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LITHUANIAN'S INFORMATIVE INVENTORY REPORT 2010

Submission under the UNECE Convention on Long-range Transboundary Air Pollution

Vilnius 2011

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PART I

SECTION I

1. INTRODUCTION

Lithuania joined the Convention on Long-range Transboundary Air Pollution (CLRTAP) in 1994. As a party to the CLRTAP Lithuania is bound annually report data on emissions of air pollutants covered in the Convention and its Protocols using the Guidelines for Estimating and Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution (EB.AIR/GE.1/2002/7). To be able to meet this reporting requirement Lithuania compiles and updates an air emission inventory of SO_2, NO_X, NMVOC, CO and NH_3, particulate matter, various heavy metals and POPs and projection.

Lithuania as a European Union member state also has an annual obligations under the Directive 2001/81/EC of the European Parliament and of the Council on national emission ceilings for certain atmospheric pollutants (NEC Directive) which requires to prepare and annually update national emissions inventory of the certain air pollutants (SO_2, NO_X, NMVOC and NH_3).

This Informative Inventory Report (IIR) covering the inventory of air pollutant emissions from Lithuania. The IIR accompanies the emission inventory for 1990, 1995, 2005 – 2010.

1.1. Institutional arrangements for inventory preparation

The Environmental Protection Agency (EPA) is subordinated to the Ministry of Environment. Starting from 2011 year, EPA under the Ministry of Environment was nominated as an entity responsible for inventory preparation by the Order of Minister of Environment No D1-1017. The EPA has an overall legal responsibility for the preparation of Lithuanian emission inventory and submits reports to CLRTAP. Until year 2005 emission inventory was compiled by Air Division specialists, Environmental Quality Department at Ministry of Environment. Air emission inventory submission for 1990, 1995, 2000, 2005-2010 was prepared by the expert team from Center for Physical sciences and Technology in co-operation with Air Division specialists, Ministry of Environment and EPA. Air emission inventory is based mainly on statistics published by Lithuanian Statistics Department (Statistical Yearbooks of Lithuania, sectoral yearbooks on energy balance, agriculture, commodities production etc.), Institute of Road Transport, Registry of Transport (State enterprise "Regitra"), emission data collected by Environment Protection Agency and other. The EPA is responsible for the coordination of inventory process, final checking and approval of inventory procedures, checking of consistency of data, documenting, processing, archiving, timely submission of inventory to the European Commission, coordination of the inventory reviews in Lithuania, keeping of archive of official submissions to the European Commission and the European Commission, informing the inventory compilers about relevant requirements for the National system.

1.2. The process of inventory preparation

In the first stage specific responsibilities are defined and allocated. Within the inventory system specific responsibilities for the different emission source categories are defined, as well as for all activities related to the preparation of the inventory, data management and reporting.

In the second stage, the inventory preparation process, were collected activity data, emission factors and all relevant information needed for finally estimating emissions. Activity data were collected from Lithuanian Department of Statistics [1-5], Institute of Road Transport, Registry of Transport, and the emission factors were proposed by the Ministry of Environment and Emission Inventory Guidebook. All data collected together with emission estimates were organised in database, where data sources are well documented for future reconstruction of the inventory.

For the inventory management and reliable data management to fulfil the data collecting and reporting requirements is needed. All emission inventory data are organised in emission inventory database and managed using PostgreSQL database management system; all needed calculations and road transport emission modelling are performed using SQL scripts developed by Centre for Physical sciences and Technology. The EPA annually submits inventory reports to the European Commission secretariat.

1.3. An assessment of completeness

1.3.1 Explanation on the use of Notation Keys

In Table 1-1 definitions and application of the notation keys in our inventory are reported.

Table 1-1. Definition of Notation Keys

Notation Key	Use of notation keys in national inventory
NO	"NO" (Not Occurring) - an activity or process does not exist within a country
NE	"NE" (Not Estimated) - emissions occur but have not been estimated or reported in this submission.
NA	"NA" (Not Applicable) - the process or activity exists but emissions are considered never to occur.
IE	"IE" (Included Elsewhere) - emissions by sources of compounds are estimated but included elsewhere in the inventory.

1.3.2 Completeness analysis

Result of completeness analysis for each pollutant is given in Table 1-2. Values in Table 1-2 are number of cells filled with corresponding notation key or value for each pollutant.

Table 1-2. Completeness analysis for each pollutant.

Pollutant	Number of cells								
	NO	NE	NA	IE	C	NR	Zero	Value	Total
SO_2	24	13	45	3	0	0	0	24	109
NO_x	23	14	43	3	0	0	0	26	109
NMVOC	23	23	28	4	0	0	0	31	109
CO	21	19	44	3	0	0	0	22	109
NH_3	17	33	37	2	0	0	0	20	109
TSP	25	29	27	3	0	0	0	25	109
PM_{10}	25	33	26	3	0	0	0	22	109
$PM_{2.5}$	25	33	26	3	0	0	0	22	109
As	20	16	60	2	0	0	1	10	109
Cd	20	17	52	2	0	0	0	18	109
Cr	20	16	53	2	0	0	0	18	109
Cu	20	16	53	2	0	0	0	18	109
Hg	20	18	57	2	0	0	0	12	109
Ni	20	16	54	1	0	0	0	18	109
Pb	20	19	51	2	0	0	0	17	109
Se	20	16	54	1	0	0	0	18	109
Zn	20	16	54	1	0	0	0	18	109
DIOX	18	29	44	2	0	0	0	17	109
benzo(a)pyrene	18	24	45	2	0	0	0	17	109
benzo(b)fluoranthene	17	24	45	1	0	0	0	17	109
benzo(k)fluoranthene	17	26	44	1	0	0	0	17	109
ideno(1,2,3-c,d)pyrene	17	26	44	2	0	0	0	17	109
PCB	3	13	90	0	0	0	0	3	109
HCH	4	8	97	0	0	0	0	0	109
HCB	13	16	78	0	0	0	0	0	109
Total	**470**	**513**	**1251**	**47**	**0**	**0**	**1**	**427**	**2725**

All major emissions from important sources were estimated and reported. Only minor emissions from few sources were not estimated due to lack of activity data or emission factors.

Aldrin, chlordane, chlordecone, DDT, dieldrin, endrin, HCB, HCH, heptachlor, mirex, pentachlorophenol (PCP) and toxaphene production, import and use is prohibited in Lithuania from 01-04-1997. SCCP and hexabromo-biphenyl are not produced in Lithuania. The data about their usage in Lithuania is not available.

1.4. Key source analysis

The lists of the Key source analysis emission sources that contributed to 95 % of the total national emissions are reported (GPG, page 17). The Key source analysis was performed for each reported pollutant separately. Memo items were not included in the Key source analysis. The results of the Key source analysis are given in Table 1-3. NFR codes of Key source categories are listed in the second columns of Table 1-3 and sorted by the level descending. Emission from each source category is listed in the third column. Level assessment (relative contribution to total national emission) of each source category is listed in the fourth column (sorted descending).

Table 1-3. Key source analysis for main pollutants 2010.

