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TRAP

Development of regional emission inventory for South East region

TRAP

Transboundary Air Pollution Health Index Development and Implementation

July, 2019

CENTER FOR CLIMATE CHANGE - ЦЕНТАР ЗА КЛИМАТСКИ ПРОМЕНИ -

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1. Introduction

1.1. Project Overview

Information on real time air pollution levels is now more necessary than ever before. At present, air pollution is one of the most significant factors posing threat to the health of individuals worldwide. It is associated with a range of diseases, symptoms and conditions that impair health and quality of human life. According to the WHO, outdoor air pollution was responsible for the deaths of some 3.7 million people under the age 60 around the world in 2012 , representing 6.7% of the global disease burden while outdoor air pollution combined are among the largest risks to health worldwide. Apart from habitants air quality impacts natural environment and biodiversity. The main sources of air pollution at both countries are mainly caused by industrial activities, transportation and heating.

Air Pollution has been recognized as of the most pressing problems in both Greece and the Former Yugoslav Republic of Macedonia, following the economic and social development of the two countries the sources of air pollution are mainly industrial activities, transport and central heating. The major challenges of transport in urban areas are the rising number of vehicles, their increased average age and traffic congestion. Air quality problems from industrial sources mainly concern areas with thermos-electrical power stations and industrial units located close to residential areas. Air quality is strongly influenced by pollutants trapped due to thermal inversions caused by from land local breezes and thermal internal boundary layers.

TRAP developed on the necessity for developing ICT applications in environmental protection, monitoring and management of the eligible areas. Environmental initiatives is a privileged field for developing cooperation in the cross-border area contributing significantly to economic and social development of the population and public health, therefore, the opportunity for mutual cooperation and understanding between public authorities, scientific institutions and residents of the area. The major challenge is the development of an integrated approach including air quality monitoring with providing health indicator for vulnerable groups of the population. TRAP project addresses a series of issues, such as:

- Identification of the emission sources and development of regional and CB emission for vulnerable groups of the population
- Assessment of each emission source
- Development of air quality plans
- Monitoring data, validation and analysis
- Basic demographic, health and public health profile
- Air quality and Health Indicators
- Joint CB comparative analysis
- Capacity Building at user level (Health and authority stakeholders)
- Air quality and health sensitization campaigns
- Protection of human health
- Citizen involvement
- Implementation of air quality directives

Partners aim to improve management and protection of areas in both countries by establishing air quality monitoring networks. The measurements of all station in areas involved in this project will create a system that will display real-time measurements through the internet. Moreover, epidemiological indicators and indicators of air quality, based on the effects of air pollution on human health, will be calculated and displayed on the web. The best way for someone to use an Air Pollution Health Indicator (APHI) is to regularly check the current index value, to pay attention to personal symptoms and self –calibrate to personal symptoms and self-calibrate to the report current APHI value. Therefore, the strategic objective of TRAP project is the creation of an ICT application integrating Air Quality Monitoring with Air Pollution Health Indicator) (APHI) in CB area.

The specific sub-objectives of the project are to:

- Develop and evaluate emission inventories at partner areas
- Assess the health risk related to air quality measurements
- Create integrated ICT tool including air quality information correlated to possible health impacts and providing emergency mechanism to policy makers and vulnerable groups
- Evaluate the CB conditions regarding air quality and transported pollution in CB areas
- Engage relevant stakeholders in order to inform them on the created tool operation and indexes
- Disseminate and communicate the project results to key stakeholders as well as to the general public and vulnerable groups

TRAP project results will positively affect and contribute to the programmes result indicator for ecosystems with improved protection status for the eligible areas of Florina, Bitola and Gevgelija where the monitoring stations will be placed. The innovative character of TRAP is served by its approach that favors the interaction and exchange of ideas as well as the knowledge diffusion and integration among the targeted stakeholders. Many of the projects activities will be jointly implemented creating unified framework for problem resolutions and providing added value to the CB area as a total. The expected results are focused on the development of an ICT tool for better air quality monitoring in CB area integrated with Air pollution Health Indicator.

1.2. Purpose of this deliverable

This document has been developed in order to provide a strategy for improving air quality in the eastern zone agglomeration, which covers only the municipalities within the Southeast Planning Region, namely Gevgelija, Strumica, Valandovo, Dojran, Radovish, Konche, Bogdanci, Bosilovo, Vasilevo, Novo Selo.

Based on the identified air emissions sources in the Southeast region of the Republic of North Macedonia, and deliverable 3.1 air emission inventory has been prepared. Both, documents are being prepared for the needs of the Municipalities within South eastern region which with support of the the Ministry of Environment and Physical Planning will define and plan measures to improve air quality in this region and their Municipalities.

The preparation of these documents is be the basis for defining possible measures to reduce emissions and their impact on air quality. Measures can be classified as short-term and long-term measures. Short-term measures should be adopted as soon as possible in order to reduce the concentrations of the most critical pollutants. It takes a long time to implement long-term measures, mainly due to the need for serious planning and significant financial resources.

1.3. Scope of the deliverable

The scope of the deliverable is to calculate the emissions of the basic pollutants, dust, heavy metals and polycyclic aromatic hydrocarbons (PAH). Based on the identified emission sources and identification of the type of potential emissions a calculation of the possible emissions that can be released into the air is made.

According to the available activity data and knowledge for the used technology the selection of emission factors for tier level (1, 2 or 3) for the pollutants CO, SO2, NO2, Polycyclic aromatic hydrocarbons (PAH), heavy metals (Cd, Pb, Hg) and dust (TSP. PM10. PM2,5) was made. This document is prepared according the latest version EMEP/EEA guidebook published in 2019, available on the (https://www.eea.europa.eu/publications/emep-eea-guidebook-2019), bearing in mind the emission factors used in the preparation of National emission inventory and Informative inventory report. In some rear cases when there are no avaliable activity data, older versions of guidebooks are used.

The emissions are be calculated by sector transport, industry, waste, agriculture, energy and some categories for solvent use.

2. Methodology

The identification of emission sources for the Southeast region has been conducted in accordance to the Guidelines for Reporting Emissions and Projections Data[i] under the United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (LRTAP). The Guideline provides tiers representing different level of methodological complexity. Usually three tiers are provided; Tier 1 is the simple (most basic) method; Tier 2, the intermediate; and Tier 3, the most demanding in terms of complexity and data requirements. Tier 1 methods apply a simple linear relation between activity data and emission factors. The activity data is derived from readily available statistical information (energy statistics, production statistics, traffic counts, population sizes, etc.). The default Tier 1 emission factors are chosen in way that they represent 'typical' or 'averaged' process conditions — they tend to be technology independent.

For preparation of this report the Tier 1 methods has been applied.

The data were collected with particularly designed questionnaire aiming to collect all necessary data from each municipality, such as: number of administrative and commercial buildings, their size, type of fuel, consumption, number of IPPC B installations, emission from

B installations, number of elaborates on environment, and has also identified all IPPC – A installation in the Southeast region.

It is important to note that all municipalities were very cooperative and provided the requested data in the due time, but unfortunately huge amount of data are still missing mainly due to fact that municipalities are not collecting these data regularly. Also, it is very important to mention that data provided are for the year 2017 or for data collected or measured up to this year.

2.1. Uncertainties at calculations of source emissions

There are some particular uncertainties for different emission sources mainly due to the lack of data on regional and local level. For the energy and industry sector there is lack of data from monitoring and reporting of emissions coming form combustion of fuel and production. Emission calculations from houselholds were made based on extrapolation of the results received from the survey conducted on representative sample for Southeast region because due to old Census from 2002, there are no data for exact population and type of fuel used at each household. For agriculture sector there are no data for fertilizers on municipality level so no calculations for this category are made at all. Also, there are uncertainties at the emission factors which are taken from Europian EMEP/Guidebook. The uncertainty in prepration of the emission inventory is present when inventories are prepared on national and local level for every country. However, the main aim is to define the key emission sources per pollutant in order to further the policy makers to be able to produce prioritizatioin of the reduction measures. This has been achived with this regional emission inventory.

3. Legislation framework

3.1. International commitments[1]

Reporting of emission data to the Executive Body (EB) of the Convention on Long-range Transboundary Air Pollution (CLRTAP) is required in order to fulfill the obligations regarding strategies and policies in compliance with the implementation of Protocols under the Convention. Parties should use the reporting procedures and are required to submit annual national emissions of SO2, NOX, NMVOC, CO and NH3, particulate matter (PM), various HM and POPs. The United Nations, Economic Commission for Europe (UNECE), adopted the LRTAP Convention in 1979. The LRTAP Convention came into force in 1983 and has been extended by eight specific protocols. For Republic of North Macedonia, status of ratification to LRTAP Convention and its Protocols is shown below:

Convention on Long-Range Transboundary Air Pollution (LRTAP) (Geneva, 1979). The Convention was ratified by means of the Law on Ratification („Official Gazette of the SFRY" No. 11/86). The Convention was taken over by the Republic of North Macedonia by means of succession with the date of effect of 30.12.1997.

♣ Law on Ratification of the Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on long-term financing of the Cooperative Programme for Monitoring and

[1] Informative Inventory Report 1990-2017

Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) ("Official Gazette of the Republic of Macedonia" No.24/2010);

♣ Law on Ratification of the Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on reduction of sulfur emissions or their transboundary transmission by at least 30 percentage ("Official Gazette of the Republic of Macedonia" No.24/2010);

♣ Law on Ratification of the Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on the control of nitrogen oxides or their transboundary fluxes ("Official Gazette of the Republic of Macedonia" No. 24/2010);

♣ Law on Ratification of the Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on the control of volatile organic compounds or their transboundary fluxes ("Official Gazette of the Republic of Macedonia" No. 24/2010);

♣ Law on Ratification of the Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution concerning further reduction of sulfur emissions ("Official Gazette of the Republic of Macedonia" No.24/2010).

♣ Law on Ratification of the Protocol to the 1979 Convention on Long-Rang Transboundary Air Pollution on heavy metals emissions ("Official Gazette of the Republic of Macedonia" No.135/2010).

♣ Law on Ratification of the Protocol to the 1979 Convention on Long-Rang Transboundary Air Pollution on persistent organic pollutants ("Official Gazette of the Republic of Macedonia" No.135/2010).

♣ Law on Ratification of the Protocol to the 1979 Convention on Long-Rang Transboundary Air Pollution to abate acidification, eutrophication and ground-level ozone ("Official Gazette of the Republic of Macedonia" No.135/2010).

♣ Regarding the Gothenburg Protocol, negotiations were ongoing in the period 2011-2014, on the proposed figures on the base year emission levels (1990 national emissions) and national emission ceilings (2010 national emissions).

The Executive Body of the Convention on its 32nd Meeting, decided to accept the last proposed figures for Annex II of the Gothenburg Protocol and Annex II of the Protocol on sulfur of 1994. With the adoption of the proposed amendments to Annex II of the Gothenburg Protocol, in September 2014, Republic of North Macedonia became a full Party to these protocols as well as first Party to the among developed countries.

3.2. National legislation

In accordance with the Law on ambient air quality Article 27-g (2), the Air Pollutant Emissions inventory for the territory of Republic of North Macedonia is performed through: 1) Calculation of emission quantities of pollutants in the air in Republic of North Macedonia; 2) Preparation of report on the annual emission inventory with emission projections; 3) Preparation of report on implementation of emission reduction measures in order to fulfill the requirements toward the 1979 Convention on Long-Range trans-boundary Air Pollution and its amendments (hereinafter: LRTAP convention). The reporting obligations to the European Environmental Agency and other relevant international organizations and to the Executive body of the LRTAP convention are set down in Article 27-d of the LAAQ.

3.3. Inventory preparation process

The preparation of the Inventory includes the following stages: Planning, Preparation, Data management, Reporting

a) Inventory planning [2]

The planning of the Inventory includes organizational aspects, related to: appointment of the team of experts, description of specific tasks and responsibilities, development of operational procedures with regard to data collection and data calculation on the activity rate and emission factors included in the database of the National Emission Inventory.

b) Inventory preparation

In the context of this Inventory preparation, the experts together with project team were involved in the identification of the sources of pollution, definition of the relevant data sources and data collection (activity data). All other activities concerning the Inventory preparation and development have been organized through this approach.

• Identification of sources of pollution

In the framework of the Inventory preparation, great attention has been devoted to the identification of the sources of pollution. This was necessary for two basic reasons: the first is based on the geographical position of this region, and the second on the level of industrial and economic development within this region (there are no nuclear power plants, gas turbines, thermal power plants, heavy industry, etc.).

• Data sources

Data from several sources have been used on the different sectors, including:

– Statistical Yearbooks of Republic of North Macedonia 1990-2017;

– Publications published by SSO in different areas (Transport, Industry in the Republic of North Macedonia, Industry and Energy, Livestock, Agriculture and Forestry);

– MAKSTAT database of the SSO

c) Data management and processing

Emission factors and activity data for different source categories are collected and calculated in separate NFR excel tables, for the period from 1990 to 2017. NFR tables are categorized in separate folders (ENERGY, INDUSTRY and SOLVENT PRODUCT USE, AGICULTURE, WASTE, TRANSPORT, NATURAL SOURCES). During each inventory preparation cycle, evaluation and update of selected emission factors of previous years is conducted, if there is an available

[2] Informative Inventory report, Republic of North Macedonia (1990-2018)

updated version of EMEP/EEA Guidebook. No changes emission factors were done during this reporting round.

The availability of data and possible time series inconsistencies are described for each source category in the sectoral chapters, further below. Mainly the problem is coming from the fact that data coming from the Statistical publications are not detailed enough, and the fact that the last Census was carried out in 2002. Taking into account such difficulties in the collection of data on activity rates, as well as the fact that Republic of North Macedonia does not yet have national emission factors with exception of those provided for the major industries, Tier 1 methodologies and the corresponding emission factors from GB 2016 were used to estimate emissions from most sources in this Inventory. Calculation of emissions with use of Tier 2 method was carried out for category 1.A.3.b.i Passenger cars.

d) Reporting

For reporting of emissions, data from separated calculated sheets tables per NFR, containing EFs, activity data and calculated emissions per pollutant, were linked to the NFR table for reporting. The NFR Reporting Tool transposes columns to rows, includes data analysis and provides emission trends. NFR Reporting tool is linked with the NFR_14 reporting template and reporting towards UNECE and EEA is carried out within the given deadline. During the preparation of the current submission of Informative Inventory Report in 2018, the below listed guidelines were followed:

• Revised 2014 Reporting guidelines (ECE/EB.AIR.125);

• Annex II of the Guidelines Recommended structure for the Informative Inventory Report (IIR) - Documentation of methods, trends, recalculations, activity data and other information relevant for understanding the inventory;

• EMEP/EEA air pollutant emission inventory guidebook - 2009;

• EMEP/EEA air pollutant emission inventory guidebook — 2013;

• EMEP/EEA air pollutant emission inventory guidebook — 2016;

• EMEP/EEA air pollutant emission inventory guidebook — 2019

The structure of the above mentioned guidelines was followed by the authors, in order to achieve transparency, consistency, completeness, comparability and accuracy of reported emission data. This IIR as the previous one, was reported after the given deadline, namely in the beginning of May due to the experts engagement in other duties. It is planned from the next year to respect the given reporting deadline also for the IIR.

