (LPG)	63.1	63.1	63.1	The default value has been used
		Other oil products	73.3	73.3	73.3	The default value has been used
		Lignite	101.0	101.2	104.11	NEF was obtained based on data about the content of S in the lignite, acquired from Thermal Power Plant REK Bitola
		Wood / Wood waste	112.0	109.6	112.0	The default value has been used

Table A-21: Comparison of CH_4 Emission Factors for the Sub-category 1.A.4.b. – Residential Sources

Code	Sub- category	Activity (fuel) [TJ]	CH4 Emission Factors [kg/TJ]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.4.b	Residential	Gas/Diesel oil	10.0	10.0	10.0	The default value has been used
		Liquefied Petroleum Gas (LPG)	5.0	-	5.0	The default value has been used
		Lignite	300.0	300.0	300.0	The default value has been used
		Wood / Wood waste	300.0	300.0	300.0	The default value has been used

Table A-22: Comparison of N_2O Emission Factors for the Sub-category 1.A.4.b. – Residential Sources

Code	Sub- category	Activity (fuel) [TJ]	N2O Emission Factors [kg/TJ]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.4.b	Residential	Gas/Diesel oil	0.6	0.6	0.6	The default value has been used
		Liquefied Petroleum Gas (LPG)	0.1	-	0.1	The default value has been used
		Lignite	1.5	1.4	1.5	The default value has been used
		Wood / Wood waste	4.0	4.0	4.0	The default value has been used

Table A-23: Comparison of CO Emission Factors for the Sub-category 1.A.4.b. – Residential Sources

Code	Sub- category	Activity (fuel) [TJ]	CO Emission Factors [g/GJ]				Explanation about the NEF
			EF Default value (EMEP/EEA Guidebook 2009)	EF value used in the SNC (2000)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
1.A.4.b	Residential	Gas/Diesel oil	46.0	20.0	46.0	46.0	The default value has been used
		Liquefied Petroleum Gas (LPG)	31.0	-	31.0	31.0	The default value has been used
		Lignite	4600.0	2000.0	4600.0	4600.0	The default value has been used
		Wood / Wood waste	5300.0	5000.0	5300.0	5300.0	The default value has been used

Table A-24: Comparison of NO_2 Emission Factors for the Sub-category 1.A.4.b. – Residential Sources

Code	Sub- category	Activity (fuel) [TJ]	N2O Emission Factors [kg/TJ]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.A.4.b	Residential	Gas/Diesel oil	0.6	0.6	0.6	The default value has been used
		Liquefied Petroleum Gas (LPG)	0.1	-	0.1	The default value has been used
		Lignite	1.5	1.4	1.5	The default value has been used
		Wood / Wood waste	4.0	4.0	4.0	The default value has been used

Table A-25: Comparison of NMVOC Emission Factors for the Sub-category1.A.4.b. – Residential Sources

Code	Sub- category	Activity (fuel) [TJ]	NMVOC Emission Factors [g/GJ]				Explanation about the NEF
			EF Default value (EMEP/EEA Guidebook 2009)	EF value used in the SNC (2000)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
1.A.4.b	Residential	Gas/Diesel oil	15.5	5.0	15.5	15.5	The default value has been used
		Liquefied Petroleum Gas (LPG)	10.5	-	10.5	10.5	The default value has been used
		Lignite	484.0	200.0	484.0	484.0	The default value has been used
		Wood / Wood waste	925.0	600.0	925.0	925.0	The default value has been used

Table A-26: Comparison of TSP Emission Factors for the Sub-category 1.A.4.b. – Residential Sources

Code	Sub- category	Activity (fuel) [GJ]	TSP Emission Factors [g/GJ]			Explanation about the NEF
			EF Default value (EMEP/EEA Guidebook 2009)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
1.A.4.b	Residential	Gas/Diesel oil	6.0	6.0	6.0	The default value has been used
		Liquefied Petroleum Gas (LPG)	5.0	5.0	5.0	The default value has been used
		Lignite	444.0	444.0	444.0	The default value has been used
		Wood /Wood waste	730.0	730.0	730.0	The default value has been used

1.5. Source Category 1.B. FUGITIVE EMISSIONS FROM FUELS

Table A-27: Comparison of CH_4 Emission Factor for the Sub-category 1.B.1.a ii – Open Cast Coal Mining

Code	Sub- category	Activity [t]	CH_4 Emission Factors [m3 CH4/t]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
1.B.1.a ii	Coal mining and handling – open cast	Lignite	0.3 - 2.0	1.50	1.50	See the explanation in the text

Table A-28: Comparison of NMVOC Emission Factor for the Sub-category 1.B.1.a – Open Cast Coal Mining

Code	Sub- category	Activity [t]	NMVOC Emission Factors [kg / t coal]				Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
1.B.1.a ii	Coal mining and handling – open cast	Lignite	0.2	-	0.2	0.2	The Default value has been used

2.0. INDUSTRIAL PROCESSES

2.1. Source Category 2.A. – MINERAL INDUSTRY

Table A-29: Comparison of CO_2 Emission Factor for the Sub-category 2.A.1. – Cement Production