	Key source analysis								(%)
SOx	1 B 2 a iv	1 A 4 b i	1 A 2 f ii	1 A 1 c	1 A 1 a	1 A 4 a i			**86,7**
	(19,9%)	(17,7%)	(15,8%)	(14,2%)	(10,5%)	(8,6%)			
NOx	1 A 3 b iii	1 A 3 b i	1 A 1 a	1 A 1 c	1 A 3 c	1 A 2 f ii	1 A 4 b i	1 A 3 b ii	**83,7**
	(36,3%)	(14,2%)	(9,9%)	(5,6%)	(5,4%)	(4,6%)	(3,8%)	(3,8%)	
NH3	4 B 1 a	4 B 8	4 B 1 b	4 D 1 a					**93,4**
	(35,6%)	(22,0%)	(18,3%)	(17,4%)					
NMVOC	3 A 2	1 A 4 b i	2 D 2	1 B 2 a iv	1 A 3 b i	1 A 2 f i	3 B 1		**81,5**
	(21,6%)	(21,3%)	(14,7%)	(11,0%)	(6,6%)	(3,3%)	(3,1%)		
CO	1 A 4 b i	1 A 3 b i							**83,2**
	(62,9%)	(20,3%)							
TSP	1 A 4 b i	1 A 2 f ii	1 A 1 a	1 A 1 c	1 A 4 a i				**86,3**
	(38,8%)	(15,4%)	(13,6%)	(10,7%)	(7,8%)				
PM10	1 A 4 b i	1 A 1 a	1 A 2 f ii	1 A 4 a i	1 A 1 c				**83,7**
	(42,4%)	(14,8%)	(12,7%)	(6,9%)	(6,9%)				
PM2,5	1 A 4 b i	1 A 1 a	1 A 2 f ii	1 A 3 b iii					**80,8**
	(48,3%)	(16,9%)	(9,7%)	(6,1%)					
Pb	1 A 3 b i	1 A 1 a	1 A 3 b vi						**81,4**
	(52,0%)	(15,3%)	(14,1%)						
Hg	1 A 1 a								**89,6**
	(89,6%)								
Cd	1 A 1 a	1 A 1 b							**90,4**
	(77,3%)	(13,1%)							
DIOX	1 A 4 b i								**86,5**
	(86,5%)								
PAH	1 A 4 b i								**93,1**
	(93,1%)								

Usage of 'NE' and 'IE' notation keys may influence Key sources analysis. Assessment of not estimated emission contribution to National Total was made according to not estimated sources emission statistical contribution to total emission given in the [5] reference. Assessment was made for main pollutants by summing relative contributions of not estimated sources according to CORINAIR90 or CORINAIR94 European countries inventory (Table 1-4). As a result, we assessed usage of notation key 'NE' influence to the key source analysis by main pollutants.

Table 1-4. Contribution of not estimated sources emission to national total.

Pollutant	Relative contribution, [%]
SO_2	0.6
NO_x	3.5
NMVOC	1
CO	0.5
NH_3	1.2
TSP	1.7

Usage of 'NE' notation key for SO_2, CO, NMVOC and NH_3 does not influence the Key source analysis. Usage of 'NE' notation key for TSP should not influence the Key source analysis. Not estimated sources of NO_x are not major sources. Most important not estimated sources are direct soil emission (NO_x contribution – 3%) and asphalt roofing (TSP contribution – 1.6 %). Methodology for these sources emission estimation will be prepared in a future.

1.5. Recalculations and other changes

Some renewals in calculations were applied. The current report contains explanation of pollutants trends and key categories, information about sectoral methodologies, recalculations. New COPERT 8.1 version; correction of activity data and sulphur/ lead content in fuels was done. The transport emissions from 2007 – 2010 was recalculated.

1.6. Emission Trends for Air Pollutant[*]

The emission ceilings of NECD are designed with the aim of attaining the European Community's interim environmental objectives set out in Article 5 of NECD by 2010. Meeting those objectives is expected to result in reduced acidification, health-and vegetation-related ground-level ozone exposure by 2010 compared with the 1990 situation. National total emissions and trends (1990–2009) as well as emission targets for air pollutants are shown in Figure 1-6 – 1-9.

In 2005-2008 GDP increased by 21,7%, but in 2009 decreased by 14,8% comparing with 2008. Energy consumption changed accordingly. During 2005-2007 period final energy consumption increased by 11,7%, but in 2009 decreased by 12,1% comparing with 2007. Accordingly of the global economical crisis Lithuania's economic development has slowed down by the end of 2008. In 2008 GDP growth has decreased to 2.9% and in 2009 GDP contracted by -14.7%.

The Ignalina Nuclear Power Plant (NPP) played a key role in the Lithuanian energy sector producing up to 70-80% of the electricity until its closure by the end on 2009. It had installed capacity of 3000MW in two RB MK-1500 (large power channel reactor) reactors. The share of electricity produced in Ignalina NPP has been taken over mainly by the Lithuanian Thermal Power Plant and the largest combined heat and power plants at Vilnius and Kaunas. The closure of the Ignalina Nuclear Power Plant in Lithuania dramatically slashed the volume of electricity produced in the Baltic states. Finding new sources of energy to satisfy the needs of both businesses and the people of the region has become an overriding strategic priority.Thus, the projected energy demand after the decommissioning of Ignalina NPP has been met by using the existing generating capacities. The country is very dependent on electricity produced from fossil and gaseous fuels which are imported from the single source.

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[*] General sources:
Country Nuclear Power Profiles: Lithuania, International Atomic Energy Agency
Ignalina Nuclear Power Plant website (www.iae.lt)
Visaginas Nuclear Power Plant Project website (www.vae.lt)
Energy supply options for Lithuania: A detailed multi-sector integrated energy demand, supply and environmental analysis, International Atomic Energy Agency, IAEA-TECDOC-1408, ISBN: 9201100043 (September 2004)
The Source Book on Soviet-Designed Nuclear Power Plants, Nuclear Energy Institute (1997)

In February 2007, the three Baltic states (Lithuania, Latvia and Estonia) and Poland agreed to build a new nuclear plant at Ignalina, initially with 3200 MWe capacity (2 x 1600 MWe). Though located next to the Soviet-era Ignalina plant, the new one was to be called Visaginas after the nearby town of that name. The Visaginas Nuclear Energy (Visagino Atominė Elektrinė, VAE) company was established in August 2008 for the new units.

Planned power reactors in Lithuania

Reactor	*Type*	*Gross MWe*	*Construction start*	*Operation*
Visaginas 1	ABWR	1350	2014?	2020

Visaginas is envisaged as the cornerstone of the new Baltic Energy Market Interconnector Plan linking to Poland, Finland and Sweden. A high-voltage (400 kV) 1000 MW interconnection, costing €250-300 million, to improve transmission capacity between Lithuania and Poland is to be built, with 500 MW by 2015 and another 500 MW by 2020. Much of the funding is from the European Union (EU). This follows inauguration of an interconnector between Estonia and Finland – Estlink-1, a 150 kV, 350 MW DC cable costing €110 million and also supported by EU funding. Estlink-2 will provide a further 650 MW in 2014. Another major transmission link under the Baltic Sea, the 700 MWe NordBalt project, is planned between Klaipeda in Lithuania and Nybro in Sweden. The €550 million project is expected to be completed by 2015 (). (The Baltic states and Belarus have good interconnection of grids from the Soviet era, but this did not extend to Poland, let alone to Germany. Kaliningrad gets all of its electricity from Russia, via the Lithuanian grid.)

Lithuania is also objecting on the same basis to Belarus plans to build a new nuclear power plant at Ostrovetsk, 23 km from the border and 55 km from Vilnius.

Statistics Lithuania informs that GDP, estimated based on available statistical data and econometric models, in 2010 compared to 2009, grew by 1.3 per cent. In 2010, a growth in the gross value added was observed in industry and energy (by 5.7 per cent) and trade, transport and communication (by 3.1 per cent). The largest decrease in the gross value added was observed in construction (by 8.6 per cent) and agriculture, forestry and fishing (by 3.1 per cent). A smaller decrease in the gross value added was observed in public administration and defence, education, health care and social work (1.9 per cent). In IV quarter 2010, GDP compared to IV quarter 2009, grew by 4.6 per cent. Such a rapid growth in the added value was conditioned by particularly good results for industry; it was also, to a considerable extent, influenced by a growth in the added value of transport and storage.