4. Pollutants

The following pollutants are part of this inventory report.

4.1. Particulate matter

Particulate matter is the general term used for a mixture of particles (solid and liquid) suspended in the air, with a wide range of sizes and chemical compositions. PM10 consists of the coarse parti-cles fraction and in addition the PM2.5 fraction, including dust, pollen, mould etc.

Particulate matter, also collectively known as aerosols, can be further categorised as either prima-ry particulate matter or secondary particulate matter. Primary particulate matter enters the at-mosphere directly (e.g. from chimneys). Secondary particulate matter is formed in the atmosphere from the oxidation and transformation of primary gaseous emissions. The gaseous emissions that contribute to particle formation are also known as precursor gases. The most important precursor gases for secondary particles are SO2, NOX, NH3 and VOCs (volatile organic compounds, a class of chemical compounds whose molecules contain carbon). The main precursor gases SO2, NOX and NH3 react in the atmosphere and form ammonium, sulphate, and nitrate compounds. These com-pounds then condense into liquid and form new particles in the air, called secondary inorganic aerosols.

Particulate matter can come from natural or from anthropogenic sources. Natural sources include sea salt, naturally suspended dust, pollen, and volcanic ash. Anthropogenic sources include fuel combustion during thermal power generation, incineration, domestic heating for households, and fuel combustion in vehicles. In cities, important local sources include vehicle exhausts, road dust re-suspension, and the burning of wood, coal or other fuels for domestic heating. These are all emission sat a low level (<20 meters height), leading to significant impacts on the concentration levels close to ground.

The health effects of PM are caused by inhalation and penetration into the lungs and blood stream, leading to adverse effects in the respiratory, cardiovascular, immune, and neural systems. Ul-trafine particles (with diameters of 0.1 micrometres or less) can also penetrate the brain via the nose. Both chemical and physical interactions between PM and lung tissues can induce irritation or damage. The smaller the particles, the deeper the penetration into the lungs.

PM_{10}

Tiny inhalable particles may be among the most harmful of all air pollutants. Particulate matter with diameter less than 10 micrometers (PM10) can penetrate deep into the human respirable system.Harmful particles are emitted into the atmosphere from numerous sources, such as vehicular exhausts, small scale residential heating, industrial processes, power plants, agricultural waste burning, backyard waste burning and wildfires.

Emitted particles can also be transported with air currents hundreds of kilometers from the emission source.Especially during the winter time PM10 concentrations in towns and cities throughout the country frequently exceed the limit values set for the protection of human health.This elevation of ambient particle concentration is obviously caused by different types of emission sources together with unfavorable meteorological conditions.However, it is likely that traffic exhausts and small scale domestic combustion are among the major contributors.

$PM_{2.5}$

Suspended particles consist of solids in the air in the form of smoke, dust and vapor, and can stay suspended for an extended period. These air particles are categorized according to the size and, at the same time, they are one of the main reasons for reduced visibility. Particles with size in diameter smaller than 50 micrometers are classified as total suspended particles (TSP). PM2.5 are so called fine particles with a size smaller or equal to 2.5 micrometers.

PM2.5 derive directly from the emission of primary particles, or is formed through secondary reactions which include VOCs, SO2 и NOX emissions deriving from energy and industrial plants, automobiles (especially trucks and buses using diesel fuels) and other combustion sources. As we can see from the figure during the winter time PM2.5 concentrations in towns and cities throughout the country are higher than the concentrations in spring period of the year, as presented on the graph. This is also like PM10 caused by a different types of emission from the production processes, traffic, residential wood burning, agricultural burning and etc. combined with the unfavorable meteorological conditions. PM2.5 is carried by the wind, so particulate matter generated in one state can affect PM2.5 levels in downwind areas.

4.2. Nitrogen dioxide NO2

Nitrogen dioxide is a reactive gas that is mainly formed by oxidation of nitrogen monoxide (NO). High temperature combustion processes (e.g. those occurring in car engines and power plants) are the major sources of NO and NO2. These two gases are collectively known as NOX. Nitrogen mon-oxide accounts for the majority of NOX emissions. A small part of NOX emissions is directly emitted as NO2, typically 5–10 % for most combustion sources. Diesel vehicles are an exception, typically emitting a higher proportion of NO2, up to as much as 70 % because their exhaust after treatment system increases the direct NO2 emissions. There are clear indications that for traffic emissions, the direct NO2 fraction is increasing significantly due to the greater penetration of diesel vehicles, especially newer diesel vehicles (Euro 4 and 5). This may lead to more frequent breaching of the NO2limit values in traffic hotspots. NO2 is an air pollutant which primarily affects the respiratory system. Short-term exposure to NO2 can result in adverse health effects such as changes in lung function in sensitive population groups, while long-term exposure can lead to more serious effects such as increased susceptibility to respiratory infection.

5.3. Carbon monoxide - CO

Carbon monoxide is a gas emitted due to incomplete combustion of fossil fuels and bio-fuels. Road transport was once a significant source of CO emissions, but the introduction of catalytic converters reduced these emissions significantly. CO concentrations tend to vary with traffic patterns dur-ing the day. The highest CO levels are found in urban areas, typically during rush hours at traffic locations. Carbon monoxide enters the body through the lungs. In the blood it is strongly bound to hemoglo-bin. Exposure to CO can reduce blood's oxygen-carrying capacity, thereby reducing oxygen deliv-ery to the body's organs and tissues. Those suffering from cardiovascular disease are the most sensitive towards CO exposure. Short-term CO exposure further affects the already-compromised ability of their bodies to respond to the increased oxygen demands of exercise or exertion. At ex-tremely high levels, CO can cause death.

5.4. Sulphur dioxide - SO_2

SO2 is produced from burning of fossil fuels and smelting of mineral ores that contain sulphur. Generally, the main anthropogenic source of SO2 is the burning of sulphur-containing fossil fuels for domestic heating, power generation and motor vehicles.

Sulphur dioxide is harmful to human health and the ecosystems. It is a major precursor to particulate matter, which is associated with significant health effects. When SO2 combines with water, it forms sulfuric acid. It is the main component of acid rain, which is a cause of deforestation and acidification of soils and waters. Sulphur can be stored in soils in certain biochemical conditions and cause postponed acidification process. Thus, SO2 emission reduction measures may take many decades before they have a positive effect.

5.5. Ozone - O3

Ozone (O3) is formed by complex chemical reactions with the emissions of precursor gases such as nitrogen oxides and hydrocarbons. Generally, in urban environments vehicular exhaust emissions are the most important contributor to the ozone concentrations. In addition to the precursor gases, the formation of O3 requires sunlight. Therefore the O3 concentrations are typically higher for example in the Mediterranean countries compared to the Northern European countries. The concentrations of O3 usually increase when the altitude increases (within couple of kilometres), thus in high altitude monitoring stations the O3 concentrations can be higher than in the lower altitude stations. In urban environments the O3 is consumed with chemical reaction of NO to form NO2 . Therefore, unlike other pollutants, the O3 concentrations are generally the highest at rural locations, lower at urban sites, and even lower at traffic locations. Sometimes, during episodes of high solar radiation and temperatures, the high O3 concentrations may occur also in urban environments. In urbanised areas the reduction of NOx emissions can lead to increase of O3 concentrations. Nevertheless, O3 concentrations are not only determined by precursor emissions but also strongly by meteorological conditions. Episodes of elevated O3 levels occur during periods of warm, sunny weather as the sunlight and high temperatures favour O3 formation.

Exposure to ozone is considered to be most damaging to the vegetation compared to any other pollutant in the air. Ozone can have significant effects on the growth of trees, vegetation in general, and important crops such as wheat, soybean and rice. Due to this, high ozone concentrations can cause significant economic losses for forestry and agriculture. Ozone is also harmful to human health.

5.6. Polycyclic aromatic hydrocarbons (PAH)

Among the air pollutants, the PAHs are one of the most dangerous for human health, since many of them are carcinogenic. PAHs in the ambient air are attached to particles (PM2.5 and PM10). The best known and most studied PAHs is the benzo(a)pyrene (B(a)P) and it is used to represent the PAHs. B(a)P is the only PAHs which has target value inthe air quality legislation. Measured B(a)P concentrations are high across large parts of Europe, mostly as a result of emissions from the domestic combustion of coal and wood.

Incomplete combustion of fuels generates the polycyclic aromatic hydrocarbons which are released to the air. Combustion of organic material always releases some PAHs compounds to air. However, typically in the urban areas the major sources of PAHs are the residential heating and exhaust gases from traffic. Some industrial processes, such as foundries and coking plants can also emit PAHs emissions.

5.7. Benzo(a)pyrene concentrations

Benzo(a)pyrene is a five-ring polycyclic aromatic hydrocarbon (PAH) and is found in fine particu-late matter that originates in incomplete combustion of various fuels. The main sources of B(a)P in Europe are waste burning, coke and steel production, vehicles, and domestic home heating, in particular wood burning. Other sources include outdoor fires and rubber tire wear. B(a)P can be considered as carcinogenic pollutant.

5.8. Heavy metals

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb)[3]. Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain.

Heavy metals in ambient air are typically attached to particles (PM2.5 and PM10). In European level, the human exposure to arsenic, cadmium, lead and nickel ambient air concentrations

[3] https://www.lenntech.com/processes/heavy/heavy-metals/heavy-metals.htm

above the limit or target values is a local problem, restricted to a few areas with specific industrial plants and activities.

Manufacture of basic metals by processing ores containing these substances, originates emissions of heavy metals to air. However, the emission volumes have declined significantly over the past two decades due to technological developments. Also, the use of fossil fuels, as well as the uncontrolled burning of waste can emit heavy metals to the air.

4.1. Main emission sources in North Macedonia[4]

Main emission sources in North Macedonia refer to national emissions identified within the National Inventory Report and it is very important to highlight that there can be significant diference with regional and local share of sources.

4.1.1. NOx

Main emission sources in North Macedonia Almost all NOx emissions are coming from the sector Energy, where the major sources of total emissions changed compared to 1990, due to growing importance of NFR sector 1.A.3 Transport. The main emission sources in 2017, are NFR source categories 1.A.3 Transport and 1.A.1 Energy Industries, which contributed with 30% (22% in 1990) and 48% (55% in 1990) respectively, of the national total NOx emissions. From NFR source category 1.A.2 Manufacturing Industries also 16% (19% in 1990) of total NOx emissions are stemming.

NFR sectors 1.B Fugitive emissions, 2 Industrial Processes and Product Use, 3 Agriculture and 5 Waste are minor sources of NOx emissions.

4.1.2. NMVOC

NMVOC emissions are emitted from different source. The key category source in 2017 are NFR source categories is 2.Industial pollution 32% (23% in 1990)followed by 1.A.4 Other Sectors (mainly residential heating) which contributed with 19% (22% in 1990), to the national total NMVOC emissions. NFR source category 1.A.3 Transport is contributing 9% in 2017 (31% in 1990) of total calculated national NMVOC emissions. Waste, Agriculture is contributing with around 15% while waste and fugitive emissions and with around 13% and 10% respectively.

4.1.3. SO2

Almost all SO2 emissions are resulting from Energy sector. So, the main emission source in 2017 is NFR source category 1.A.1 Energy Industries (Public electricity and heat production), which contributed with 88% (94% in 1990) to the national total SO2 emissions. About 10% (4% in 1990) of total emissions are stemming from NFR source category 1.A.2 Manufacturing Industries.

Other NFR sectors produce minor SO2 emissions.

[4] Informative Inventory Report 1990-2017

4.1.4. NH3

NH3 emissions are mainly resulting from the Agriculture sector contributing with 92% both in 1990 and in 2017 to national total NH3 emissions. Within Agriculture sector NH3 is almost exclusively emitted by source category 3.B Manure Management (52,01% in 2017) and emissions from cattle have the highest contribution (30,80%).

About 5% (7% in 1990) of the total emissions are stemming from NFR source category 1.A.4 Other Sectors (residential heating).

NFR sectors 1.B Fugitive emissions and 1.A.3 Transport are minor sources of NH3 emissions.

4.1.5. CO_2

Almost all CO emissions are resulting from the Energy sector. So, the main emission sources in 2017 are NFR sectors 1.A.4 Other Sectors (residential heating) and 1.A.3 Transport, contributing with 59% (51% in 1990) and 21% (39% in 1990) to the national total CO emissions repectively. Further smaller emission sources in 2017are 1.A.2 Manufacturing Industries, 5 Waste and 1.A1 Energy Industries with shares of 11%, 5% and 3%, respectively.

NFR sectors 1.B Fugitive emissions, 2 Industrial Processes and Product Use and 1A.5.Other sources are minor sources of CO emissions.

4.1.6. PM10

The main emission sources for PM10 in 2017 are NFR sectors 1.A.4 Other Sectors (residential heating), with a share of 37% (25% in 1990) in total PM10 emissions, 2 Industrial Processes and Product Use (mainly 2.C.2 Ferroalloys Production) with 13% (47% in 1990) and 1.A.1 Energy Industries with 26% (18% in 1990). With a share of 15% in 2017(6% in 1990), the sector Agriculture is also contributing to the total PM10 emissions.

NFR sectors 1.B Fugitive emissions and 5 Waste are minor sources of PM10 emissions.

4.1.7. PM 2.5.

Same as for PM10, the main emission sources for PM2.5 in 2017are NFR sectors 1.A.4 Other Sectors (residential heating) with a share of 62% (36% in 1990) in total PM10 emissions, 1.A.1 Energy Industries with 18% (11% in 1990) andthe contribution of the NFR sector - 2 Industrial Processes and Product Use (mainly 2.C.2 Ferroalloys Production) is very low, contributing onlywith 5% (48% in 1990) due to the fact the two major plants for production of ferroallows were out of operation, Transport is contributing with 4%.

NFR sectors 1B Fugitive emissions, 3 Agriculture and 5 Waste are minor sources of PM2.5 emissions.

4.1.8. Pb

The most important emission sources of Pb in 2017are NFR sectors 1 Energy with shares in national total emissions of 34% from 1.A.2 and 21% in 1.A.4, 1A1a with share of20% in Industrial Processes and Product Use with share of21%. In 1990 the situation was different, where the key sector was use of leaded petrol in transport sector which led to contribution of NFR 1.A.3 with 84% and Industrial Processes and Product Use with share of 14%. While the energy sector, meaning 1.A.1, 1.A.2 and 1.A.4 contribute with around 1 %. Within NFR sector

2 Industrial Processes and Product Use, all Pb emissions result from 2.C Metal Production (2.C.1 Iron and Steel Production) with a share of 14% in 1990 and 21% in 2017, due to the fact that leaded petrol was eliminated in 2004. The reduction of 98% compare to 1990 is due to the elimination of the use of leaded petrol. However, due to the fact that EF used for calculation of Pb emissions up to 2004 are not documented, there is a high uncertainty of estimation of lead emissions in 1.A.3 transport, so these emissions should be recalculated with the use of COPERT V model.