Code	Sub- category	Activity [t]	CO_2 Emission Factors [Mg/Mg]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
2A1	Cement Production	Clinker	0.51	0.4985	0.542	The NEF was obtained based on data about the content of CaO and MgO in clinker, acquired from TITAN Cementarnica Usje

2.2. Source Category 2.C – METAL INDUSTRY

Table A-30: Comparison of CO_2 Emission Factors for the Sub-category 2.C.1. – Iron and Steel Production

Code	Sub- category	Activity [t]	CO_2 Emission Factors [Mg/Mg]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
2C1	Iron and Steel production	Steel (produced in electric arc furnace)	0.08	0.3750	0.090	The NEF was obtained based on the data for used reducing agents. electrode mass and the content of C in the finished product, acquired from MAKSTIL

Table A-31: Comparison of CO_2 Emission Factors for the Sub-category 2.C.2. – Ferroalloys Production

Code	Sub- category	Activity [t]	CO_2 Emission Factors [Mg/Mg]			Explanation about the NF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
2C2	Production of Ferrosilicon	Ferrosilicon (75% Si)	4.00	3.9	4.1782	The NEF was obtained based on the data for used reducing agents, electrode mass and the finished product. acquired from SILMAK
	Production of ferromanganese	Ferromanganese (3% C)	1.3 (7% C); 1.5 (1% C)	-	1.3457	The NEF was obtained based on the data for used reducing agents, electrode mass and the content of C in the finished product. acquired from SKOPSKI LEGURI
	Production of silicon manganese	Silicon manganese	1.4	1.7	1.5511	
	Production of ferronickel	Ferronickel	-	3.96	4.0158	The NEF was obtained based on the data for used reducing agents, electrode mass and the content of C in the ore. acquired from FENI INDUSTRY

Source Category 2.D – OTHER INDUSTRY

Table A-32: Comparison of NMVOC Emission Factors for the Sub-category 2.D.2. – Food and Drinks

Code	Sub- category	Activity	NMVOC Emission Factors [kg/Mg product]				Explanation about the NEF
			EF Default value (EMEP/EEA Guidebook 2009)	EF value used in the SNC (2000)	EF value used in CORINAIR (2010)	National Emission Factor (NEF)	
2.D.2	Bread	Mg bread	4.5	8	4.5	4.5	The Default value has been used
	Cookies. biscuits. cereals	Mg product	1	1	1	1	The Default value has been used
	Meat. fish. poultry	Mg product	0.3	0.3	0.3	0.3	The Default value has been used
	Sugar	Mg sugar	10	10	10	10	The Default value has been used
	Margarine and solid cooking fats	Mg product	10	10	10	10	The Default value has been used
	Fodder	Mg fooder	1	-	1	1	The Default value has been used
	Roasting coffee	Mg beans	0.55	0.55	0.55	0.55	The Default value has been used
	Wine with undefined colour	hl wine	0.08	0.08	0.08	0.08	The Default value has been used
	Red wine	hl wine	0.08	0.08	0.08	0.08	The Default value has been used

	White wine	hl wine	0.035	0.035	0.035	0.035	The Default value has been used
	Beer (including the non-alcohol one)	hl wine	0.035	0.035	0.035	0.035	The Default value has been used
	Alcohol drinks	hl alcohol	15	15	15	15	The Default value has been used

2.4. Source Category 2.A.6 – ROAD PAVING WITH ASPHALT

Table A-33: Comparison of TSP Emission Factor for the sub-category 2.A.6. – Road Paving with Asphalt

Code	Sub- category	Activity (asphalt) [Mg]	TSP Emission Factors [kg/Mg asphalt]			Explanation about the NEF
			EF Default value (EMEP/EEA Guidebook 2009)	EF value used in CORINAIR (2010год.)	National Emission Factor (NEF)	
2.A.6	Road paving with asphalt	Asphalt	14.0	14.0	14.0	The Default value has been used

3.0. AGRICULTURE

3.1. Source Category 4.A Enteric Fermentation

Table A-34: Comparison of CH_4 Emission Factor for the Sub-category 4.A. – Enteric Fermentation

Code	Sub- category	Activity	CH4 Emission Factors [kg/head/year]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
4A1	Cattle Dairy	Head	81.0	81.0	81.0	The default value has been used
	Cattle Non – Dairy	Head	56.0	56.0	56.0	The default value has been used
4A2	Buffalo	Head	55.0	55.0	55.0	The default value has been used
4A3	Sheep	Head	5.0	5.0	5.0	The default value has been used
4A4	Goats	Head	5.0	-	5.0	The default value has been used
4A5	Camels and lamas	Head	0.0	-	0.0	The default value has been used
4A6	Horses	Head	18.0	18.0	18.0	The default value has been used
4A7	Mules and Asses	Head	0.0	-	0.0	The default value has been used
4A8	Swine	Head	1.0	1.0	1.0	The default value has been used
4A9	Poultry	Head	0.0	-	0.0	The default value has been used
4A10	Other	Head	0.0	-	0.0	The default value has been used