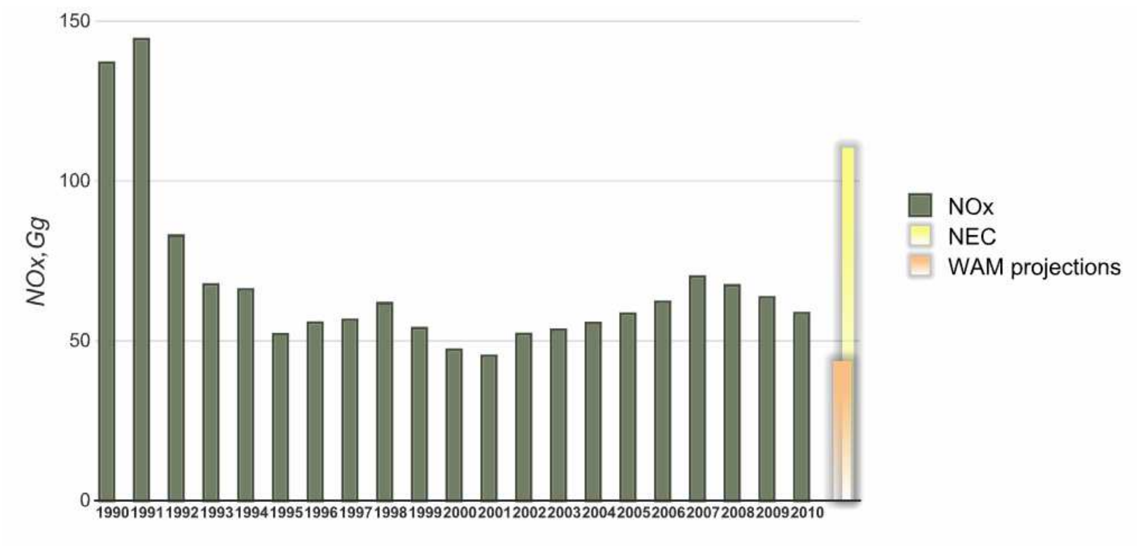
Fuel consumption in transport sector is dominated by diesel oil (56 %) and petrol (27 %). Passenger cars are mostly using petrol fuel and gas, whereas buses and heavy duty vehicles run mainly on diesel fuel. The use of liquefied petroleum gas is strongly influenced by the fluctuation of fuel prices. In navigation diesel fuel and fuel oil are used.

District heating has an approximately 68% market share in the Lithuanian heat market, including delivery to industry. Approx. 58% of households are connected to the heating grid, the remaining percentage is due to the industrial and commercial sector. In total, 19,7 TWh heat was delivered to the grid system in 1997. Gas has a 55% share and oil 37% of input for district heat production.

Lithuania is mostly a lowlands country, and as such does not have huge amounts of hydroelectric power potential. There are two major hydroelectric facilities on the Nemunas, both near the city of Kaunas; the larger of these is a pumped storage facility that eventually (after a second phase of construction) could have a capacity of as much as 1 600 MWe.

1.6.1 **NO_x**

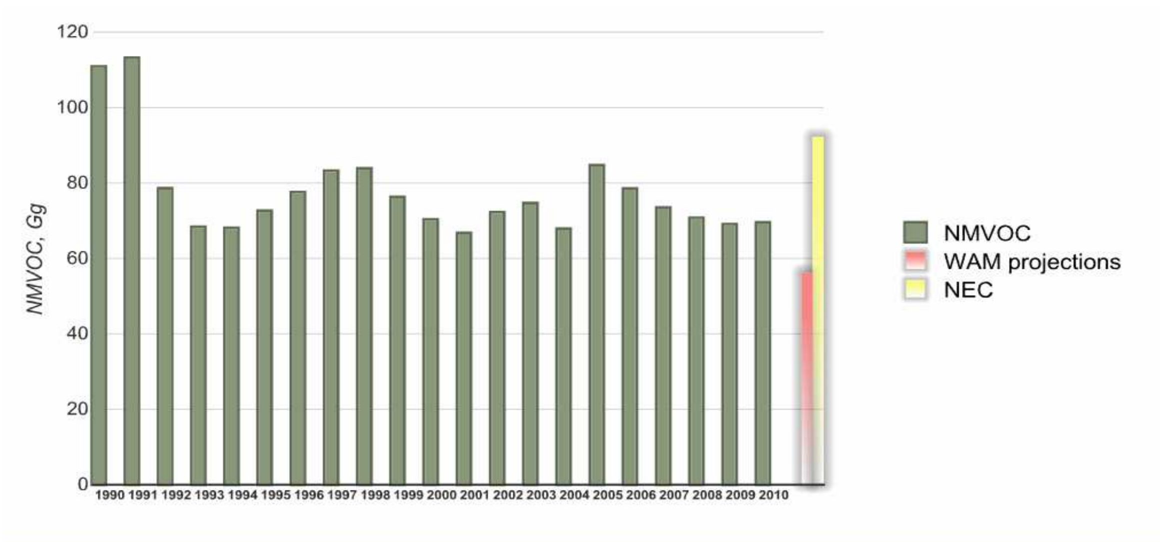
In 2008, NO_x emissions per GDP (expressed in terms of grams of NOX per EUR of GDP) in the average EU-27 was 0.9 g/EUR and in Lithuania 2.3 g/EUR.



*A **with additional measures (WAM)** projection is taking into account all currently implemented and adopted plus all planned policies and measures.

Figure 1-6-1. National total emission trend for NO_x.

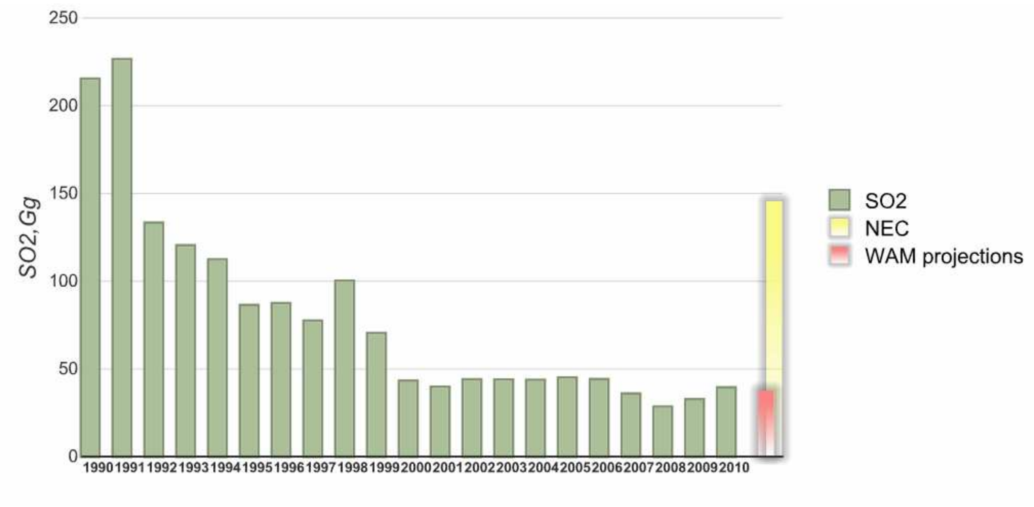
1.6.2. **NMVOC**



*A **with additional measures (WAM)** projection is taking into account all currently implemented and adopted plus all planned policies and measures.

Figure 1-6-2. National total emission trend for NMVOC.

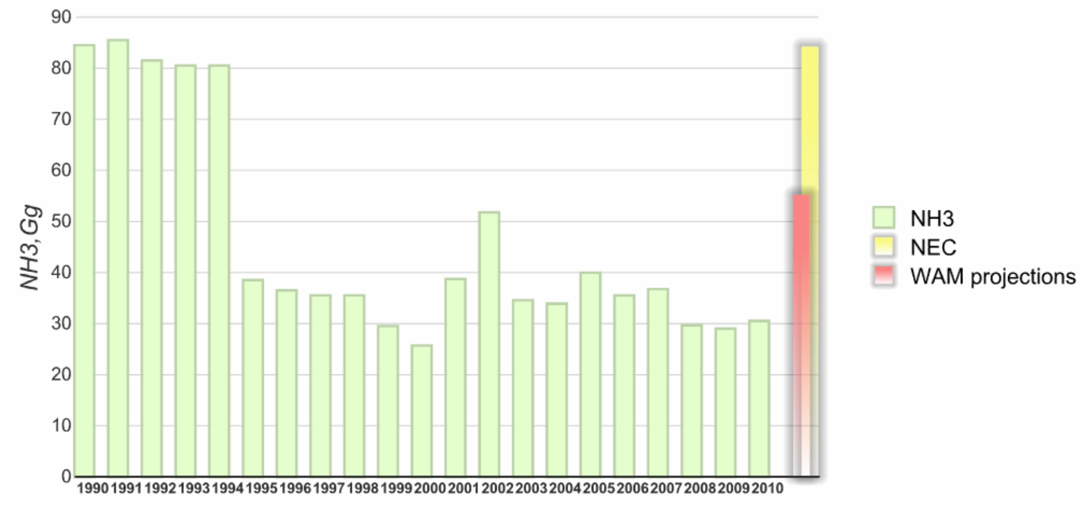
1.6.3. SO_2



*A **with additional measures (WAM)** projection is taking into account all currently implemented and adopted plus all planned policies and measures.