Pb emissions from NFR sectors 1.B Fugitive Emissions, 3 Agriculture and 5 Waste are minor sources.

5. ENERGY (NFR SECTOR 1)

5.1 Manufacturing industries and construction– NFR 1.A.2

This category includes emissions from manufacturing industries. It provides the methodology, emission factors as well as relevant activity data necessary for calculation of the exhaust emissions for the following 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 — Other

Due to the lack of data for the only the emissions for the catacory 1.A.2.a, 1.A.2.b and 1.A.2.f were calculated.

5.1.2 Iron and steel —1.A.2.a

This category includes emissions from manufacturing industries. Due to the lack of data only the emissions from the company Dojran Steel are calculated.

5.1.2.1 Methodology

The Tier 1 approach for process emissions from industrial combustion installations uses the general equation:

$E_{pollutants} = \sum AR_{fuelconsumption} \text{ x } EF_{fuel, pollutant}$

$E_{Pollutant}$ = emissions of pollutant (kg),

$AR_{fuel\ consumption}$ = fuel used in the industrial combustion (TJ) for each fuel,

$EF_{fuel,pollutant}$ = an average emission factor (EF) for each pollutant for each unit of fuel type used (kg/TJ).

5.1.2.2. Activity data

The quantity of fuel is taken from the questionarue for emission in the environment from Dojran Steel, that was provided by the Ministry for Environment and Phisical Planing. The activity data are given in Table 3.

Table 1 Activity data for source category 1.A.2.a

Heavy Fuels [TJ]
83,48

5.1.2.3 Emissions factor

Tier 1 emission factors have been used for calculation of emissions. Emission factors are given in Table 2.

Table 2 Emission factors for source category 1.A.2 - Stationary combustion in manufacturing industries and construction for liquid fuel

Pollutant	Value	Unit	References
NOx	513	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
NMVOC	25	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
SOx	47	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
PM2.5	20	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
PM10	20	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
TSP	20	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
BC	56	% of PM2.5	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
CO	66	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Pb	0,08	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Cd	0,006	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Hg	0,12	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
As	0,03	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Cr	0,2	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Cu	0,22	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Ni	0,008	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Se	0,11	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Zn	29	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
PCDD/PCDF	1,4	ng I-Teq/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
benzo(a) pyren	1,9	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
benzo(b) fluoranthen	15	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
benzo(k) fluoranthen	1,7	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Indeno (1.2.3-cd) pyren	1,5	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17

5.1.2.4 Calculated emssions

In the table below are given the annual emissions per ton per pollutant from category 1.A.2.a for the Southeast region.

Table 3 Calculated emissions for category 1.A.2.a

CO [t/a]	NM VOC [t/a]	NOx [t/a]	SOx [t/a]	PM_{10} [t/a]	$PM_{2,5}$ [t/a]	TSP [t/a]	Pb [t/a]	Cd [t/a]	Hg [t/a]
5.5098	2.0870	42.8260	3.9236	1.6696	1.6696	1.6696	0.000007	0.000001	0.000010

benzo(a) pyren [t/a]	benzo(b) fluoranthen [t/a]	benzo(k) fluoranthen [t/a]	Indeno (1,2,3-cd) pyren [t/a]	HCB [t/a]	PCDD/ PCDF (dioxins/ furans) [t/a]
0.0002	0.0013	0.0001	0.0001	0	0.1169

5.1.3 Non-ferrous metals —1.A.2.b

This category includes emissions from manufacturing industries. Due to the lack of data only the emissions from the company Bucim are calculated.

5.1.3.1 Methodology

The Tier 1 approach for process emissions from industrial combustion installations uses the general equation:

$E_{pollutants} = \sum AR_{fuelconsumption} \text{ x } EF_{fuel, pollutant}$

$E_{Pollutant}$ = emissions of pollutant (kg),

$AR_{fuel\ consumption}$ = fuel used in the industrial combustion (TJ) for each fuel,

$EF_{fuel,pollutant}$ = an average emission factor (EF) for each pollutant for each unit of fuel type used (kg/TJ).

5.1.3.2. Activity data

The quantity of fuel is taken from the questionairre for emission in the environment from Bucim, that was provided by the Ministry for Environment and Phisical Planing. The activity data are given in Table 4.

Table 4 Activity data for source category 1.A.2.b

Biomass [TJ]	Heavy Fuels [TJ]
1,01	234,38

5.1.3.3 Emissions factor

Tier 1 emission factors have been used for calculation of emissions. Emission factors are given in

Table 5 and Table 6.

Table 5 Emission factors for source category 1.A.2 - Stationary combustion in manufacturing industries and construction for liquid fuel

Pollutant	Value	Unit	References
NOx	513	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
NMVOC	25	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
SOx	47	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
PM2.5	20	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
PM10	20	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
TSP	20	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
BC	56	% of PM2.5	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
CO	66	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Pb	0,08	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Cd	0,006	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Hg	0,12	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
As	0,03	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Cr	0,2	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Cu	0,22	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Ni	0,008	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Se	0,11	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Zn	29	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
PCDD/PCDF	1,4	ng I-Teq/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
benzo(a)	1,9	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
benzo(b)	15	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
benzo(k)	1,7	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Indeno	1,5	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17

Table 6 Emission factors for source category 1.A.2 - Stationary combustion in manufacturing industries and construction for biomass

Pollutant	Value	Unit	References
NOx	91	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
NMVOC	300	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
SOx	11	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
PM2.5	140	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
PM10	143	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
BC	28	% of PM2.5	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
TSP	150	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
CO	570	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
Pb	27	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
Cd	13	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
Hg	0,56	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
As	0,19	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
Cr	23	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
Cu	6	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
Ni	2	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
Se	0,5	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
Zn	512	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
PCDD/PCDF	100	ng I-Teq/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
benzo(a) pyren	10	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
benzo(b) fluoranthen	16	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
benzo(k) fluoranthen	5	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
Indeno (1.2.3-cd) pyren	4	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
HCB	5	µg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18
PCBs	0,06	µg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 18

5.1.3.4 Calculated emssions

In the table below are given the annual emissions per ton per pollutant from category 1.A.2.a for the Southeast region.

Table 7 Calculated emissions for category 1.A.2.b

CO [t/a]	NM VOC [t/a]	NOx [t/a]	SOx [t/a]	PM_{10} [t/a]	$PM_{2,5}$ [t/a]	TSP [t/a]	Pb [t/a]	Cd [t/a]	Hg [t/a]
16.0454	6.1628	120.3300	11.0271	4.8322	4.8292	4.8393	0.000046	0.000015	0.000029

benzo(a) pyren [t/a]	benzo(b) fluoranthen [t/a]	benzo(k) fluoranthen [t/a]	Indeno (1,2,3-cd) pyren [t/a]	HCB [t/a]	PCDD/ PCDF (dioxins/ furans) [t/a]

0.0005	0.0035	0.0004	0.0004	0	0.4292

5.1.4 Other —1.A.2.f

This category includes emissions from manufacturing industries. Due to the lack of data only the emissions from the companies Nemetali Ograzden, Elenica and Zikol are calculated.

5.1.4.1 Methodology

The Tier 1 approach for process emissions from industrial combustion installations uses the general equation:

$E_{pollutants} = \sum AR_{fuelconsumption} \times EF_{fuel,\ pollutant}$

$E_{Pollutant}$ = emissions of pollutant (kg),

$AR_{fuel\ consumption}$ = fuel used in the industrial combustion (TJ) for each fuel,

$EF_{fuel,pollutant}$ = an average emission factor (EF) for each pollutant for each unit of fuel type used (kg/TJ).

5.1.4.2. Activity data

The quantity of fuel is taken from the questionarue for emission in the environment from the companies Nemetali Ogrzaden, Elenica and Zikol, that were provided by the Ministry for Environment and Phisical Planing. The activity data are given in Table 8

Table 8 Activity data for source category 1.A.2.f

Natural gas [TJ]	Heavy Fuels [TJ]
2,07	17,73

5.1.4.3 Emissions factor

Tier 1 emission factors have been used for calculation of emissions. Emission factors are given in Table 9 and Table 10.

Table 9 Emission factors for source category 1.A.2 - Stationary combustion in manufacturing industries and construction for liquid fuel

Pollutant	Value	Unit	References

NOx	513	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
NMVOC	25	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
SOx	47	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
PM2.5	20	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
PM10	20	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
TSP	20	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
BC	56	% of PM2.5	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
CO	66	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Pb	0,08	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Cd	0,006	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Hg	0,12	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
As	0,03	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Cr	0,2	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Cu	0,22	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Ni	0,008	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Se	0,11	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Zn	29	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
PCDD/PCDF	1,4	ng I-Teq/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
benzo(a) pyren	1,9	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
benzo(b)	15	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
benzo(k)	1,7	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17
Indeno (1.2.3-cd)	1,5	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 17

Table 10 Emission factors for source category 1.A.2 - Stationary combustion in manufacturing industries and construction for gaseous fuel

Pollutant	Value	Unit	References
NOx	74	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
NMVOC	23	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
SOx	0,67	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
PM2.5	0,78	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
PM10	0,78	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
TSP	0,78	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
BC	4	% PM2.5	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
CO	29	g/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
Pb	0,011	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
Cd	0,0009	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
Hg	0,54	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
As	0,1	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
Cr	0,013	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16

Cu	0,0026	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
Ni	0,013	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
Se	0,058	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
Zn	0,73	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
PCDD/PCDF	0,52	ng I- Teq/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
benzo(a) pyren	0,72	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
benzo(b) fluoranthen	2,9	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
benzo(k) fluoranthen	1,1	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16
Indeno (1.2.3-cd) pyren	1,08	mg/GJ	GB 2016 Table 3-3 emission factor for source category 1.A.2, page 16

5.1.4.4 Calculated emssions

In the table below are given the annual emissions per ton per pollutant from category 1.A.2.f for the Southeast region.

Table 11 Calculated emissions for category 1.A.2.f

CO [t/a]	NM VOC [t/a]	NOx [t/a]	SOx [t/a]	PM_{10} [t/a]	$PM_{2,5}$ [t/a]	TSP [t/a]	Pb [t/a]	Cd [t/a]	Hg [t/a]
1.2303	0.4909	9.2490	0.8347	0.3562	0.3562	0.3562	0.000001	0.000000	0.000003

benzo(a) pyren [t/a]	benzo(b) fluoranthen [t/a]	benzo(k) fluoranthen [t/a]	Indeno (1,2,3-cd) pyren [t/a]	HCB [t/a]	PCDD/ PCDF (dioxins/ furans) [t/a]
0.00004	0.0003	0.00003	0.00003	0	0.0259

5.2. Transport

This chapter covers the emissions from road transport. It provides the methodology, emission factors as well as relevant activity data necessary for calculation of the exhaust emissions for the following categories of road vehicles:

- passenger cars (NFR code 1.A.3.b.i)
- light commercial vehicles (1) (< 3.5 t) (NFR code 1.A.3.b.ii)
- heavy-duty vehicles (2) (> 3.5 t) and buses (NFR code 1.A.3.b.iii)
- mopeds and motorcycles (NFR code 1.A.3.b.iv)

5.2.1. Road transport: Passenger cars 1 A 3 b i

5.2.1.1. Methodology

The Tier 2 methodology or emissions calculation included in the EEA Guidebook 2013, has been used for calculation of the emission from road transport. The Tier 2 approach allows to estimate the emission for a given vehicles fleet, when the information concerning the number of vehicles classified by categories, fuel and emission standards is known.

The Tier 2 approach considers the fuel used by different vehicle categories and their emission standards that are multiplied by the appropriate emission factor, which depends on the type of the fuel and type of technology of combustion in stationary sources, and the type of mobile equipment and machinery, respectively.

The Tier 2 approach for exhaust emissions uses the following general equation:

The emission E for a certain pollutant i and a vehicles category j is calculated as following:

$$E_{i,j} = \sum_k (N_{j,k} \cdot M_{j,k} \cdot EF_{i,j,k})$$

where:

$N_{j,k}$ = number of vehicles in the fleet of category j and technology k.

$M_{j,k}$ = average annual distance driven per vehicle of category j and technology k.

$EF_{i,j,k}$ = technology-specific emission factor of pollutant i for vehicle category j and technology k.

Sulfur dioxide emissions are estimated by assuming that all sulfur in the fuel is transformed completely into SO2, using the formula:

$$E_{SO2m} = (2 \cdot k_{S,m} \cdot FC_m)$$

where:

$K_{S,m}$= weight related sulfur content in fuel of type m

FC_m = fuel consumption of fuel m

5.2.1.2. Activity data

The data for annual average mileage of a vehicle category, data of the vehicle stock and data for the driven kilometer per type of vehicle wehre provided by the Ministry of Environment and physical planning.

5.2.1.3. Emission factors

Emisson factors are taken from the Informative Inventory Report for the North Macedonia 2018 prepared by Ministry of Environment and Physical Planning – MEIC.

Table 12. Emission factor for source category 1.A.3.bi Road Transport: Passenger cars used for calculation of emissions by use of Tier 2 methodologies

Fuel type	g/km	CO	NH_3	NM	NOx	Pb	$PM_{2.5}$	B(a)P
gasoline	EURO 0	24,60	0,002	2	2,66	0,0000182	0,0022	0,00000048
gasoline	EURO 1	4,07	0,0922	0	0,46	0,0000182	0,0022	0,0000003
gasoline	EURO 2	2,04	0,1043	0	0,24	0,0000182	0,0022	0,00000032
gasoline	EURO 3	1,80	0,0342	0,10	0,09	0,0000182	0,0011	0,00000032
gasoline	EURO 4	0,63	0,0342	0	0,06	0,0000182	0,0011	0,00000032
gasoline	EURO 5	0,63	0,0123	0	0,06	0,0000182	0,0014	0,00000032
gasoline	EURO 6	0,63	0,0123	0	0,06	0,0000182	0,0014	0,00000032
diesel	EURO 0	0,69	0,001	0	0,71	0,0000182	0,2209	0,00000174
diesel	EURO 1	0,41	0,001	0	0,69	0,0000182	0,0842	0,00000174
diesel	EURO 2	0,30	0,001	0	0,72	0,0000182	0,0548	0,00000174
diesel	EURO 3	0,09	0,001	0	0,77	0,0000182	0,0391	0,00000174
diesel	EURO 4	0,09	0,001	0	0,58	0,0000182	0,0314	0,00000174
diesel	EURO 5	0,04	0,0019	0	0,61	0,0000182	0,0021	0,00000174
diesel	EURO 6	0,05	0,00	0	0,50	0,0000182	0,0015	0,00000174
other	EURO 0	6,83	0,002	1	2,36	1,82E-05	0,0022	1,00E-08
other	EURO 1	3,57	0,088	0	0,41	1,82E-05	0,0022	1,00E-08
other	EURO 2	2,48	0,1007	0	0,18	0,0000182	0,0022	0,00000001
other	EURO 3	1,79	0,0338	0	0,09	0,0000182	0,0011	0,00000001
other	EURO	0,62	0,0338	0	0,06	1,82E-05	0,0011	1,00E-08
other	EURO	0,62	0,0338	0	0,06	1,82E-05	n.a.	n.a.
other	EURO	0,62	0,0338	0	0,06	1,82E-05	n.a.	n.a.