3.2. 4.B Manure Management

Table A-35: Comparison of CH_4 Emission Factor for the Sub-category 4.B. – Manure Management

Code	Sub-category	Activity	CH4 Emission Factors [kg/head/year]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)	EF value used in the SNC (2000)	National Emission Factor (NEF)	
4B1	Cattle Dairy	Head	6.0	6.0	6.0	The default value has been used
	Cattle Non – Dairy	Head		4.0		The default value has been used
4B2	Buffalo	Head	3.0	3.0	3.0	The default value has been used
4B3	Sheep	Head	0.1	0.1	0.1	The default value has been used
4B4	Goats	Head	0.0	-	0.0	The default value has been used
4B5	Camels and lamas	Head	0.0	-	0.0	The default value has been used
4B6	Horses	Head	1.1	1.1	1.1	The default value has been used
4B7	Mules and Asses	Head	0.0	-	0.0	The default value has been used
4B8	Swine	Head	4.0	4.0	4.0	The default value has been used
4B9	Poultry	Head	0.0	0.0	0.0	The default value has been used

Table A-36: Comparison of NO_2 Emission Factors for the Sub-category 4.B. – Manure Management

Code	Sub-category	Activity	N2O Emission Factors [kg N2O- N/kg nitrogen excreted]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)*	EF value used in the SNC (2000)	National Emission Factor (NEF)	
4B1	Pasture / Range / Paddock System	Head	0.02	0.02	0.02	The default value has been used
4B2	Daily spread System	Head	0	0	0	The default value has been used
4B3	Solid storage system	Head	0.005	0.005	0.005	The default value has been used
4B4	Dry lot system	Head	0.02	0.02	0.02	The default value has been used
4B5	Liquid/Slurry system	Head	0.0	0.0	0.0	The default value has been used
4B6	Uncovered anaerobic lagoon	Head	0.0	0.0	0.0	The default value has been used
4B7	Pit storage below animal confinements	Head	0.002	0.002	0.002	The default value has been used
4B8	Anaerobic Digester system	Head	0.0	0.0	0.0	The default value has been used
4B9	Cattle and swine deep bedding system. without mixing	Head	0.01	0.01	0.01	The default value has been used
4B10	Cattle and swine deep bedding system with active mixing	Head	0.07	0.07	0.07	The default value has been used
4B11	Poultry manure with bedding or without	Head	0.001	0.001	0.001	The default value has been used

* Table 10.21.Volume 4. Chapter 10. 2006 Guidelines for National Greenhouse Gas Inventories. page 10.62

3.3 4.D Agricultural Soils

Table A-37: Comparison of CH_4 Emission Factor for the Sub-category 4.D. – Rise Cultivation

Code	Sub-category	Activity	N2O Emission Factors [kg/ha/year]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)†	EF value used in the SNC (2000)	National Emission Factor (NEF)	
4B1	Irrigated	Intermittently flooded	1.30	1	1.30	The default value has been used
	Rainfed	/	/	/	/	The default value has been used
4B2	Deep water	/	/	/	/	The default value has been used
4B3	Other	/	/	/	/	The default value has been used

† Table 5.11.Chapter 5. Volume 4. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Page 5.49

Table A-38: Comparison of NO_2 Emission Factors for the Sub-category 4.D.- Agricultural Soils

Code	Sub-category	Activity	N2O Emission Factors [kg N2O–N (kg N[]			Explanation about the NEF
			EF Default value (2006 IPCC Guidelines)‡	EF value used in the SNC (2000)	National Emission Factor (NEF)	
4D1	Type of N input to soil	Synthetic fertilizer	0.01	0.01	0.01	The default value has been used
		N-fixing crops	0.01	0.01	0.01	The default value has been used
		Crop residue	0.01	0.01	0.01	The default value has been used

‡ Table 11.1. Volume 4. Chapter 5. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. page 11.11

4.0. WASTE

4.1. Source Category 6.A – Solid Waste Disposal

Table A-39: Comparison of parameters for the source category 6.A – Solid Waste Disposal

Code	Sub-category	Parameter	Value used in the SNC (2000)	Proposed value	Explanation
6A	Solid Waste Disposal	Methane Correction Factor (MCF)	0.70	0.60	The default value has been used
		DOC share in the MSW	0.17	0.19	See the explanation in the text
		Share of decomposing DOC	0.77	0.77	The default value has been used
		Share of carbon released as methane	0.50	0.50	The default value has been used
		Methane use per year (kt CH4)	0.00	0.00	The default value has been used
		One minus correction factor for methane oxidation	1.00	1.00	The default value has been used

4.2. Source Category 6.B – Waste Water Handling –N_2O Sewerage Emissions

Table A-40: Comparison of Parameters for the source category 6.B – Waste Water Handling

Code	Sub-category	Parameter	Value used in the SNC (2000)	Proposed value	Explanation
6B	Waste water handling	Annual protection intake (kg/person/yr)	33.90	27.55	The value has been obtained from FAOSTAT for MK 2009
		Emission Factor EF_6 (kg N_2O-N / kg sewerage N)	0.01	0.01	The default value has been used
		N fraction in protein	0.16	0.16	The default value has been used