Figure 1-6-3. National total emission trend for SO_2.

1.6.4. NH_3



*A **with additional measures (WAM)** projection is taking into account all currently implemented and adopted plus all planned policies and measures.

Figure 1-6-4. National total emission trend for NH_3.

1.7. Quality Assurance and quality control procedures

Quality Control (QC)

Quality Control (QC) is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

- Provide routine and consistent checks to ensure data correctness and completeness;
- Identify and address errors and omissions;
- Document and archive inventory material.

QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardized procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting.

Quality assurance (QA)

Quality Assurance (QA) activities include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews verify that data quality objectives were met, ensure that the inventory represents the best possible estimates of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the QC programme. In the inventory preparation process, general quality control procedures have been applied. Some specific quality control procedures related to check of activity data and emission factors were applied in previous submissions with new or updated emission factors and activity data from other sources (Environmental Pollution Register, direct communication with operators).

2. ENERGY

After the collapse of the Soviet Union and the reestablishment of Independence in 1990, Lithuania substantially changed its core economic and institutional values. Lithuania has inherited the economy wherein energy consumption per unit of production was 3 times higher than in analogous West European industries. After Lithuania had succeeded from the Soviet Union, the latter critically curtailed the supplies of energy and other resources. As a result, the economic output of Lithuania decreased by one third in 1992 and by one fourth in 1993.

A very sharp increase in primary energy prices and loss of the former Eastern markets brought about a noticeable decline of national energy industry and energy exports. Energy demand and its production decreased almost by half.

By now, however, the declining trend has been successfully reversed. In 2009-2010 the national emission decreased due to the world economical crisis which slightly reflected in the country's emissions.

2.1. Stationary combustion

This chapter covers fuel combustion emissions from boilers, gas turbines, stationary engines and other stationary equipments in energy, industry, commercial/institutional, household and agriculture sectors (stationary sources in NFR sector 1A). Emissions from large point sources were reported separately in Excel template Table IV 3C. The sources provided in inventory as large point sources are:

- 7 power stations
- 6 regional boiler houses
- 2 chemical plants
- 1 oil refinery
- 1 cement plant

Data on direct emissions from large point sources was obtained from their annual emission questionnaires submitted to the Ministry of Environment. Emissions from area sources are estimated according to statistical fuel consumption data.

Emission factors for SOx, NOx, CO, NMVOC, NH3, TSP, PM10, PM2.5, heavy metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn) and POP's are described in this chapter. Emissions were estimated by multiplying heat value of combusted fuel by corresponding emission factor.

2.1.1. Main pollutants

Emission factors for sulphur dioxide (SO_2) and particulate matter (PM) were calculated using the national methodology given in [8] reference. In this methodology are prescribed multipliers, which multiplied by the fuel sulphur and ash contents gives the emission factors. These calculated emission factors are equal for all fuel consuming objects (Tables 2-1 and 2-2).

Table 2-1. Emission factors for SO_2, [kg/GJ].

Fuel	Fuel sulphur content, µg/GJ	Multiplier	Emission factor
Hard coal	1.82	0.714	1.29
Crude oil	0.24	0.488	0.12

Residual oil	2.2	0.488	1.05
Gas oil	0.8	0.468	0.37

Table 2-2. Emission factors for PM, [kg/GJ].

Fuel	Fuel ash content,	Multiplier	Emission factor
Hard coal	10	0.04365	0.4365
Peat	5	0.164	0.82
Crude oil	0.03	0.249	0.007
Residual oil	0.08	0.249	0.0199

National emission factors of other pollutants, i.e. CO, NOx, NMVOC, SO2 and PM, were taken from [8] reference. Emissions from coke combustion were estimated using hard coal's emission factors, emissions from charcoal and agriculture waste combustion were estimated using wood's emission factors. Particle size distribution was taken from [7] reference (Table 2-3).

Table 2-3. Particle size distribution, [%].

Fuel	PM10	PM2.5
Coal, coke	52	13
Wood, peat	96	93
Heavy fuel oil (energy, industry)	85	60
Heavy fuel oil (domestic)	65	25
Light fuel oil (energy)	50	19
Light fuel oil (industry)	50	14
Light fuel oil (domestic)	53	47

National emission factors have been developed on the basis of international experience, to which local circumstances have been applied, by scientist Prof. B. Jaskelevicius. Emission factors were assigned to a number of energy generating facilities categories that are in line with the categories used in national fuel and energy balance.

Different emission factors are set depending on the sector, where fuel is used: electricity production, heat power stations, industry, small enterprises, households, transport (Table 2-4). Moreover, different transport means are distinguished: motor cars, railways, water transport, air transport and agricultural machines.

Table 2-4. Correspondence between NFR sectors and national energy sector classification.

NFR sectors	National energy sector classification
1A1a	Power plants
1A1a	Heat boiler houses
1A1b	Industry
1A1c	Industry
1A2	Industry
1A3a i (ii)	Air transport

1A3a ii (ii)	Air transport
1A3c	Railway transport
1A3d i	Water transport
1A3d ii	Water transport
1A4a	Small companies
1A4b i	Households
1A4c i	Small companies
1A5c ii	Agricultural machines

Annex 1 presents national emissions factors for the following 19 types of fuel: oil, coal, fuel wood, natural gas, peat, other natural fuel, heavy fuel oil, orimulsion, household furnace fuel, vehicle gasoline, diesel fuel oil, aviation gasoline, liquefied natural gas, kerosine, other processed fuel, combustible auxiliary energy resources, other products of refinery and shale oil.

2.1.2. Heavy metals

Most of the heavy metals considered (As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn) are normally released as compounds (e.g. oxides, chlorides) in association with particulates. Only Hg and Se are at least partly present in the vapour phase. Less volatile elements tend to condense onto the surface of smaller particles in the flue gas stream. Therefore, enrichment in the finest particle fractions is observed. The content of heavy metals in coal is normally several orders of magnitude higher than in oil (except occasionally for Ni in heavy fuel oil) and in natural gas. For natural gas only emissions of mercury are relevant. During the combustion of coal, particles undergo complex changes, which lead to evaporation of volatile elements. The rate of volatility of heavy metal compounds depends on fuel characteristics (e.g. concentrations in coal, fraction of inorganic components, such as calcium) and on technology characteristics (e.g. type of boiler, operation mode).

Due to there is no national data about concentrations of heavy metals in the fuel the emission factors for heavy metals were taken from the CORINAIR database, which was installed with CollectER II (Table 2-5).

Table 2-5. Fuel combustion emission factors for heavy metals, [mg/GJ].

Material	Emission factors			
	Residual oil	Natural gas	Hard coal	Lignite
As	12.20	0	5.61	2.90
Cd	24.40	0	0.22	0.25
Cr	61.00	0	4.09	3.02
Cu	24.40	0	7.00	0.99
Hg	24.40	0.1	4.27	10.33
Ni	853.66	0	7.34	2.49
Pb	31.71	0	19.11	2.60
Se	0	0	0.68	0
Zn	24.39	0	22.7	8.68

2.1.3. PAH and other POP's

Emission factors for PAH were derived from [10] reference, resulting emission factors are reported in Table 2-6. Emission factors for dioxins/furans were taken from [6] reference and emission factors for PCB's were taken from [9] reference (Table 2-7).

Table 2-6. PAH emission factors, [mg/GJ].