Source: Informative Inventory Report for the North Macedonia 2018

5.2.1.4. Calculated emission

In the table below are given the annual emissions per ton per pollutant from category 1 A 3 b i for the Southeast region.

Table 13. Calculated emissions for category Passenger cars 1 A 3 b i

CO [t/a]	NH_3 [t/a]	NMVOC [t/a]	NOx [t/a]	Pb [t/a]	TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]	B(a)P [t/a]
1163.886825	12.671797	116.023219	294.18155	0.008188	13.7908195	13.79082	13.79082	0.000498

5.2.2. Road transport: Light duty vehicles 1 A 3 b ii

5.2.2.1. Methodology

The Tier 2 methodology or emissions calculation included in the EEA Guidebook 2013, has been used for calculation of the emission from road transport. The Tier 2 approach allows to estimate the emission for a given vehicles fleet, when the information concerning the number of vehicles classified by categories, fuel and emission standards is known.

The Tier 2 approach considers the fuel used by different vehicle categories and their emission standards that are multiplied by the appropriate emission factor, which depends on the type of the fuel and type of technology of combustion in stationary sources, and the type of mobile equipment and machinery, respectively.

The Tier 2 approach for exhaust emissions uses the following general equation:

The emission E for a certain pollutant i and a vehicles category j is calculated as following:

$$E_{i,j} = \sum_k (N_{j,k} \cdot M_{j,k} \cdot EF_{i,j,k})$$

where:

$N_{j,k}$ = number of vehicles in the fleet of category j and technology k.

$M_{j,k}$ = average annual distance driven per vehicle of category j and technology k.

$EF_{i,j,k}$ = technology-specific emission factor of pollutant i for vehicle category j and technology k.

Sulfur dioxide emissions are estimated by assuming that all sulfur in the fuel is transformed completely into SO2, using the formula:

$$E_{SO2m} = (2 \cdot k_{S,m} \cdot FC_m)$$

where:

$K_{S,m}$= weight related sulfur content in fuel of type m

FC_m = fuel consumption of fuel m

5.2.2.2. Activity data

The data for annual average mileage of a vehicle category, data of the vehicle stock and data for the driven kilometer per type of vehicle wehre provided by the Ministry of Environment and physical planning.

5.2.2.3. Emission factors

Emisson factors are taken from the Informative Inventory Report for the North Macedonia 2018 prepared by Ministry of Environment and Physical Planning – MEIC.

Table 14. Emission factor for source category 1.A.3.bii Road Transport: Light duty vehicles used for calculation of emissions by use of Tier 2 methodologies

Type	Technology	CO	NH_3	NMVOC	NOx	B(a)P
Gasoline <3.5t	Conventional	25,5	0,0025	3,44	3,09	4,80E-07
Gasoline <3.5t	Euro1	8,82	0,0758	0,614	0,563	3,20E-07
Gasoline <3.5t	Euro2	5,89	0,091	0,304	0,23	3,20E-07
Gasoline <3.5t	Euro3	5,05	0,0302	0,189	0,129	3,20E-07
Gasoline <3.5t	Euro4	2,01	0,0302	0,128	0,064	3,20E-07
Gasoline <3.5t	Euro5	1,3	0,0123	0,096	0,064	3,20E-07
Gasoline <3.5t	Euro6	1,3	0,0123	0,096	0,064	3,20E-07
Diesel <3.5 t	Conventional	1,34	0,0012	0,133	1,66	2,85E-06
Diesel <3.5 t	Euro1	0,577	0,0012	0,141	1,22	6,30E-07
Diesel <3.5 t	Euro2	0,577	0,0012	0,149	1,22	6,30E-07
Diesel <3.5 t	Euro3	0,473	0,0012	0,094	1,03	6,30E-07
Diesel <3.5 t	Euro4	0,375	0,0012	0,035	0,831	6,30E-07
Diesel <3.5 t	Euro5	0,075	0,0019	0,035	1,18	6,30E-07
Diesel <3.5 t	Euro6	0,075	0,0019	0,035	0,953	6,30E-07

Source: Informative Inventory Report for the North Macedonia 2018

5.2.2.4. Calculated emission

In the table below are given the annual emissions per ton per pollutant from category 1 A 3 b ii for the Southeast region.

Table 15. Calculated emissions for category Light duty vehicles 1 A 3 b ii

CO [t/a]	NH_3 [t/a]	NMVOC [t/a]	NOx [t/a]	Pb [t/a]	TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]	B(a)P [t/a]
102.8670	0.3192	13.0066	75.6404	0.0003	6.4534	6.4534	6.4534	0.0001

5.2.3. Road transport: Heavy duty vehicles 1 A 3 b iii

5.2.3.1. Methodology

The Tier 2 methodology or emissions calculation included in the EEA Guidebook 2013, has been used for calculation of the emission from road transport. The Tier 2 approach allows to estimate the emission for a given vehicles fleet, when the information concerning the number of vehicles classified by categories, fuel and emission standards is known.

The Tier 2 approach considers the fuel used by different vehicle categories and their emission standards that are multiplied by the appropriate emission factor, which depends on the type of the fuel and type of technology of combustion in stationary sources, and the type of mobile equipment and machinery, respectively.

The Tier 2 approach for exhaust emissions uses the following general equation:

The emission E for a certain pollutant i and a vehicles category j is calculated as following:

$E_{i,j} = \sum_k (N_{j,k} \cdot M_{j,k} \cdot EF_{i,j,k})$

where:

$N_{j,k}$ = number of vehicles in the fleet of category j and technology k.

$M_{j,k}$ = average annual distance driven per vehicle of category j and technology k.

$EF_{i,j,k}$ = technology-specific emission factor of pollutant i for vehicle category j and technology k.

Sulfur dioxide emissions are estimated by assuming that all sulfur in the fuel is transformed completely into SO2, using the formula:

$E_{SO2m} = (2 \cdot k_{S,m} \cdot FC_m)$

where:

$K_{S,m}$= weight related sulfur content in fuel of type m

FC_m = fuel consumption of fuel m

5.2.3.2. Activity data

The data for annual average mileage of a vehicle category, data of the vehicle stock and data for the driven kilometer per type of vehicle wehre provided by the Ministry of Environment and physical planning.

5.2.3.3. Emission factors

Emisson factors are taken from the Informative Inventory Report for the North Macedonia 2018 prepared by Ministry of Environment and Physical Planning – MEIC.

Table 16. Emission factor for source category 1.A.3.bii Road Transport: Heavy duty vehicles used for calculation of emissions by use of Tier 2 methodologies

Type	Technology	CO	NH_3	NMVOC	NOx	Pb	$PM_{2.5}$	B(a)P
Gasoline >3.5 t	Conventional	59,5	0,0019	5,25	6,6	5,84E-06	0,057	4,80E-07
Diesel <=7.5 t	Conventional	1,85	0,0029	1,07	4,7	6,47E-06	0,333	9,00E-07
Diesel <=7.5 t	HD Euro I - 91/542/EEC I	0,657	0,0029	0,193	3,37	5,43E-06	0,129	9,00E-07
Diesel <=7.5 t	HD Euro II - 91/542/EEC II	0,537	0,0029	0,123	3,49	5,22E-06	0,061	9,00E-07
Diesel <=7.5 t	HD Euro III - 2000	0,584	0,0029	0,115	2,63	5,47E-06	0,0566	9,00E-07
Diesel <=7.5 t	HD Euro IV - 2005	0,047	0,0029	0,005	1,64	5,17E-06	0,0106	9,00E-07
Diesel <=7.5 t	HD Euro V - 2008	0,047	0,011	0,005	0,933	5,17E-06	0,0106	9,00E-07

Diesel <=7.5 t	HD Euro VI	0,047	0,011	0,005	0,18	5,17E-06	0,0005	9,00E-07
Diesel 7.5 - 16 t	Conventional	2,13	0,0029	0,776	8,92	9,48E-06	0,3344	9,00E-07
Diesel 7.5 - 16 t	HD Euro I - 91/542/EEC I	1,02	0,0029	0,326	5,31	8,36E-06	0,201	9,00E-07
Diesel 7.5 - 16 t	HD Euro II - 91/542/EEC II	0,902	0,0029	0,207	5,5	8,05E-06	0,104	9,00E-07
Diesel 7.5 - 16 t	HD Euro III - 2000	0,972	0,0029	0,189	4,3	8,39E-06	0,0881	9,00E-07
Diesel 7.5 - 16 t	HD Euro IV - 2005	0,071	0,0029	0,008	2,65	7,85E-06	0,0161	9,00E-07
Diesel 7.5 - 16 t	HD Euro V - 2008	0,071	0,011	0,008	1,51	7,85E-06	0,0161	9,00E-07
Diesel 7.5 - 16 t	HD Euro VI	0,071	0,011	0,008	0,291	7,85E-06	0,0005	9,00E-07
Diesel 16 - 32 t	Conventional	1,93	0,0029	0,486	10,7	1,31E-05	0,418	9,00E-07
Diesel 16 - 32 t	HD Euro I - 91/542/EEC I	1,55	0,0029	0,449	7,52	1,14E-05	0,297	9,00E-07
Diesel 16 - 32 t	HD Euro II - 91/542/EEC II	1,38	0,0029	0,29	7,91	1,11E-05	0,155	9,00E-07
Diesel 16 - 32 t	HD Euro III - 2000	1,49	0,0029	0,278	6,27	1,13E-05	0,13	9,00E-07
Diesel 16 - 32 t	HD Euro IV - 2005	0,105	0,0029	0,01	3,83	1,06E-05	0,0239	9,00E-07
Diesel 16 - 32 t	HD Euro V - 2008	0,105	0,011	0,01	2,18	1,06E-05	0,0239	9,00E-07
Diesel 16 - 32 t	HD Euro VI	0,105	0,011	0,01	0,422	1,06E-05	0,0012	9,00E-07
Diesel >32 t	Conventional	2,25	0,0029	0,534	12,8	1,54E-05	0,491	9,00E-07
Diesel >32 t	HD Euro I - 91/542/EEC I	1,9	0,0029	0,51	9,04	1,36E-05	0,358	9,00E-07
Diesel >32 t	HD Euro II - 91/542/EEC II	1,69	0,0029	0,326	9,36	1,33E-05	0,194	9,00E-07
Diesel >32 t	HD Euro III - 2000	1,79	0,0029	0,308	7,43	1,36E-05	0,151	9,00E-07
Diesel >32 t	HD Euro IV - 2005	0,121	0,0029	0,012	4,61	1,26E-05	0,0268	9,00E-07
Diesel >32 t	HD Euro V - 2008	0,121	0,011	0,012	2,63	1,26E-05	0,0268	9,00E-07
Diesel >32 t	HD Euro VI	0,121	0,011	0,012	0,507	1,26E-05	0,0013	9,00E-07

Source: Informative Inventory Report for the North Macedonia 2018

5.2.3.4. Calculated emission

In the table below are given the annual emissions per ton per pollutant from category 1 A 3 b iii for the Southeast region.

Table 17. Calculated emissions for category Heavy duty vehicles 1 A 3 b iii

CO [t/a]	NH_3 [t/a]	NMVOC [t/a]	NOx [t/a]	Pb [t/a]	TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]	B(a)P [t/a]
209.30558	0.1256035	27.731165	129.74456	0.000227576	4.3147005	4.3147005	4.3147005	3.44949E-05

5.2.4. Road transport: Buses 1 A 3 b iii

5.2.4.1. Methodology

The Tier 2 methodology or emissions calculation included in the EEA Guidebook 2013, has been used for calculation of the emission from road transport. The Tier 2 approach allows to estimate the emission for a given vehicles fleet, when the information concerning the number of vehicles classified by categories, fuel and emission standards is known.

The Tier 2 approach considers the fuel used by different vehicle categories and their emission standards that are multiplied by the appropriate emission factor, which depends on the type of the fuel and type of technology of combustion in stationary sources, and the type of mobile equipment and machinery, respectively.

The Tier 2 approach for exhaust emissions uses the following general equation:

The emission E for a certain pollutant i and a vehicles category j is calculated as following:

$$E_{i,j} = \sum_k (N_{j,k} \cdot M_{j,k} \cdot EF_{i,j,k})$$

where:

$N_{j,k}$ = number of vehicles in the fleet of category j and technology k.

$M_{j,k}$ = average annual distance driven per vehicle of category j and technology k.

$EF_{i,j,k}$ = technology-specific emission factor of pollutant i for vehicle category j and technology k.

Sulfur dioxide emissions are estimated by assuming that all sulfur in the fuel is transformed completely into SO2, using the formula:

$$E_{SO2m} = (2 \cdot k_{S,m} \cdot FC_m)$$

where:

$K_{S,m}$= weight related sulfur content in fuel of type m

FC_m = fuel consumption of fuel m

5.2.4.2. Activity data

The data for annual average mileage of a vehicle category, data of the vehicle stock and data for the driven kilometer per type of vehicle wehre provided by the Ministry of Environment and physical planning.

5.2.4.3. Emission factors

Emisson factors are taken from the Informative Inventory Report for the North Macedonia 2018 prepared by Ministry of Environment and Physical Planning – MEIC.

Table 18. Emission factor for source category 1.A.3.bii Road Transport: Buses used for calculation of emissions by use of Tier 2 methodologies

Type	EURO class	CO	NH_3	NMVOC	NOx	Pb	$PM_{2.5}$	B(a)P
Urban Buses Standard	Conventional	5,71	0,0029	1,99	16,5	1,90E-05	0,909	9,00E-07

Urban Buses Standard	HD Euro I - 91/542/EEC I	2,71	0,0029	0,706	10,1	1,61E-05	0,479	9,00E-07
Urban Buses Standard	HD Euro II - 91/542/EEC II	2,44	0,0029	0,463	10,7	1,55E-05	0,22	9,00E-07
Urban Buses Standard	HD Euro III - 2000	2,67	0,0029	0,409	9,38	1,62E-05	0,207	9,00E-07
Urban Buses Standard	HD Euro IV - 2005	0,223	0,0029	0,022	5,42	1,54E-05	0,0462	9,00E-07
Urban Buses Standard	HD Euro V - 2008	0,223	0,0029	0,022	3,09	1,54E-05	0,0462	9,00E-07
Urban Buses Standard	HD Euro VI	0,223	0,0029	0,022	0,597	1,54E-05	0,0023	9,00E-07

Source: Informative Inventory Report for the North Macedonia 2018

5.2.4.4. Calculated emission

In the table below are given the annual emissions per ton per pollutant from category 1 A 3 b iii for the Southeast region.