Source	Fuel	BaP*	BbF*	BkF*	I_P*
Electricity plants	Coal	3.870	1.381	1.381	1.238
Electricity plants	Wood	0.326	0.256	0.256	0.140
Electricity plants	Heavy fuel oil	0.003	0.009	0.009	0.015
Electricity plants	Gas-oil	0.003	0.009	0.009	0.009
Electricity plants	Diesel	0.081	0.043	0.067	0.161
Electricity plants	Lignite	0.023	0.014	0.010	0.022
Heat plants	Coal	0.006	6.171	6.171	0.112
Heat plants	Wood	0.326	0.256	0.256	0.140
Heat plants	Heavy fuel oil	0.003	0.009	0.009	0.015
Heat plants	Gas-oil	0.003	0.009	0.009	0.009
Heat plants	Diesel	0.081	0.043	0.067	0.161
Heat plants	Lignite	0.023	0.014	0.010	0.022
Industry	Coal	0.006	6.171	6.171	0.112
Industry	Wood	0.326	0.256	0.256	0.140
Industry	Heavy fuel oil	0.003	0.009	0.009	0.015
Industry	Gas-oil	0.081	0.043	0.067	0.161
Industry	Diesel	0.023	0.014	0.010	0.022
Industry	Lignite	119.40	79.620	79.620	79.620
Comm./Inst. plants	Coal	0.009	0.698	0.698	0.016
Comm./Inst. plants	Wood	0.003	0.009	0.009	0.015
Comm./Inst. plants	Heavy fuel oil	0.003	0.009	0.009	0.009
Comm./Inst. plants	Gas-oil	0.023	0.014	0.010	0.022
Comm./Inst. plants	Diesel	119.40	79.620	79.620	79.620
Comm./Inst. plants	Lignite	179.80	207.00	114.00	279.10
Domestic plants	Coal	0.058	0.058	0.058	0.058
Domestic plants	Wood	0.036	0.052	0.052	0.028
Domestic plants	Heavy fuel oil	0.058	0.058	0.058	0.058
Domestic plants	Natural gas	204.90	136.60	136.60	136.60
Domestic plants	Gas-oil	0.326	0.256	0.256	0.140
Domestic plants	Lignite	0.003	0.009	0.009	0.015

*Abbreviations: BaP – benzo(a)pyrene, BbF – benzo(b)fluoranthene, BkF - benzo(k)fluoranthene, I_P - indeno(1,2,3-c,d)pyrene.

Table 2-7. PCB and dioxin/furan emission factors.

Fuel	*PCB [µg/GJ]*	*DIOX [ng I-Teq/GJ]*
Coal	144	2.4
Wood	350	90.0
Heavy fuel oil	90	25.0
Light fuel oil	90	25.0
Lignite	257	4.5

2.2. TRANSPORT

Since 1990, the Government of Lithuania has adopted a number of important decisions on the reduction of transport pollution, i.e. national programmes like "Transport and the Protection of Environment", "Measures for the Implementation of the National Transport Development Programme", and other programmes aimed at reducing the negative impact of transport on the environment and on people's health. Due to a difficult economic situation, the implementation of these programmes is slower than expected.

Please note that emissions from mobile sources are calculated based on fuel sold in Lithuania, thus national total emissions include.

The main document, analysing transport impact on the environment is the State Program "Transport and Environmental Protection". It includes the the activities to be followed:

1. On motor road transport:
   rational distribution of traffic flows,
   perfection of means for selection and training of drivers,
   trolley-bus network development in Vilnius and Kaunas,
   optimisation of fuel prices,
   construction of new biotransport routes.
2. On railway transport:
   electrification of Lithuanian railways,
   pipeline transport development for oil products transportation.
3. On Sea transport:
   power supply from the municipal power network to the ships in the port.
4. On the Entire Means of Transport:
   the formation of the fleet of various means of transport, taking into account the existing ecological requirements,
   development and implementation of national ecological standards.

2.2.1. Road transport

Calculations of emissions from road transport (NFR sector 1A3b) are based on:

- statistical fuel consumption data from Energy balance
- traffic intensity, estimated by Institute of Transport
- road transport fleet data, taken from Registry of Transport (State Enterprise "Regitra"). Emission factors and fuel consumption factors for NO_X, NMVOC, CO, TSP and NH3 emission estimations were calculated using COPERT IV model. Road transport was differentiated into the passenger cars, light duty vehicles, heavy duty vehicles, buses and motorcycles categories.

2.2.1.1. Main pollutant emissions

The emissions of SO_2 are estimated by assuming that all sulphur in the fuel is transformed completely into SO_2 using the equation [5]:

$$E_{SO_2,j}^{CALC} = 2 \cdot k_{S,m} \cdot FC_{jm}^{CALC}, \qquad (1)$$

where, $k_{S,m}$ - weight related sulphur content in fuel of type m [kg/kg fuel]. Calculation results are listed in Table 2-8.

Table 2-8. Emission factors for SO_2, [g/kg].

Fuel	k	Emission factor
Gasoline	0.005 0.001	1
Diesel oil	0.002 0.001	4

CO, NMVOC, NO_x, NH_3, TSP emission factors and fuel consumption factors were calculated using COPERT IV model. Emission factors were calculated for urban, rural and highway modes from average speed of transport at these modes (Table 2-9).

Table 2-9. Average speed of transport categories at different driving modes, [km/h].

Transport category/ Driving modes	Urban	Rural	Highway
Passenger cars	30	70	100
Light duty vehicles	25	65	100
Heavy duty vehicles	25	65	90
Buses	20	65	85
Motorcycles	30	70	90

Fuel was distributed to transport categories, types, ecology standards and driving modes according to mileage data taken from Institute of Transport and transport fleet data taken from Transport Registry. Following particle size distributions were taken from [7] reference: PM_{10} – 96 % of TSP, $PM_{2.5}$ – 86.5 % of TSP. Result of emission factors estimation are listed in Tables 2-10 - 2-14.

Table 2-10. Emission factors for passenger cars [g/GJ].

Engine type	Ecology standard	CO	NO_x	NMVOC	NH_3	TSP	PM_{10}	$PM_{2.5}$
Highway								
Gasoline < 1.4 l	PRE ECE	5647.45	736.13	453.76	0.73	0	0	0
	ECE 15/00-01	8747.2	950.35	526.78	0.94	0	0	0
	ECE 15/02	3683.29	1297.18	423.62	0.89	0	0	0
	ECE 15/03	3397.9	1460.83	423.62	0.89	0	0	0
	ECE 15/04	2054.12	1274.14	334.09	0.96	0	0	0
	Euro I	1650.39	307.89	53.52	51.96	0	0	0
	Euro II	1122.26	110.84	11.24	51.96	0	0	0
	Euro III	924.22	73.89	8.03	51.96	0	0	0
	Euro IV	561.13	40.03	1.61	51.96	0	0	0
Gasoline 1.4 – 2.0 l	PRE ECE	4638.78	935.53	372.72	0.6	0	0	0
	ECE 15/00-01	7049.99	1185.09	424.57	0.76	0	0	0
	ECE 15/02	3159.93	1255.94	363.43	0.77	0	0	0
	ECE 15/03	2915.09	1328.12	363.43	0.77	0	0	0
	ECE 15/04	1882.38	1545.7	306.16	0.88	0	0	0
	Euro I	1141.55	251.88	39.16	47.53	0	0	0
	Euro II	776.26	90.68	8.22	47.53	0	0	0
	Euro III	639.27	60.45	5.48	47.53	0	0	0

	Euro IV	388.13	32.74	1.17	47.53	0	0	0
Gasoline > 2.0 l	PRE ECE	4014.39	1422.62	322.55	0.52	0	0	0
	ECE 15/00-01	6411.98	1893.98	386.15	0.69	0	0	0
	ECE 15/02	2667.39	1188.38	306.78	0.65	0	0	0
	ECE 15/03	2460.71	1486.76	306.78	0.65	0	0	0
	ECE 15/04	1401.74	1204.26	227.98	0.65	0	0	0
	Euro I	436.5	233.01	51.7	44.72	0	0	0
	Euro II	296.82	83.88	12.41	44.72	0	0	0
	Euro III	244.44	55.92	8.27	44.72	0	0	0
	Euro IV	152.77	30.29	2.58	44.72	0	0	0
Diesel < 2.0 l	Conventional	179.7	246.87	28.81	0.47	79.48	76.3	68.75
	Euro I	81.36	305.55	14.47	0.49	35.52	34.1	30.72
	Euro II	81.36	305.55	14.47	0.49	35.52	34.1	30.72
	Euro III	81.36	235.27	12.3	0.49	25.57	24.55	22.12
	Euro IV	81.36	161.94	9.99	0.49	15.98	15.34	13.83
Diesel > 2.0 l	Conventional	179.7	402.56	28.81	0.47	79.48	76.3	68.75
	Euro I	81.36	305.55	14.47	0.49	35.52	34.1	30.72
	Euro II	81.36	305.55	14.47	0.49	35.52	34.1	30.72
	Euro III	81.36	235.27	12.3	0.49	25.57	24.55	22.12
	Euro IV	81.36	161.94	9.99	0.49	15.98	15.34	13.83
LPG	Conventional	3914.25	1151.7	197.15	0	0	0	0
	Euro I	1429.78	119.61	33.38	0	0	0	0
	Euro II	972.25	43.06	7.01	0	0	0	0
	Euro III	800.68	28.71	5.01	0	0	0	0
	Euro IV	486.13	15.55	1	0	0	0	0
Rural								
Gasoline < 1.4 l	PRE ECE	8025.24	855.96	663.02	0.83	0	0	0
	ECE 15/00-01	7435.75	1058.88	645	1.03	0	0	0
	ECE 15/02	4144.67	1062.45	536.28	1.01	0	0	0
	ECE 15/03	4444.4	1138.77	536.28	1.01	0	0	0
	ECE 15/04	2604.71	1098.09	470.44	1.05	0	0	0
	Euro I	334.69	213.79	49.02	60.09	0	0	0
	Euro II	227.59	76.97	10.29	60.09	0	0	0
	Euro III	187.43	51.31	7.35	60.09	0	0	0
	Euro IV	113.79	27.79	1.47	60.09	0	0	0
Gasoline 1.4 – 2.0 l	PRE ECE	6587.88	914.26	544.27	0.68	0	0	0
	ECE 15/00-01	6470.81	1198.98	561.29	0.89	0	0	0
	ECE 15/02	3693.62	1070.7	477.92	0.9	0	0	0
	ECE 15/03	3960.73	1161.97	477.92	0.9	0	0	0
	ECE 15/04	2303.89	1281.48	416.11	0.93	0	0	0
	Euro I	485.79	181.25	43.09	51.87	0	0	0
	Euro II	330.34	65.25	9.05	51.87	0	0	0
	Euro III	272.05	43.5	6.03	51.87	0	0	0
	Euro IV	165.17	23.56	1.29	51.87	0	0	0
Gasoline > 2.0 l	PRE ECE	5517.35	1167.24	455.83	0.57	0	0	0
	ECE 15/00-01	5790.74	1635.65	502.3	0.8	0	0	0
	ECE 15/02	2959.45	965.43	382.92	0.72	0	0	0
	ECE 15/03	3173.46	1241.74	382.92	0.72	0	0	0
	ECE 15/04	1948.15	1081.17	351.86	0.79	0	0	0
	Euro I	400.53	199.75	80.79	49.2	0	0	0
	Euro II	272.36	71.91	19.39	49.2	0	0	0
	Euro III	224.3	47.94	12.93	49.2	0	0	0
	Euro IV	140.18	25.97	4.04	49.2	0	0	0
Diesel < 2.0 l	Conventional	268.08	246.02	48.91	0.57	75.13	72.12	64.99

	Euro I	60.57	270.74	18.2	0.55	19.15	18.38	16.56
	Euro II	60.57	270.74	18.2	0.55	19.15	18.38	16.56
	Euro III	60.57	208.47	15.47	0.55	13.78	13.23	11.92
	Euro IV	60.57	143.49	12.56	0.55	8.62	8.27	7.45
Diesel > 2.0 l	Conventional	268.08	410.71	48.91	0.57	75.13	72.12	64.99
	Euro I	60.57	270.74	18.2	0.55	19.15	18.38	16.56
	Euro II	60.57	270.74	18.2	0.55	19.15	18.38	16.56
	Euro III	60.57	208.47	15.47	0.55	13.78	13.23	11.92
	Euro IV	60.57	143.49	12.56	0.55	8.62	8.27	7.45
LPG	Conventional	1146.38	1248.46	322.09	0	0	0	0
	Euro I	695.58	136.15	34.23	0	0	0	0
	Euro II	472.99	49.01	7.19	0	0	0	0
	Euro III	389.52	32.68	5.13	0	0	0	0
	Euro IV	236.5	17.7	1.03	0	0	0	0
Urban								
Gasoline < 1.4 l	PRE ECE	9508.97	496.65	828.67	0.58	0	0	0
	ECE 15/00-01	7718.4	563.16	745.54	0.65	0	0	0
	ECE 15/02	7134.59	547.27	812.13	0.72	0	0	0
	ECE 15/03	7480.48	568.38	812.13	0.72	0	0	0
	ECE 15/04	4745.53	642.04	726.25	0.8	0	0	0
	Euro I	1232.18	130.9	111.4	26.74	0	0	0
	Euro II	837.88	47.12	23.39	26.74	0	0	0
	Euro III	690.02	31.42	16.71	26.74	0	0	0
	Euro IV	418.94	17.02	3.34	26.74	0	0	0
Gasoline 1.4 – 2.0 l	PRE ECE	8028.98	480.96	699.7	0.49	0	0	0
	ECE 15/00-01	6518.66	545.5	629.65	0.55	0	0	0
	ECE 15/02	5996.81	519.83	682.62	0.6	0	0	0
	ECE 15/03	6287.54	521.96	682.62	0.6	0	0	0
	ECE 15/04	3891.13	639.59	595.5	0.66	0	0	0
	Euro I	1105.03	100.56	66.46	20.24	0	0	0
	Euro II	751.42	36.2	13.96	20.24	0	0	0
	Euro III	618.82	24.13	9.3	20.24	0	0	0
	Euro IV	375.71	13.07	1.99	20.24	0	0	0
Gasoline > 2.0 l	PRE ECE	6508.72	491.56	567.21	0.39	0	0	0
	ECE 15/00-01	5860.85	618.34	566.11	0.5	0	0	0
	ECE 15/02	4867.48	476.11	554.07	0.49	0	0	0
	ECE 15/03	5103.46	661.96	554.07	0.49	0	0	0
	ECE 15/04	3134.75	596.46	479.74	0.53	0	0	0
	Euro I	1284.48	107.3	74.33	16.19	0	0	0
	Euro II	873.44	38.63	17.84	16.19	0	0	0
	Euro III	719.31	25.75	11.89	16.19	0	0	0
	Euro IV	449.57	13.95	3.72	16.19	0	0	0
Diesel < 2.0 l	Conventional	262.11	201.13	65.03	0.34	83.4	80.07	72.14
	Euro I	244.45	319.35	39.31	0.39	30.56	29.34	26.44
	Euro II	244.45	319.35	39.31	0.39	30.56	29.34	26.44
	Euro III	244.45	245.9	33.41	0.39	22.01	21.13	19.04
	Euro IV	244.45	169.26	27.12	0.39	13.75	13.2	11.9
Diesel > 2.0 l	Conventional	262.11	311.04	65.03	0.34	83.4	80.07	72.14
	Euro I	244.45	319.35	39.31	0.39	30.56	29.34	26.44
	Euro II	244.45	319.35	39.31	0.39	30.56	29.34	26.44
	Euro III	244.45	245.9	33.41	0.39	22.01	21.13	19.04
	Euro IV	244.45	169.26	27.12	0.39	13.75	13.2	11.9
LPG	Conventional	1287.03	747.93	511.25	0	0	0	0
	Euro I	694.61	152.71	136.53	0	0	0	0

	Euro II	472.33	54.98	28.67	0	0	0	0
	Euro III	388.98	36.65	20.48	0	0	0	0
	Euro IV	236.17	19.85	4.1	0	0	0	0

Table 2-11. Emission factors for light duty vehicles [g/GJ].