Table 19. Calculated emissions for category Buses 1 A 3 b iii

CO [t/a]	NH_3 [t/a]	NMVOC [t/a]	NOx [t/a]	Pb [t/a]	TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]	B(a)P [t/a]
50.7071	0.0612	12.1988	196.7222	0.0003	6.1107	6.1107	6.1107	0

5.2.5. Road transport: Mopeds and motorcycles 1 A 3 b iv

5.2.5.1. Methodology

The Tier 2 methodology or emissions calculation included in the EEA Guidebook 2013, has been used for calculation of the emission from road transport. The Tier 2 approach allows to estimate the emission for a given vehicles fleet, when the information concerning the number of vehicles classified by categories, fuel and emission standards is known.

The Tier 2 approach considers the fuel used by different vehicle categories and their emission standards that are multiplied by the appropriate emission factor, which depends on the type of the fuel and type of technology of combustion in stationary sources, and the type of mobile equipment and machinery, respectively.

The Tier 2 approach for exhaust emissions uses the following general equation:

The emission E for a certain pollutant i and a vehicles category j is calculated as following:

$$E_{i,j} = \sum_k (N_{j,k} \cdot M_{j,k} \cdot EF_{i,j,k})$$

where:

$N_{j,k}$ = number of vehicles in the fleet of category j and technology k.

$M_{j,k}$ = average annual distance driven per vehicle of category j and technology k.

$EF_{i,j,k}$ = technology-specific emission factor of pollutant i for vehicle category j and technology k.

Sulfur dioxide emissions are estimated by assuming that all sulfur in the fuel is transformed completely into SO2, using the formula:

$E_{SO2m} = (2 \cdot k_{S,m} \cdot FC_m)$

where:

$K_{S,m}$= weight related sulfur content in fuel of type m

FC_m = fuel consumption of fuel m

5.2.5.2. Activity data

The data for annual average mileage of a vehicle category, data of the vehicle stock and data for the driven kilometer per type of vehicle wehre provided by the Ministry of Environment and physical planning.

5.2.5.3. Emission factors

Emisson factors are taken from the Informative Inventory Report for the North Macedonia 2018 prepared by Ministry of Environment and Physical Planning – MEIC.

Table 20. Emission factor for source category 1.A.3.biv Road Transport: Mopeds and motorcycles used for calculation of emissions by use of Tier 2 methodologies

Capacity	EURO class	CO	NH3	NMVOC	NOx	Pb	$PM_{2.5}$	B(a)P
<50	Conventional	14,7	0,001	8,28	0,056	0,000011	0,176	9,6E-08
<50	Mop - Euro 1	5,65	0,001	1,96	0,2	0,000011	0,0425	6,4E-08
<50	Mop - Euro 2	3,5	0,001	1,665	0,17	0,000011	0,0165	6,4E-08
<50	Mop - Euro 3	2,25	0,001	1,15	0,17	0,000011	0,011	6,4E-08
<250	Conventional	28,55	0,0019	6,015	0,146	1,08E-06	0,087	3,2E-07
<250	Mop - Euro 1	14,95	0,0019	3,45	0,2365	1,01E-06	0,039	3,2E-07
<250	Mop - Euro 2	9,185	0,0019	1,3395	0,2105	9,7E-07	0,01775	3,2E-07
<250	Mop - Euro 3	2,88	0,0019	0,6355	0,237	8,82E-07	0,00655	3,2E-07

<750	Conventional	25,7	0,0019	1,68	0,233	1,23E-06	0,014	3,2E-07
<750	Mop - Euro 1	13,8	0,0019	1,19	0,477	1,19E-06	0,014	3,2E-07
<750	Mop - Euro 2	7,17	0,0019	0,918	0,317	1,19E-06	0,0035	3,2E-07
<750	Mop - Euro 3	3,03	0,0019	0,541	0,194	1,19E-06	0,0035	3,2E-07
>750	Conventional	21,1	0,0019	2,75	0,247	1,48E-06	0,014	3,2E-07
>750	Mop - Euro 1	10,1	0,0019	1,5	0,579	1,53E-06	0,014	3,2E-07
>750	Mop - Euro 2	7,17	0,0019	0,994	0,317	1,53E-06	0,0035	3,2E-07
>750	Mop - Euro 3	3,03	0,0019	0,587	0,194	1,53E-06	0,0035	3,2E-07

Source: Informative Inventory Report for the North Macedonia 2018

5.2.5.4. Calculated emission

In the table below are given the annual emissions per ton per pollutant from category 1 A 3 b iv for the Southeast region.

Table 21. Calculated emissions for category Mopeds and motorcycles 1 A 3 b iv

CO [t/a]	NH_3 [t/a]	NMVOC [t/a]	NOx [t/a]	Pb [t/a]	TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]	B(a)P [t/a]
1163.886825	12.671797	116.023219	294.18155	0.008187725	13.7908195	13.7908195	13.7908195	0.0004978

5.2.6. Gasoline evaporation (from vehicles) 1.A.3.b.v

This chapter provides the methodology, emission factors and relevant activity data to enable evaporative emissions of NMVOCs from gasoline vehicles (NFR code 1.A.3.b.v) to be calculated. The term 'evaporative emissions' refers to the sum of all fuel-related NMVOC emissions not deriving from fuel combustion.

Most evaporative emissions of VOCs, emanate from the fuel systems (tanks, injection systems and fuel lines) of petrol vehicles. Evaporative emissions from diesel vehicles are considered negligible, due to the presence of heavier hydrocarbons and the relatively low vapor pressure of diesel fuel and can be neglected in the calculations.

5.2.6.1. Methodology

The Tier 1 approach for calculating evaporative emissions uses the general equation from EMEP/EEA Guidebook 2013:

$$E_{voc} = \sum_j N_j \cdot EF_{voc,j} \cdot 365$$

where:

E_{voc} = the emissions of VOC (g/year);

N_j = the number of vehicles in category j.

EF_{voc} = the emission factor of VOC for vehicle category j (g/vehicle/day).

j = the vehicle category (passenger cars. light-duty vehicles and two-wheel vehicles.)

5.2.6.2. Activity data

The number of vehicles per category were provided by the Ministry of Environment and physical planning true the data base from the MOI.

5.2.6.3. Emission factors

Emisson factors are taken from the Informative Inventory Report for the North Macedonia 2018 prepared by Ministry of Environment and Physical Planning – MEIC.

Table 22. Emission factor for source category 1.A.3.bv Road Transport: Gasoline evaporation for gasoline fueled road vehicles — when daily temperature range is around 10 to 25 °C

Pollutant	Vehicle type	Value	Unit	References
NMVOC	Gasoline PCs	14,8	g/vehicle/day	GB 2009 1.A.3.b.v Gasoline evaporation. Table 3-2. pg. 9 evaporative emissions emission factors for gasoline fueled road vehicles — when daily temperature range is around 10 to 25 °C.
NMVOC	Gasoline LDVs	22,6	g/vehicle/day	GB 2009 1.A.3.b.v Gasoline evaporation. Table 3-2. pg. 9 evaporative emissions emission factors for gasoline fueled road vehicles — when daily temperature range is around 10 to 25 °C.
NMVOC	Two-wheel vehicles	3,0	g/vehicle/day	GB 2009 1.A.3.b.v Gasoline evaporation. Table 3-2. pg. 9 evaporative emissions emission factors for gasoline fueled road vehicles — when daily temperature range is around 10 to 25 °C.

Source: Informative Inventory Report for the North Macedonia 2018

5.2.6.4. Calculated emission

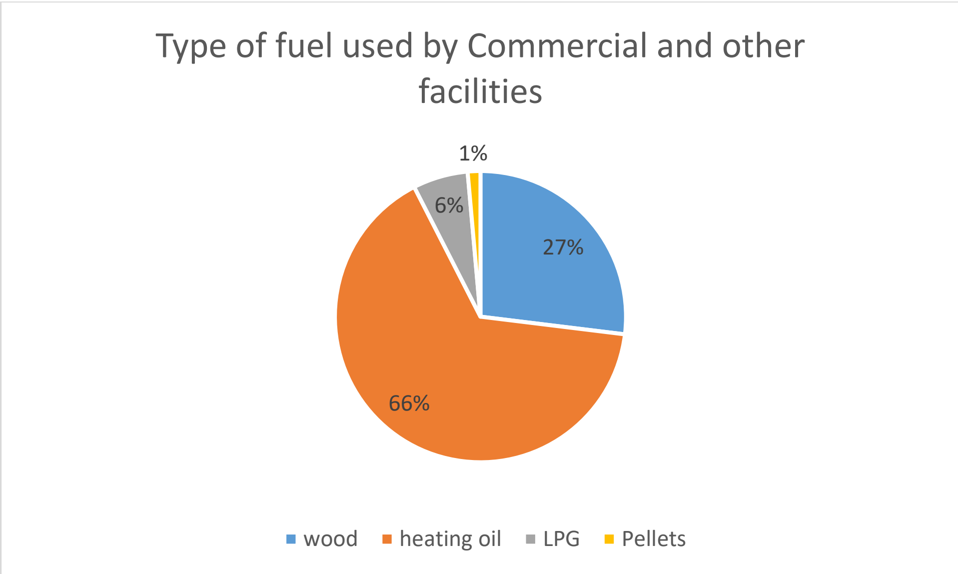
In the table below are given the annual emissions per ton per pollutant from category 1 A 3 b v for the Southeast region.

Table 23. Calculated emissions for category Gasoline evaporation for gasoline fueled road vehicles — when daily temperature range is around 10 to 25 °C

Vehicle type	NMVOC [t/a]
Passenger cars	69.015952
Light-duty vehicles	3.126371
Two-wheel vehicles	0.811395

5.3. Commercial / institutional: Stationary 1 A 4 a i

Within the Commercial/Institutional sector, mainly liquid fuels are used, followed by wood and only small portion of the sector are using LPG and pellets.



Picture 1. Type of fuel used by Commercial and other facilities

5.3.1. Methodology

The Tier 1 methodology has been selected by using default emission factors from the Informative Inventory Report for the North Macedonia 2018 prepared by Ministry of Environment and Physical Planning – MEIC. The Tier 1 approach for process emissions from small combustion installations uses the general equation:

$E_{pollutants} = \sum AR_{fuel\ consumption} \times EF_{fuel\ pollutants}$

where:

$E_{pollutants}$ = the emission of the specified pollutant,

$\sum AR_{fuel\ consumption}$ = the activity rate for fuel consumption,

$EF_{fuel\ pollutants}$ = the emission factor for this pollutant.

5.3.2. Activity data

The data for this sector were gathered via questionaries that where send to the each municiplaties of the Southeeast region. The collected data don't cover all the institutions, since some of the municipalities didn't provide data for the fuel consumption.

Fuel	TJ
Wood	11.77
Heating oil	28.85
LPG	8.41
Pellets	0.62

5.3.3. Emission factor

Emission factors are taken the Informative Inventory Report for the North Macedonia 2018 prepared by Ministry of Environment and Physical Planning – MEIC. Emission factors for different type of fuels are presented in Table 24,Table 25 and Table 26

Table 24 Tier 1 emission factors for NFR source category 1.A.4.a, using gaseous fuels

Pollutant	Value	Unit	References
NOx	70	g/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
NMVOC	2,5	g/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
SOx	0,5	g/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
$PM_{2.5}$	0,5	g/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
BC	4	%PM2.5	GB 2016 Table 3-8 emission factor for source category 1.A.4.a.i, page 39
PM_{10}	0,5	g/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
TSP	0,5	g/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
CO	25	g/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
Pb	0,984	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
Cd	0,515	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
Hg	0,234	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
As	0,0937	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
Cr	0,656	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
Cu	0,398	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
Ni	0,984	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
Se	0,0112	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
Zn	13,6	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
PCDD/PCDF	2	ng I-TEQ/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
benzo(a) pyren	0,562	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
benzo(b) fluoranthen	0,843	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26

benzo(k) fluoranthen	0,843	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26
Indeno (1.2.3-cd) pyren	0,843	mg/GJ	GB 2009 Table 3-8 emission factor for source category 1.A.4.a.i, page 26

Table 25 Tier 1 emission factors for NFR source category 1.A.4.a using liquid fuels

Pollutant	Value	Unit	References
NOx	100	g/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
NMVOC	10	g/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
SOx	140	g/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
$PM_{2.5}$	16,5	g/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
BC	56	% PM2.5	GB 2016 Table 3-8 emission factor for source category 1.A.4.a.i, page 40
PM_{10}	21,5	g/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
TSP	27,5	g/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
CO	40	g/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
Pb	16	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
Cd	0,3	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
Hg	0,1	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
As	1	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
Cr	12,8	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
Cu	7,2	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
Ni	260	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
Zn	8	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
PCDD/PCDF	10	ng I-TEQ/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
benzo(a) pyren	5,2	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
benzo(b) fluoranthen	6,2	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
benzo(k) fluoranthen	4	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27
Indeno (1.2.3-cd) pyren	2,2	mg/GJ	GB 2009 Table 3-9 emission factor for source category 1.A.4.a.i, page 27

Table 26 Tier 1 emission factors for NFR source category 1.A.4.a using biomass

Pollutant	Value	Unit	References
NOx	150	g/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
NMVOC	146	g/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
SOx	38,4	g/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
PM2.5	149	g/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
PM10	150	g/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
BC	28	% PM2.5	GB 2016 Table 3-8 emission factor for source category 1.A.4.a.i, page 41
TSP	156	g/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
CO	1.600	g/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
Pb	24,8	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.

Cd	1,8	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
Hg	0,7	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
As	1,4	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
Cr	6,5	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
Cu	4,6	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
Ni	2	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
Se	0,5	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
Zn	144	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
PCB	0,06	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
PCDD/PCDF	326	ng I-TEQ/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
benzo(a) pyren	44,6	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
benzo(b) fluoranthen	64,9	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
benzo(k) fluoranthen	23,4	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
Indeno (1.2.3-cd) pyren	22,3	mg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.
HCB	6	µg/GJ	GB 2009 Table 3-10 emission factor for source category 1.A.4.a.i.

5.3.4. Calculated emission

In the table below are give the calculations for emissions from category Stationary 1 A 4 a I per ton per pollutant.