Engine type	Ecology standard	CO	NO_x	NMVOC	NH_3	TSP	PM_{10}	$PM_{2.5}$
Highway								
Gasoline	Conventional	6054.66	1344.06	195.04	0.72	0	0	0
	Euro I	1213.08	158.92	23.24	30.5	0	0	0
	Euro II	739.98	54.03	5.58	30.5	0	0	0
	Euro III	630.8	33.37	3.25	30.5	0	0	0
	Euro IV	339.66	15.89	1.39	30.5	0	0	0
Diesel	Conventional	311.92	342.74	26.37	0.25	87.39	83.9	75.6
	Euro I	194.93	346.15	29.6	0.28	42.71	41	36.9
	Euro II	194.93	346.15	29.6	0.28	42.71	41	36.9
	Euro III	159.84	290.77	18.35	0.28	28.62	27.47	24.7
	Euro IV	126.7	235.38	6.81	0.28	14.95	14.35	12.9
Rural								
Gasoline	Conventional	2316.18	1188.86	277.84	0.76	0	0	0
	Euro I	279.6	129.74	35.5	32.44	0	0	0
	Euro II	170.56	44.11	8.52	32.44	0	0	0
	Euro III	145.39	27.25	4.97	32.44	0	0	0
	Euro IV	78.29	12.97	2.13	32.44	0	0	0
Diesel	Conventional	358.42	299.25	37.49	0.36	107.73	103.42	93.19
	Euro I	132.09	392.54	42.48	0.4	26.48	25.42	22.91
	Euro II	132.09	392.54	42.48	0.4	26.48	25.42	22.91
	Euro III	108.31	329.74	26.34	0.4	17.74	17.03	15.35
	Euro IV	85.86	266.93	9.77	0.4	9.27	8.9	8.02
Urban								
Gasoline	Conventional	5800.27	518.76	641.71	0.43	0	0	0
	Euro I	1549.64	90.04	59.11	12.91	0	0	0
	Euro II	945.28	30.61	14.19	12.91	0	0	0
	Euro III	805.81	18.91	8.28	12.91	0	0	0
	Euro IV	433.9	9	3.55	12.91	0	0	0
Diesel	Conventional	320.78	650.03	38.14	0.24	68.74	65.99	59.46
	Euro I	151.94	370.88	41.96	0.27	26.66	25.59	23.06
	Euro II	151.94	370.88	41.96	0.27	26.66	25.59	23.06
	Euro III	124.59	311.54	26.02	0.27	17.86	17.15	15.45
	Euro IV	98.76	252.2	9.65	0.27	9.33	8.96	8.07

Table 2-12. Emission factors for heavy-duty vehicles [g/GJ].

Weight	Ecology standard	CO	NO_x	NMVOC	NH_3	TSP	PM_{10}	$PM_{2.5}$
Highway								
3.5 – 7.5 t	Conventional	312.67	621.92	147.76	0.57	36.12	34.68	31.25
	Euro I	171.97	559.72	110.82	0.57	23.48	22.54	20.31
	Euro II	156.34	404.25	103.43	0.57	14.45	13.87	12.5
	Euro III	109.43	282.97	72.4	0.57	10.11	9.71	8.75
	Euro IV	79.73	197.77	50.68	0.57	1.91	1.84	1.66
7.5 – 16 t	Conventional	208.52	530.86	98.54	0.38	46.64	44.77	40.34
	Euro I	114.69	477.78	73.9	0.38	30.32	29.1	26.22
	Euro II	104.26	345.06	68.98	0.38	18.66	17.91	16.14
	Euro III	72.98	241.54	48.28	0.38	13.06	12.54	11.3

	Euro IV	53.17	168.81	33.8	0.38	2.47	2.37	2.14
16 – 32 t	Conventional	157.16	679.98	74.27	0.29	42.72	41.01	36.95
	Euro I	102.16	373.99	55.7	0.29	27.77	26.66	24.02
	Euro II	102.16	305.99	48.27	0.29	10.68	10.25	9.24
	Euro III	71.51	214.19	33.79	0.29	7.48	7.18	6.47
	Euro IV	52.18	149.6	23.62	0.29	1.41	1.35	1.22
> 32 t	Conventional	122.43	806.16	57.85	0.22	35.97	34.53	31.12
	Euro I	79.58	443.39	43.39	0.22	23.38	22.45	20.23
	Euro II	79.58	362.77	37.61	0.22	8.99	8.63	7.78
	Euro III	55.7	253.94	26.32	0.22	6.3	6.04	5.45
	Euro IV	40.65	177.36	18.4	0.22	1.19	1.14	1.03
Rural								
3.5 – 7.5 t	Conventional	522.8	553.87	262.2	0.76	60.65	58.22	52.46
	Euro I	313.68	387.71	196.65	0.76	39.42	37.84	34.1
	Euro II	287.54	304.63	183.54	0.76	24.26	23.29	20.98
	Euro III	201.28	213.24	128.48	0.76	16.98	16.3	14.69
	Euro IV	146.91	148.99	89.94	0.76	3.21	3.09	2.78
7.5 – 16 t	Conventional	317.19	648.41	159.08	0.46	71.67	68.81	62
	Euro I	190.31	453.89	119.31	0.46	46.59	44.72	40.3
	Euro II	174.45	356.63	111.36	0.46	28.67	27.52	24.8
	Euro III	122.12	249.64	77.95	0.46	20.07	19.27	17.36
	Euro IV	89.13	174.42	54.57	0.46	3.8	3.65	3.29
16 – 32 t	Conventional	213.6	897.96	107.13	0.31	58.36	56.03	50.49
	Euro I	128.16	538.78	69.63	0.31	37.94	36.42	32.82
	Euro II	106.8	404.08	64.28	0.31	14.59	14.01	12.62
	Euro III	74.76	282.86	44.99	0.31	10.21	9.81	8.83
	Euro IV	54.47	197.55	31.5	0.31	1.93	1.85	1.67
> 32 t	Conventional	159.1	1002.18	79.8	0.23	46.77	44.9	40.46
	Euro I	95.46	601.31	51.87	0.23	30.4	29.19	26.3
	Euro II	79.55	450.98	47.88	0.23	11.69	11.23	10.11
	Euro III	55.69	315.69	33.51	0.23	8.19	7.86	7.08
	Euro IV	40.57	220.48	23.46	0.23	1.54	1.48	1.34
Urban								
3.5 – 7.5 t	Conventional	754.67	796.58	450.78	0.57	88.6	85.05	76.64
	Euro I	377.34	557.61	338.08	0.57	57.59	55.28	49.81
	Euro II	301.87	398.29	315.54	0.57	35.44	34.02	30.65
	Euro III	211.31	278.8	220.88	0.57	24.81	23.81	21.46
	Euro IV	153.95	195.16	154.62	0.57	4.7	4.51	4.06
7.5 – 16 t	Conventional	423.77	911.1	253.13	0.32	98.67	94.73	85.35
	Euro I	211.89	637.77	189.84	0.32	64.14	61.57	55.48
	Euro II	169.51	455.55	177.19	0.32	39.47	37.89	34.14
	Euro III	118.66	318.89	124.03	0.32	27.63	26.52	23.9
	Euro IV	86.45	223.22	86.82	0.32	5.23	5.02	4.52
16 – 32 t	Conventional	269.51	1041.22	160.98	0.2	74.78	71.78	64.68
	Euro I	148.23	572.67	80.49	0.2	48.6	46.66	42.04
	Euro II	121.28	416.49	72.44	0.2	18.69	17.95	16.17
	Euro III	84.9	291.54	50.71	0.2	13.09	12.56	11.32
	Euro IV	61.99	204.08	35.42	0.2	2.47	2.37	2.13
> 32 t	Conventional	205.19	1134.53	122.56	0.15	60.41	57.99	52.25
	Euro I	112.85	623.99	61.28	0.15	39.26	37.69	33.96
	Euro II	92.33	453.81	55.15	0.15	15.1	14.5	13.06
	Euro III	64.63	317.67	38.61	0.15	10.57	10.15	9.14
	Euro IV	47.19	222.37	26.96	0.15	1.99	1.91	1.72

Table 2-13. Emission factors for buses [g/GJ].