Table 27. Calculated emissions from category 1 A 4 a i

1.A.4.a I Commercial / institutional: stationary	NO_X [t/a]	CO [t/a]	NMVOC [t/a]	SOx [t/a]	TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]	PB [t/a]	Cd [t/a]	Hg [t/a]
Biomass	1.1275	7.0623	3.7170	0.1363	2.1063	2.0196	1.9824	0.000335	0.0002	0.0000069
LPG	0.6226	0.2440	0.1935	0.0056	0.0066	0.0066	0.0066	0.0000001	0	0.0000008
Heating oil	8.8270	2.6827	0.5769	2.7116	0.6058	0.6058	0.5192	0.000231	0	0.0000029

benzo(a) pyren [t/a]	benzo(b) fluoranthen [t/a]	benzo(k) fluoranthen [t/a]	Indeno (1,2,3-cd) pyren [t/a]	HCB [t/a]	PCDD/ PCDF (dioxins/ furans) [t/a]
0.0001	0.0002	0.0001	0.00004956	0.0000000619	1.2390
0	0	0.0000000093	0.00000000909	0	0.0044
0	0	0.0000000490	0.00000004327	0.0000000063	0.1731

The percentage of fuel that participate at emissions of each pollutant for this category is given below in the table. In this cateogory the amount of NOx is mainly coming from heating oil, CO from burning biomass, NMVOC from biomass (83%). SOx is emitted from using heating oil and TSP, PM10 and PM 2,5 are mainly emitted from burning biomass (approximately 78%).

Table 28. Calculated emissions given in percentages for category 1 A 4 a i

Fuel	NO_X	CO	NMVOC	SOx	TSP	PM_{10}	$PM_{2.5}$
Biomass	11%	71%	83%	5%	77%	77%	79%
LPG	6%	2%	4%	0%	0%	0%	0%
Heating oil	83%	27%	13%	95%	22%	23%	21%
Total	100%	100%	100%	100%	100%	100%	100%

5.4. Residential – stationary combustion - 1 A 4 b i

Within the Residential sector, mainly solid biomass is used while liquid fuels, solid fuels and natural gas have minor importance.

The data for this chapter were taken from the Report from the conducted survey for emissions from household heating in the South-eastern region. The survey was conducted in the period of January – beginning of March 2020 and end of June – middle of July 2020.

This survey included households of the municipalities located in the South - eastern region, a total number of 10, as follows: Gevgelija, Strumica, Radovis, Dojran, Valandovo, Vasilevo, Bogdanci, Bosilovo, Novo Selo and Konce. The scope of the research included both the urban (cities) and rural areas (villages) of the region.

Total number of 1451 questionnaire forms were filled, out of which 1404 were assessed as relevant for further analysis and preparation of the Report.

However, beside the fact that there is representative sample of households surveyed, still there are particular weaknesses such as lack of data due to the old census which doesn't provide correct information on the households and other needed data.

5.4.1. Methodology

The Tier 1 methodology has been selected by using default emission factors from the Guidebook 2009/2016. The Tier 1 approach for process emissions from small combustion installations uses the general equation:

$E_{pollutants} = \sum AR_{fuel\ consumption} \times EF_{fuel\ pollutants}$

where:

$E_{pollutants}$ = the emission of the specified pollutant,

$\sum AR_{fuel\ consumption}$ = the activity rate for fuel consumption,

$EF_{fuel\ pollutants}$ = the emission factor for this pollutant.

5.4.2. Activity data

The data for the Southeast region were taken from the survey "Report from the conducted survey for emissions from household heating in the South-eastern region".

Table 29. Average amount of energy consumed per household for the Southeast planning region

Fuel	Quantity
Wood (m^3)	11.53
Pellets (t)	4.25
Briquettes (t)	9.10
Extra light (t)	1.33
TNG (kg)	1.640

5.4.2. Emission factors

For biomass, the default emission factors of the Guidebook 2019 have been selected for NO_x, NMVOC, SO_2, CO, NH_3, TSP, PM10 and PM2.5.

Table 30 Emission factors for biomass for source category 1.A.4.bi - Residential: Stationary

Pollutant	Value	Unit	References
NOx	50	g/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
NMVOC	600	g/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
SOx	11	g/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
NH3	70	g/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
PM2.5	740	g/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
PM10	760	g/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
TSP	800	g/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
BC	10	%PM2.5	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
CO	4000	g/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
Pb	27	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
Cd	13	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
Hg	0.56	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
As	0.19	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
Cr	23	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
Cu	6	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
Ni	2	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
Se	0.5	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
Zn	512	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
PCB	0.06	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35

PCDD/PCDF	800	ng I-TEQ/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
benzo(a) pyren	121	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
benzo(b) fluoranthene	111	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
benzo(k) fluoranthene	42	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
Indeno (1.2.3-cd) pyren	71	mg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35
HCB	5	µg/GJ	GB 2019 Table 3-6 emission factor for source category 1.A.4.b.i. page 35

Table 31 Emission factors for natural gas for source category 1.A.4.bi - Residential: Stationary

Pollutant	Value	Unit	References
NOx	51	g/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
NMVOC	1.9	g/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
SOx	0.3	g/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
PM2.5	1.2	g/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
BC	5.4	% PM2.5	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
PM10	1.2	g/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
TSP	1.2	g/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
CO	26	g/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
Pb	0.0015	mg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
Cd	0.00025	mg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
Hg	0.1	mg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
As	0.12	mg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
Cr	0.00076	mg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
Cu	0.000076	mg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
Ni	0.00051	mg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
Se	0.011	mg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
Zn	0.0015	mg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
PCDD/ PCDF	1.5	ng I-TEQ/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
benzo(a) pyren	0.56	µg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
benzo(b)fluoranthene	0.84	µg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
benzo(k) fluoranthene	0.84	µg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**
Indeno (1.2.3-cd) pyren	**0.84**	µg/GJ	**GB 2019 Table 3-4 emission factor for source category 1.A.4.b.i.page 33**

Table 32 Emission factors for liquid fuels for source category 1.A.4.bi - Residential: Stationary

Pollutant	Value	Unit	References
NOx	51	g/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**

NMVOC	0.69	g/GJ	**GB 2009 Table 3-5 emission factor for source category 1.A.4.b.i. page 23**
SOx	140	g/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
PM2.5	3.7	g/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
BC	8.5	% PM2.5	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
PM10	3.7	g/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
TSP	6	g/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
CO	57	g/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
Pb	15.5	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
Cd	1.5	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
Hg	0.03	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
As	0.9	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
Cr	15.5	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
Cu	7.9	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
Ni	240	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
Zn	8.5	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
PCDD/PCDF	10	ng I-TEQ/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
benzo(a) pyren	22	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
benzo(b) fluoranthene	25.7	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
benzo(k) fluoranthene	12.5	mg/GJ	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**
Indeno (1.2.3-cd) pyren	**14.8**	**mg/GJ**	**GB 2019 Table 3-5 emission factor for source category 1.A.4.b.i. page 34**

5.4.3. Calculated emissions

In the table below are given the annual emissions per ton per pollutant from category 1 A 4 b i for the Southeast region.

Table 33. Calculated emissions for category 1 A 4 b i

1.A.4.b.i Residential plants	CO [t/a]	NH_3 [t/a]	NM VOC [t/a]	NOx [t/a]	SOx [t/a]	PM_{10} [t/a]	$PM_{2,5}$ [t/a]	TSP [t/a]
Biomass	10874.7379	190.3079	1631.2	135.9342	29.9055	2066.2002	2011.8265	2174.9476
LPG	0.3122	0.0000	0.0228	0.6124	0.0036	0.0144	0.0144	0.0648
Heating oil	0.7694	0.0000	0.0093	0.6884	1.8897	0.0499	0.0499	0.0810

Pb [t/a]	Cd [t/a]	Hg [t/a]	benzo(a) pyren [t/a]	benzo(b) fluoranthen [t/a]	benzo(k) fluoranthen [t/a]	Indeno (1,2,3-cd) pyren [t/a]	HCB [t/a]	PCDD/ PCDF (dioxins/ furans) [t/a]

0.0734	0.0353	0.0015	0.3290	0.3018	0.1142	0.1930	0	2174.9476
0	0	0	0	0	0	0	0	0.0180
0.0002	0.00002	0	0.0003	0.0003	0.0002	0.0002	0	0.1350

From the table below where participation of the type of fuel in emission of each pollutant is given in percentages it is evident that the biomass is main main pollutan in the residential sector.

Table 34. Calculated emission given in percentages for category 1 A 4 b i

Fuel	CO	NH_3	NM VOC	NOx	SOx	PM_{10}	$PM_{2,5}$	TSP
Biomass	99.99%	100%	99.998%	99.052%	94.046%	99.997%	99.997%	99.993%
LPG	0.003%	0 %	0.001%	0.446%	0.011%	0.001%	0.001%	0.003%
Heating oil	0.007%	0%	0.001%	0.502%	5.943%	0.002%	0.002%	0.004%
Total	100%	100%	100%	100%	100%	100%	100%	100%

6. INDUSTRIAL PROCESESS AND PRODUCT USE (NFR SECTOR 2)

6.1. Sector overview

This chapter includes information on the estimation (calculation) of the emissions of NEC gases, CO, particle matter (PM), heavy metals (HM) and persistent organic pollutant (POP) as well as activity data and their references and emission factors reported under NFR category Industrial Processes (taken from EMEP Guidebooks 2009/2013/2016) for the period from 1990-2016.

This category comprises emissions from the following sub categories: Mineral Products, Chemical Industry, Metal Production and Other products and solvents used.

The following NFR categories are covered in this sector:

- Quarrying and mining of minerals other than coal – NFR 2.A.5.a

- Domestic solvent use including fungicides – NFR 2.D.3.a

- Degrsing – NFR 2.D.3.e

- Dry cleaning – NFR 2.D.3.f

6.2 Quarrying and mining of minerals other than coal – NFR 2.A.5.a

This subchapter elaborates quarrying and mining of minerals other than coal and it does not include emissions from the combustion of fuels in the plant or transport machinery.

6.2.1 Methodology

Tier 1 method is used for calculation of emissions in this sector. The quantities of different minerals (like marble, talk, silica, gypsum, etc.) were summarized for calculation of activity data per reporting year.

$E_{pollutant} = \sum AR_{production} \times EF_{pollutant}$

where:

$E_{pollutants}$ = the emission of the specified pollutant,

$\sum AR_{production}$ = the activity rate for the quarrying/mining,

$EF_{pollutant}$ = the emission factor for this pollutant.

6.2.2 Activity data

The activity data where taken from the annual reports from the company Bucim and from the request for IPPC A permit from Nemetali Ograzden. The mineral produced for 2017 is 4.529.255 t.

6.2.3 Emission factors

For estimation of emissions for PM2.5, PM10 and TSP the used emission factors were taken from GB 2016. These emission factors are given in Table below.

Table 35 Emission factors for minerals produced for 2.A.5.a source category - Quarrying and mining of minerals other than coal

Pollutant	Value	Unit	References
TSP	102	g/Mg mineral	GB 2016 2.A.5.a Quarrying and mining of minerals other than coal. Table 3-1. pg. 5
PM10	50	g/Mg mineral	GB 2016 2.A.5.a Quarrying and mining of minerals other than coal. Table 3-1. pg. 5
PM2.5	5.0	g/Mg mineral	GB 2016 2.A.5.a Quarrying and mining of minerals other than coal. Table 3-1. pg. 5

6.2.4 Calculated emissions

In the table below are given the annual emissions per ton per pollutant from category 2.A.5 for the Southeast region.

Table 36. Calculated emissions from category 2.A.5

TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]

461,9840	226,4628	22,6463

6.3 Domestic solvent use including fungicides NFR 2.D.3.a

This category covers the use of fungicides in agriculture.

6.3.1 Methodology

The Tier 1 method has been applied. This method assumes an averaged or typical technology and abatement implementation in the country, and includes an integrated emission factor and emission factors for sub-processes within the source category.

6.3.2 Activity data

The activity data – number of population for this source category have been taken from Makstat database - Assessment of the population according age and gender, by municipality and by statistical region. It should be emphasized that the last census in the country was carried out in 2002, and therefore the data for the period 2017 are estimated population numbers. The data for the populitaion is taken from the Makstat database, the estimated population for 2017 for the Souteast region is 173.522.

6.3.3 Emission factors

The emission factor for calculation of NMVOC emissions coming from this sector are presented in the following table.

Table 37 Emission factors for the source category 2.D.3.a - Domestic solvents use including fungicides

Pollutant	Value	Unit	References
NMVOC	1	kg/person/year	GB 2009 3.D.2 Domestic solvent use including fungicides. Table 3-1. pg. 6

6.3.4 Calculated emissions

In the table below are given the annual emissions per ton per pollutant from category 2.D.3.a for the Southeast region.

Table 38. Calculated emissions from category 2.A.5

NM VOC [t/a]
208.0860

6.4 Degreasing - NFR 2.D.3.e

Degreasing is a process of cleaning products from water-insoluble substances such as grease, fats, oils, waxes, carbon deposits, fluxes and tars. In most cases, the process is applied to metal products, but also plastic, fiberglass, printed circuit boards and other products are treated by the same process.

6.4.1 Methodology

The Tier 1 method has been applied. This method assumes an averaged or typical technology and abatement implementation in the country and includes an integrated emission factor and emission factors for sub-processes within the source category.

6.4.2 Activity data

The activity data – number of population for this source category have been taken from Makstat database - Assessment of the population according age and gender, by municipality and by statistical region. It should be emphasized that the last census in the country was carried out in 2002, and therefore the data for the period 2017 are estimated population numbers. The data for the populitaion is taken from the Makstat database, the estimated population for 2017 for the Souteast region is 173.522.

6.4.3 Emission factors

Emission factor for the calculation of NMVOC emissions is presented below.

Table 39 Emission factor for source category 2.D.3.e - Degreasing

Pollutant	Value	Unit	References
NMVOC	0,85	kg/inhabitant/year	Informative Inventory Report of Republic of Serbia for 2013[5] which refers to GB 2006

6.2.4 Calculated emissions

In the table below are given the annual emissions per ton per pollutant from category 2.A.5 for the Southeast region.

Table 40. Calculated emissions from category 2.A.5

NM VOC [t/a]
147.3943

5 The Republic of Serbia Informative Inventory Report to LRTAP Convention, Belgrade, 2012

6.5 Dry cleaning – NFR 2.D.3.f

Dry cleaning refers to any process of removal of contamination from furs, leather, down leathers, textiles or other objects made of fibers using organic solvents. The most significant pollutants from dry cleaning are non-methane volatile organic compounds.

6.5.1 Methodology

The calculation in this category is based on the volume of solvents, including chlorinated organic chlorinated solvents using Tier 1 method. This method assumes an averaged or typical technology, and abatement implementation in the country, and includes an integrated emission factor and emission factors for sub-processes within the source category.

6.5.2 Activity data

Due to the lack of data on textile treatment, the activity data considered in this source category is population. The data for the populitaion is taken from the Makstat database, the estimated population for 2017 for the Souteast region is 173.522.

6.4.3 Emission factors

Emission factor for the calculation of NMVOC emissions is presented below.

Table 41 Emission factor for source category 2.D.3.e - Degreasing

Pollutant	Value	Unit	References
NMVOC	0,3	kg/inhabitant/year	GB 2013 2.D.3.f Dry cleaning. pg. 6

6.2.4 Calculated emissions

In the table below are given the annual emissions per ton per pollutant from category 2.A.5 for the Southeast region.

Table 42. Calculated emissions from category 2.A.5

NM VOC [t/a]
52.0215

7. AGRICULTURE (NFR SECTOR 3)

The Agriculture sector is a major source category for ammonia emissions. 89% of the total national emissions of NH_3 are emitted from the agricultural sector.

7.1. Manure management NFR 3.B

The Tier 1 default approach following the GB 2013 and the GB 2016 has been used.

Emission factors for NOx, NMVOC and PM have been obtained from EMEP/EEA Air Pollutant GB 2013. Separate default Tier 1 EFs are provided for slurry and litter-based manure management systems to be multiplied with the animal numbers of the appropriate livestock categories.

7.1.1. Activity data

The input data in this sub-sector is the number of registered heads of each domestic animal species. All activity data for the Southeast region is derived from the Mak Stat data base 2017. The numbers per livestock category are presented in Table 43. Number of different categories of poultry are presented inTable 44.

Table 43 Domestic livestock population

Dairy	Non-Diary	Total Swine	Fattening pigs	Sows	Sheep	Goats	Horses
6975	23643	15032	13432	1600	75117	20551	5107

Table 44 Domestic poultry

Laying hens	Broilers	Livestock category – Population size [heads] *		
		Ducks	Geese	Turkeys
111065	3552	1005	1262	668

7.1.2. Emission factors

Table 45 and Table 43 provide emission factors taken from the EMEP EEA GB 2013 (updated July 2015 version) and for NH3 from EMEP EEA GB 2016, for each livestock category. These factors have been used for the estimation of NOX NMVOC and NH3 emissions. For NMVOC and cattle, the average mean of both EFs (NMVOC EF with and EF without silage feeding) has been used (for details see description below). EF for NMVOC are same in EMEP EEA GB 2013 and 2016.

Table 45 NH_3 emission factors for source categories 3.B - Manure management and 3.D - Agricultural Soils

NFR code	NH_3		
	Housing, storage, yard	**Manure application**	**Grazing**
	kg AAP-1 a-1	**kg AAP-1 a-1**	**kg AAP-1 a-1**
3B1a Dairy cattle	16,9	8,8	2,9
3B1b Non-dairy cattle	6,2	2,2	0,8
3B2 Sheep	0,4	0,2	0,8
3B3 Swine-fattening pigs	4,0	2,7	0,0
3B3 Swine-sows	9,0	6,0	0,0
3B4d Goats	0,4	0,2	0,8
3B4e Horses	7,0	1,7	6,1
3B4gi Laying hens	0,32	0,15	0,0
3B4gii Broilers	0,15	0,07	0,0
3B4giii Turkeys	0,56	0,39	0,0
3B4giv Other poultry (ducks)	0,45	0,23	0,0
3B4giv Other poultry (geese)	0,30	0,05	0,0

Table 46 NOx and NMVOC emission factors for source category 3B - Manure management

NFR code	Pollutants	
	NOx	**NMVOC**
	kg AAP-1 a-1	**kg AAP-1 a-1**
3B1a Dairy cattle	0,154	12,992
3B1b Non-dairy cattle	0,094	6,252
3B2 Sheep	0,005	0,169
3B3 Swine-fattening pigs	0,001	0,551
3B3 Swine-sows	0,004	1,704
3B4d Goats	0,005	0,542
3B4e Horses	0,131	7,781
3B4gi Laying hens	0,003	0,165
3B4gii Broilers	0,001	0,108
3B4giii Turkeys	0,005	0,489
3B4giv Other poultry (ducks)	0,004	0,489
3B4giv Other poultry (geese)	0,001	0,489

Emissions of particulate matter (PM) occurring from animal husbandry were calculated with the EMEP/EEA Tier 1 methodology provided in the EMEP/EEA Guidebook 2013 (updated version July 2015). The Tier 1 methodology multiplies average animal numbers with the particular default emission factors listed in the following table:

Table 47 TSP, PM10 and PM2.5 emission factors for source category 3.B - Manure management

NFR code	TSP	PM10	PM2.5	Reference
	kg/capita	kg/capita	kg/capita	
3B1a Dairy cattle	1,38	0,63	0,41	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**
3B1b Non-dairy cattle	0,59	0,27	0,18	**GB 2013 updated July 2015 - Table 3,3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**
3B2 Sheep	0,139	0,0556	0,0167	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**
3B3 Swine- fattening pigs	0,75	0,34	0,06	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**
3B3 Swine- sows	1,53	0,69	0,12	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**
3B4d Goats	0,139	0,0556	0,0167	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**
3B4e Horses	0,48	0,22	0,14	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**
3B4gi Laying hens	0,119	0,119	0,023	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**
3B4gii Broilers	0,069	0,069	0,009	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**
3B4giii Turkeys	0,52	0,52	0,07	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**
3B4giv Other	0,14	0,14	0,02	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates**
poultry (ducks)				**of EF for particle emissions from animal husbandry (housing).**
3B4giv Other poultry (geese)	0,24	0,24	0,03	**GB 2013 updated July 2015 - Table 3.3 Default Tier 1 estimates of EF for particle emissions from animal husbandry (housing).**

7.1.3. Calculated emissions

In the table below are given the annual emissions per ton per pollutant from category 3 B for the Southeast region.

Table 48. Calculated emissions from category 3 B

Category	NOx [t/a]	NMVOC [t/a]	NH_3 [t/a]	TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]
3B1a Dairy cattle	1.0742	90.6192	117.8775	9.6255	4.3943	2.8598
3B1b Non-dairy cattle	2.2224	147.8160	146.5866	13.9494	6.3836	4.2557
3B2 Sheep	0.3756	12.6948	30.0468	10.4413	4.1765	1.2545
3B3 Swine-fattening pigs	0.0134	7.4010	53.728	10.074	4.5669	0.8059
3B3 Swine- sows	0.0064	2.7264	14.4	2.448	1.104	0.192
3B4d Goats	0.1028	11.1386	8.2204	2.8566	1.1426	0.3432
3B4e Horses	0.669	39.7376	35.749	2.4514	1.1235	0.7150

3B4gi Laying hens	0.3332	18.3257	35.5408	13.2167	13.2167	2.5545
3B4gii Broilers	0.0036	0.3836	0.5328	0.2451	0.2451	0.032
3B4giii Turkeys	0.0033	0.3267	0.3741	0.3474	0.3474	0.0468
3B4giv Other poultry (ducks)	0.004	0.4914	0.4523	0.1407	0.1407	0.0201
3B4giv Other poultry (geese)	0.0013	0.6171	0.3786	0.3029	0.3029	0.0379
TOTAL	4.81	332.28	443.89	66.10	37.14	13.12

The percentage of participation of each category livestock at different emissions is given below in the table. Sheeps are the biggest pollutant, emitting highest percentage of all pollutants. Dairy and non-dairy cattle are also important emitter of emissions.

Table 49. Calculated emissions given in percentages for category 3 B

Category	NOx	NMVOC	NH3	TSP	PM_{10}	$PM_{2.5}$
3B1a Dairy cattle	22%	27%	27%	15%	12%	22%
3B1b Non-dairy cattle	46%	44%	33%	21%	17%	32%
3B2 Sheep	8%	4%	7%	16%	11%	10%
3B3 Swine-fattening pigs	0%	2%	12%	15%	12%	6%
3B3 Swine-sows	0%	1%	3%	4%	3%	1%
3B4d Goats	2%	3%	2%	4%	3%	3%
3B4e Horses	14%	12%	8%	4%	3%	5%
3B4gi Laying hens	7%	6%	8%	20%	36%	19%
3B4gii Broilers	0%	0%	0%	0%	1%	0%
3B4giii Turkeys	0%	0%	0%	1%	1%	0%
3B4giv Other poultry (ducks)	0%	0%	0%	0%	0%	0%
3B4giv Other poultry (geese)	0%	0%	0%	0%	1%	0%
TOTAL	100%	100%	100%	100%	100%	100%

Emission calculations from fertilizers source category Inorganic N-fertilizers (NFR 3.D.a.1) are not being calculation due to the lack of data on municipality level.

8. WASTE (NFR SECTOR 5)

The chapter includes calculation of NOx, SO2, CO, NMVOC, Particulates, heavy metals and persistent organic compounds (POPs). Emissions addressed in this chapter include emissions from the next subcategories:

- 5.A - Solid waste disposal on land
- 5.C.2 - Open burning of waste
- 5.D.2 - Industrial wastewater handling

8.1. Solid waste disposal on land (NFR 5.A)

Within this category the emissions arising from solid waste disposal shall be accounted for, whereby municipal and industrial waste shall be considered. However, it has to be taken into account that only waste which still undergoes biological or chemical degradation is relevant. Therefore, inert waste (like construction waste) shall not be included.

8.1.1. Activity data

Total municipal solid waste generation was calculated by multiplying with population data. Data on population is available in the Statistical Yearbooks of Macedonia, although before 1990 data were interpolated between decades. According to information from the statistical office about 99% of municipal solid waste is landfilled, for that reason it was assumed that 100% of municipal solid waste was deposited on uncategorized landfills. In order to determine the waste fraction, information published in an EEA study "Municipal Waste Management in FYROM (2013), page 7-8" was used.

8.1.2. Emission factor

The emission factors used to calculate emission from particulate matter are as outlined in the GB 2016 for source category 5.A.

Table 50 Emission factors for source category 5.A- Biological treatment of waste

Pollutant	Value	Unit	Reference
NMVOC	1,56	kg/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.A Biological treatment of waste – Solid waste disposal on land
TSP	0,463	g/Mg	GB 2016Table 3-1 Tier 1 emission factors for source category 5.A Biological treatment of waste – Solid waste disposal on land
PM10	0,219	g/Mg	GB 2016Table 3-1 Tier 1 emission factors for source category 5.A Biological treatment of waste – Solid waste disposal on land
PM2.5	0,33	g/Mg	GB 2016Table 3-1 Tier 1 emission factors for source category 5.A Biological treatment of waste – Solid waste disposal on land

8.1.3. Calculated emissions

In the table below are given the annual emissions per ton per pollutant from category 5 A for the Southeast region.

Table 51. Calculated emissions for category 5 A

NMVOC [t/a]	TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]
96,6123	0,0287	0,0136	0,0020

8.2. Open burning of waste- NFR 5.C.2

8.2.1. Methodology

The simpler methodology involves the use of a single emission factor for each pollutant representing the emission per mass of waste burned, combined with activity statistics:

$E_{pollutant} = AR_{production} \times EF_{pollutant}$

This requires a prior knowledge of the weight of agricultural waste produced per hectare of forestry, orchard and farmland. It is assumed that open burning of agricultural waste (except stubble burning) is mainly practiced in forestry, orchard and arable farming; emissions from open burning for other types of farming are likely to be less significant and are assumed to be negligible. The average amount of waste burned for arable farmland is therefore 5.C.2 Open burning of waste GB 2013/2009 estimated to be 25 kg/hectare. This approach has been used for estimation of activity data. The activity data were calculated when the agriculture area expressed in hectares was multiplied with the factor 25 and divided by 1000 which equals to the waste burned in kg.

8.2.2. Activity data

Data on arable farmland taken from the statistical office and calculated waste burned are presented in the following table. Data on arable farmland are taken from State Statistical Office of the Republic of Macedonia, Field crops, orchards and vineyards, 2017.

Table 52 Activity data for source category 5.C.2 - Open burning of waste

Arable farmland [hectare]	Waste [kg]
59534	1488,35

8.2.3. Emission Factors

The emission factors used are as outlined in the GB 2016 for source category 5.C.2.

Table 53. Emission factors for source category 5.C.2.

Pollutant	Value	Unit	References
NOx	3,18	kg/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
NMVOC	1,23	kg/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
SOx	0,11	kg/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
PM2.5	4,19	kg/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
PM10	4,51	kg/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
TSP	4,64	kg/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
BC	42	% of PM2.5	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
CO	55,83	kg/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
Pb	0,49	g/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
Cd	0,1	g/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
Cr	0,01	g/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
Cu	0,2	g/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
Se	0,07	g/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
"PCDD/PCDF (dioxins/furans)"	10	mg I-Teq/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
benzo(a) pyren	2,33	g/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
benzo(b) fluoranthen	4,63	g/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning
benzo(k) fluoranthen	5,68	g/Mg	GB 2016 Table 3-1 Tier 1 emission factors for source category 5.C.2 Small-scale waste burning

8.2.4. Calculated emissions

In the table below are given the annual emissions per ton per pollutant from 5. C. 2.

Table 54. Calculated emissions from category 5.C.2

NOX [t/a]	CO [t/a]	NMVOC [t/a]	SOx [t/a]	TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]
0,0047	0,0831	0,0018	0,0002	0,0069	0,0067	0,0062

8.3. Waste total

In the table below are given the annual emissions per ton per pollutant from total waste for the Southeast region.

Table 55. Calculated emissions for waste in total

Category	NOX [t/a]	CO [t/a]	NMVOC [t/a]	SOx [t/a]	TSP [t/a]	PM_{10} [t/a]	$PM_{2.5}$ [t/a]
5.A Biological treatment of waste - Solid waste disposal on land			96,6123		0,0287	0,0136	0,0020
5.C.2 Small-scale waste burning	0,0047	0,0831	0,0018	0,0002	0,0069	0,0067	0,0062
Total	0,004733	0,083095	96,61408	0,000164	0,03558	0,020275	0,00828

The table below shows that solid waste disposal on land contribute mainly with NMVOC emission and significant with emissions of particulate matters, especially total suspended and PM 10. Small scale waste burning contributes mainly with NOx, CO and SOx emissions and signifant percent (75%) with PM 2,5 emissions.

Table 56. Emissions in percentage for waste in total

Category	NOX	CO	NMVOC	SOx	TSP	PM_{10}	$PM_{2.5}$
5.A Biological treatment of waste - Solid waste disposal on land	0%	0%	100%	0%	81%	67%	25%
5.C.2 Small-scale waste burning	100%	100%	0%	100%	19%	33%	75%
Total	100%	100%	100%	100%	100%	100%	100%

8.4. Industrial wastewater handling- NFR 5.D.2

The information for activity data were provided by the Ministry of Environment and Phisical Planing. The wastewater handled in treatment plants for 2017 was 193.928 m^3.

8.4.1. Emission Factors

The emission factors applied are given in the EMEP 2019 guidebook, Table 3-3, Tier 2 emission factors for source category 5.D Wastewater handling, latrines on page 9, which allowed the calculation of NMVOC emission from domestic and industry wastewater handling. The emission factor used is 15mg NMVOC per m^3 wastewater. There is an available emission factor on ammonia, but it has not been used for calculation of ammonia emissions, because until now there is no available data on number of people connected to latrines.

8.4.2. Calculated emissions

In the table below are given the annual emissions per ton per pollutant from 5. D. 2.

Table 57. Calculated emissions from category 5.C.2

NMVOC [t/a]
0.00291

9. NATURAL SOURCES

This chapter describes emissions from (naturally or man-induced) burning of non-managed and managed forests and other vegetation, excluding agricultural burning of stubble, etc.

This sector includes information and description of the methodologies applied for estimating emissions for NMVOC, NH_3, NOx, SOx and CO as well as references to activity data and emission factors concerning emissions coming from the forest fires.

9.1. Forest fires – NFR 11.B

9.1.1 Methodology

Tier 1 approach was used, using the given default Emission factors from the GB2019.

$E_{pollutant} = \Sigma AR_{burned} \times EF_{pollutant}$

Where:

$E_{pollutant}$ = is the emission of a certain pollutant;

AR_{burned} = is the total area that has been burned/wood burned;

$EF_{pollutant}$ = is the emission factor for this pollutant.

9.1.2 Activity Data

The activity data for this sector are taken from the Makstat database. The area burned from forest fires in 2017 was 823 ha.

9.1.3 Emission factors

Calculation of emission parameters was used, and emission factors were taken from the GB 2019.

Table 58. Emission factors for source category 11.B.

Pollutant	Value	Unit	References
NOx	100	kg/ha area burned	**GB 2019 11B Forest fires. Table 3-1. pg. 9**
CO	3000	kg/ha area burned	**GB 2019 11.B Forest fires. Table 3-1. pg. 9**
NMVOC	300	kg/ha area burned	**GB 2019 11.B Forest fires. Table 3-1. pg. 9**
SOx	20	kg/ha area burned	**GB 2019 11.B Forest fires. Table 3-1. pg. 9**
NH_3	**20**	**kg/ha area burned**	**GB 2019 11.B Forest fires. Table 3-1. pg. 9**

9.1.3. Calculated emissions

In the table below are given the annual emissions per ton per pollutant from 11. B.

Table 59. Calculated emissions from category 5.C.2

NO_X [t/a]	CO [t/a]	NMVOC [t/a]	SOx [t/a]	NH_3 [t/a]
82.3	2469	246.9	16.46	16.46

10. REVIEW OF THE EMISSION INVENTORY IN THE SOUTHEAST REGION

In table below are given the emissions in tons per year, per category per NFR sector for Southeast region.

Table 60 Nomenclature for reporting format (NFR) - Format for Southeast region

ENERGY - (NFR SECTOR 1)	CO	NH_3	NM VOC	NOx	SOx	PM10	PM2,5	TSP	PB	Cd	Hg	benzo(a) pyren	benzo(b) fluoranthen	benzo(k) fluoranthen	Indeno (1,2,3-cd) pyren	PAHs	HCB	PCDD/ PCDF (dioxins/ furans)
1.A.2.a Iron and steel	5.5098		2.0870	42.8260	3.9236	1.6696	1.6696	1.6696	0.000007	0.000001	0.000010	0.0002	0.0013	0.0001	0.0001	0.0017	0.0000	0.1169
1.A.2.b Non-ferrous metals	16.0454		6.1628	120.3300	11.0271	4.8322	4.8292	4.8393	0.000046	0.000015	0.000029	0.0005	0.0035	0.0004	0.0004	0.0047	0.0000	0.4292
1.A.2.f Other	1.2303		0.4909	9.2490	0.8347	0.3562	0.3562	0.3562	0.000001	0.0000001	0.000003	0.0000	0.0003	0.0000	0.0000	0.0004	0.0000	0.0259
1.A.3.b.i Passenger cars	1163.886825	12.671797	116.023219	294.18155	66.4279569	13.7908195	13.7908195	13.7908195	0.008187725			0.000497789				0.000497789		
1.A.3.b.iI Light duty vehicles	102.866975	0.3192	13.006555	75.640375	7.2066816	6.453352	6.453352	6.453352	0.000285339			6.146210000E-05				6.14621E-05		
1.A.3.b.iii Heavy duty vehicles	209.30558	0.1256035	27.731165	129.74456	14.3573364	4.3147005	4.3147005	4.3147005	0.000227576			3.44949E-05				3.44949E-05		
1.A.3.b.iii Buses	50.707085	0.0612495	12.19881	196.722175	4.113018	6.1106565	6.1106565	6.1106565	0.000289179			1.73745E-05				1.73745E-05		
1.A.3.b.iv Mopeds &	1163.886825	12.671797	116.023219	294.18155	0.44075016	13.7908195	13.7908195	13.7908195	0.008187725			0.000497789				0.000497789		

motorcycles																		
1.A.3.b.v Gasoline evaporation for gasoline fueled road vehicles			72.953718															
1.A.4.a.i Commercial / institutional: stationary	9.989006938		4.487443304	10.57714076	2.853490628	2.631901759	2.50819261	2.718631495	0.000565393	0.000165397	1.06644E-05	0.000130013	0.000198696	6.20081E-05	4.96122E-05	0.000440329	6.8296E-08	1.416450134
1.A.4.b.i Residential plants	10875.81952	190.3079138	1631.242818	137.2350166	31.79885213	2066.264559	2011.890869	2175.093416	0.073613718	0.035363148	0.001524069	0.329264503	0.302130963	0.11436356	0.193236455	0.938995481	1.35934E-05	2175.100578
INDUSTRIAL PROCESSES AND PRODUCT USE (NFR SECTOR 2)																		
2.A.5.a Quarrying and mining of minerals other than coal						226.46275	22.646275	461.98401										
2.D.3.a Domestic solvents use including fungicides			208.2264															
2.D.3.e Degreasing			147.4937															
2.D.3.f Dry Cleaning			52.0566															

AGRICULTURE (NFR SECTOR 3)																		
3B1a Dairy cattle		117.8775	90.6192	1.07415		4.3943	2.8598	9.6255										
3B1b Non-dairy cattle		146.5866	147.8160	2.222442		6.3836	4.2557	13.94937										
3B2 Sheep		30.0468	12.6948	0.375585		4.1765	1.2545	10.441263										
3B3 Swine-fattening pigs		53.728	7.4010	0.013432		4.5669	0.8059	10.074										
3B3 Swine-sows		14.4	2.7264	0.0064		1.1040	0.1920	2.448										
3B4d Goats		8.2204	11.1386	0.102755		1.1426	0.3432	2.856589										
3B4e Horses		35.749	39.7376	0.669017		1.1235	0.7150	2.45136										
3B4gi Laying hens		35.5408	18.3257	0.333195		13.2167	2.5545	13.216735										
3B4gii Broilers		0.5328	0.3836	0.003552		0.2451	0.0320	0.245088										
3B4giii Turkeys		0.37408	0.3267	0.00334		0.3474	0.0468	0.34736										
3B4giv Other poultry (ducks)		0.45225	0.4914	0.00402		0.1407	0.0201	0.1407										
3B4giv Other poultry (geese)		0.3786	0.6171	0.001262		0.3029	0.0379	0.30288										
WASTE (NFR SECTOR 5)																		
5.A Biological treatmen			96.61225392			0.013562874	0.002043721	0.028674022										

t of waste - Solid waste disposal on land																		
5.C.2 Small-scale waste burning	0.083094581		0.001830671	0.004732953	0.000163719	0.006712459	0.006236187	0.006905944										
5.D.2 Waste water handling			0.00290892															
11.B Forest fires	2469	16.46	246.9	82.3	16.46													
TOTAL	**16068.3304**	**676.5044**	**3085.9796**	**1397.8012**	**159.4437**	**2383.8421**	**2101.4862**	**2757.2560**	**0.0914**	**0.0355**	**0.0016**	**0.3312**	**0.3074**	**0.1150**	**0.1938**	**0.9473**	**0.000014**	**2177.0890**

In table below are given the emissions in %, per category per NFR sector for Southeast region.

Table 61 Nomenclature for reporting format (NFR) - Format for Southeast region in percent

	CO	NH_3	NM VOC	NOx	SOx	PM10	PM2,5	TSP	PB	Cd	Hg	benzo(a) pyren	benzo(b) fluoranthen	benzo(k) fluoranthen	Indeno (1,2,3-cd) pyren	HCB	PCDD/ PCDF (dioxins/ furans)
ENERGY - (NFR SECTOR 1)																	
1.A.2. COMBUSTION IN INDUSTRY	0.14%	0.00%	0.28%	12.33%	9.90%	0.29%	0.33%	0.25%	0.06%	0.04%	2.66%	0.20%	1.64%	0.50%	0.26%	0.04%	0.03%
1.A.3 TRANSPORT	16.75%	3.82%	11.60%	70.86%	58.04%	1.87%	2.12%	1.61%	18.79%	0.00%	0.00%	0.33%	0.00%	0.00%	0.00%	0.00%	0.00%
1.A.4 COMBUSTION IN HOUSEHOLDS AND ADMINISTRATIVE CAPACITIES	67.75%	28.13%	53.01%	10.57%	21.73%	86.79%	95.86%	78.98%	81.15%	99.96%	97.34%	99.47%	98.36%	99.50%	99.74%	99.96%	99.97%

2. INDUSTRIAL PROCESSES AND PRODUCT USE (NFR SECTOR 2)	0.00%	0.00%	13.21%	0.00%	0.00%	9.50%	1.08%	16.76%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3. AGRICULTURE (NFR SECTOR 3)	0.00%	65.61%	10.77%	0.34%	0.00%	1.56%	0.62%	2.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5. WASTE (NFR SECTOR 5)	0.00%	0.00%	3.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
11. NATURAL RESOURCES (NFR SECTOR 11)	15.37%	2.43%	8.00%	5.89%	10.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	100.00%	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

11. CONCLUSIONS

According to the calculated contribution of different emission sources in the total emissions per pollutant on national level, using the available activity data we can conclude the following:

NOx emissions

Almost all NOx emissions are coming from the sector Energy. Namely, the main emission sources in 2017 are NFR source categories: 1.A.2. Combustion in industry, 1.A.3 transport and 1.A.4 combustion in households and administrative capacities which contributed with 94% of the regional total NOx emissions, from which around 71% are from the category 1.A.3 transport. The rest 6% of the NOx emission comes from the Category Natural resources.

NMVOC emissions

NMVOC emissions are emitted from different sources. The key category source in 2017 is Energy (NFR SECTOR 1) contributed with 65% of the regional total NMVOC emissions. The other category that contributes to the NM VOC emission are: Industrial processes and product use (NFR sector 2) countributing with 13%, Agriculture (NFR sector 3) with 11%, Natural resources (NFR sector 11) with around 8% and Waste (NFR sector 5) is contributing with 3% NMVOC emissions.

SO_2 emissions

Almost all SO2 emissions are resulting from Energy sector. Consequently, the main emission source in 2017 is as expected Energy with around 90% of the total regional SO2 emissions. Within the Energy sector, SO_2 is almoust exclusively emitted by source category 1.A.3 Transport contribuiting with 58%, 1.A.4 Combustion in households and administrative capacities is contributing with around 22% and respectilvly category 1.A.2. Combustion in industry with around 10%. About 10% of the total regiaonal emissions are stemming from NFR source category natural resources (NFR sector 11).

NH_3 emissions

NH_3 emissions are mainly resulting from the Agriculture sector contributing with 66% to regional total NH_3 emissions. The Energy sector is contributing with 32% and the sector Natural resources is contributing with 2% to the toral regional NH_3 emissions.

CO emissions

Almost all CO emissions are resulting from the Energy sector. As a Result, the main emission sources in 2017 are NFR sectors 1.A.4 combustion in households and administrative capacities, contributing with around 68%, following by source category 1.A.3 transport contribuiting with around 17% to the regional total CO emissions. Further smaller emission sources in 2017 are source category 1.A.2 1.A.2. Combustion in industry with shares of around 0.2%. The rest 15% of CO emssions are from the Sector Natural resources.

PM_{10} emissions

The main emission sources for PM_{10} in 2017 are NFR sectors 1.A.4 combustion in households and administrative capacities with a share of around 87% in total PM_{10} emissions. The sector industrial processes and product use is contributing to the total PM_{10} emissions with 9.5%.

$PM_{2.5}$ emissions

Similar to PM_{10}, the main emission sources for $PM_{2.5}$ in 2017 are NFR sectors 1.A.4 combustion in households and administrative capacities with a share of around 96% in total $PM_{2.5}$ emissions.

TSP emissions

The main emission sources for TSP in 2017 are 1.A.4 combustion in households and administrative capacities with around 79% and 2.A.5.a Quarrying and mining of minerals other than coal with 17%.

Lead (Pb) emissions

The most important emission sources of Pb in 2017 are categories 1.A.4 combustion in households and administrative capacities with around 81% and 1.A.3 transport with around 19%. The rest less then 0.1% of Pb emssions is from the category 1.A.2. Combustion in industry.

Cadmium (Cd) emissions

The most important emission source of Cd is in the regional total emissions is 1.A.4 combustion in households and administrative capacities with almoust 100%.

Mercury (Hg) emissions

The most important emission source of Hg is in the regional total emissions is 1.A.4 combustion in households and administrative capacities with around 98%. The rest 2% is contribuiting from source category 1.A.2. Combustion in industry.

PAH-4 emissions

The most important emission source of PAH-4 emissions is in the regional total emissions is 1.A.4 combustion in households and administrative capacities with almoust 100%.

Dioxin and Furan emissions (PCDD/F)

The most important emission source of Dioxin and Furan emissions (PCDD/F) is in the regional total emissions is 1.A.4 combustion in households and administrative capacities with almoust 100%.

Hexachlorobenzene (HCB) emissions

The most important emission source of Hexachlorobenzene (HCB) emissions is in the regional total emissions is 1.A.4 combustion in households and administrative capacities with almoust 100%.

12. Recommendations

Given the fact that highest percentage (from 70%-99%) of almost all pollutants (PM_{10}, TSP, Pb, Cd, Hg, benzenes, dioxins and furans and CO) comes from Energy sector, i.e. combustion in households and administrative capacities, concete measures need to be defined and undertaken at this particular sector. In this regards all municipalities and Southeast Planning Region need to create their policies to reduce air emissions from these sectors and plan a financial resource for fossil fuel switch at their administrative capacities and households. Detail inventories and measures for reduction of this sector should be part of their Air quality local plans, however the identification of emission sources per pollutant on regional level gives a very solid base for preparation of these local inventories.