Bus type	Ecology standard	CO	NO_x	NMVOC	NH_3	TSP	PM_{10}	$PM_{2.5}$
Highway								
Coaches	Conventional	179.59	921.71	100.71	0.35	41.16	39.52	35.61
	Euro I	116.74	506.94	75.54	0.35	26.76	25.69	23.14
	Euro II	116.74	414.77	65.46	0.35	10.29	9.88	8.9
	Euro III	81.72	290.34	45.82	0.35	7.2	6.92	6.23
	Euro IV	59.63	202.78	32.03	0.35	1.36	1.3	1.18
Rural								
Coaches	Conventional	216.98	913.47	123.24	0.34	48.39	46.45	41.86
	Euro I	130.19	548.08	80.11	0.34	31.45	30.19	27.21
	Euro II	108.49	411.06	73.95	0.34	12.1	11.61	10.46
	Euro III	75.94	287.74	51.76	0.34	8.47	8.13	7.32
	Euro IV	55.33	200.96	36.23	0.34	1.6	1.53	1.38
Urban								
Urban buses	Conventional	394.57	1174.31	124.13	0.19	53.96	51.8	46.67
	Euro I	197.29	822.02	93.1	0.19	35.07	33.67	30.34
	Euro II	157.83	587.16	86.89	0.19	21.58	20.72	18.67
	Euro III	110.48	411.01	60.83	0.19	15.11	14.5	13.07
	Euro IV	80.49	287.71	42.58	0.19	2.86	2.75	2.47
Coaches	Conventional	317.2	1083.23	190.59	0.18	62.73	60.22	54.26
	Euro I	174.46	595.77	95.3	0.18	40.77	39.14	35.27
	Euro II	142.74	433.29	85.77	0.18	15.68	15.05	13.56
	Euro III	99.92	303.3	60.04	0.18	10.98	10.54	9.5
	Euro IV	72.96	212.31	41.93	0.18	2.07	1.99	1.79

Table 2-14. Emission factors for motorcycles [g/GJ].

Engine type	Ecology standard	CO	NO_x	NMVOC	NH_3	TSP	PM_{10}	$PM_{2.5}$
Highway								
2-stroke > 50 cm³	Conventional	17230.13	78.41	5343.2	1.29	0	0	0
	97/24/EC	20795.8	44.33	4590.39	1.61	0	0	0
4-stroke < 250 cm³	Conventional	23992.76	223.35	716.41	1.4	0	0	0
	97/24/EC	10094.42	295.57	291.08	1.5	0	0	0
4-stroke 250 – 750 cm³	Conventional	17126.12	232.84	697.81	1.42	0	0	0
	97/24/EC	10094.42	295.57	291.08	1.5	0	0	0
4-stroke > 750 cm³	Conventional	13703.09	214.44	811.9	1.24	0	0	0
	97/24/EC	10094.42	295.57	291.08	1.5	0	0	0
Rural								
2-stroke > 50 cm³	Conventional	17975.71	62.06	5925.14	1.41	0	0	0
	97/24/EC	17477.41	31.67	5139.66	1.71	0	0	0
4-stroke < 250 cm³	Conventional	22473.86	206.79	820.34	1.71	0	0	0
	97/24/EC	7800.24	261.69	394.64	1.68	0	0	0
4-stroke 250 – 750 cm³	Conventional	17152.78	200.09	752.53	1.59	0	0	0
	97/24/EC	7800.24	261.69	394.64	1.68	0	0	0
4-stroke > 750 cm³	Conventional	11982.41	176.78	1069.98	1.33	0	0	0
	97/24/EC	7800.24	261.69	394.64	1.68	0	0	0
Urban								
2-stroke > 50 cm³	Conventional	17975.71	62.06	5925.14	1.41	0	0	0
	97/24/EC	17477.41	31.67	5139.66	1.71	0	0	0
4-stroke < 250 cm³	Conventional	22473.86	206.79	820.34	1.71	0	0	0
	97/24/EC	7800.24	261.69	394.64	1.68	0	0	0
4-stroke 250 – 750 cm³	Conventional	17152.78	200.09	752.53	1.59	0	0	0
	97/24/EC	7800.24	261.69	394.64	1.68	0	0	0
4-stroke > 750 cm³	Conventional	11982.41	176.78	1069.98	1.33	0	0	0
	97/24/EC	7800.24	261.69	394.64	1.68	0	0	0

2.2.1.2. Lead (Pb) and other heavy metals emissions

Emissions of lead are estimated by assuming that 75 % of lead contained in the fuel is emitted into air [5]. Then the equation is:

$$E_{Pb,j}^{CALC} = 0.75 \cdot k_{Pb,m} \cdot FC_{jm}^{CALC} , \qquad (2)$$

where, $k_{Pb,m}$ – weight related lead content of gasoline (type m) in [kg/kg fuel]. The emission factor for lead is given in the Table 2-15.

Table 2-15. Emission factor for lead (Pb).

Fuel	k	Emission factor, mg/kg
Gasoline	$1.73 \cdot 10^{-5}$	13

With regard to the emission of other heavy metal species, emission factors provided correspond both to fuel content and engine wear. Therefore it is considered that the total quantity is emitted to the atmosphere (no losses in the engine). Heavy metal emissions depends on metal content in fuel, therefore emissions were calculated according to consumed fuel (Table 2-16). LPG doesn't contain heavy metal; therefore there are no heavy metals emissions from road transport using LPG.

Table 2-16. Heavy metal emission factors for all vehicle categories in [mg/kg fuel] [5].

Category	Cadmium	Copper	Chromium	Nickel	Selenium	Zinc
Road transport	0.01	1.7	0.05	0.07	0.01	1

2.2.1.3. PAH's and other POP's emissions

PAH and dioxins/furans emission factors were taken from [5] reference, PCB – from [6] reference and listed in the Table 2-17. Emission factors were converted to mass per heat value units according to the fuel consumption factors estimated with COPERT IV and inserted into CORINAIR database.

Table 2-17. PAH's and other POP's bulk (hot + cold) emission factors [5].

Species	Emission factors (µg/km)					
	Gasoline PC & LDV		Diesel PC & LDV		HDV	LPG
	Pre Euro I	Euro I & on	DI	IDI	DI	
indeno(1,2,3-c,d)pyrene	1.03	0.39	0.70	2.54	1.40	0.01
benzo(k)fluoranthene	0.30	0.26	0.19	2.87	6.09	0.01
benzo(b)fluoranthene	0.88	0.36	0.60	3.30	5.45	0
benzo(ghi)perylene	2.90	0.56	0.95	6.00	0.77	0.02
fluoranthene	18.22	2.80	18.003	38.32	21.39	1.36
benzo(a)pyrene	0.48	0.32	0.63	2.85	0.90	0.01
PCB's	0.0012	0.0012	0.05	0.05	5.39	0
Dioxins/furans, [ng I-Teq/km]	0.0315	0.0315	0.0015	0.0015	0.0109	0

2.2.1.4. Gasoline evaporation

Gasoline evaporation emissions are estimated according to mileage of separate road transport categories consuming gasoline and number of vehicles consuming gasoline. Mileage of road transport categories was estimated according to statistical fuel consumption data, fuel consumption factors calculated by COPERT III and mileage data estimated by Institute of Transport. NMVOC emission factors were taken from [18] literature (Table 2-18).

Table 2-18. NMVOC emission factors for gasoline evaporation [18].

	NMVOC emission factors	Units
Passenger cars		
Diurnal and hot soak emissions in summer	3642.00	g/vehicle
Diurnal and hot soak emissions in winter	4807.00	g/vehicle
Running losses in summer	0.022	g/km
Running losses in winter	0.006	g/km
Light duty vehicle		
Diurnal and hot soak emissions in summer	3642.00	g/vehicle
Diurnal and hot soak emissions in winter	4807.00	g/vehicle
Running losses in summer	0.022	g/km
Running losses in winter	0.006	g/km
Motorcycles		
Diurnal and hot soak emissions in summer	1457.00	g/vehicle
Diurnal and hot soak emissions in winter	1923.00	g/vehicle
Running losses in summer	0.009	g/km
Running losses in winter	0.002	g/km

2.2.1.5. Tyre, brake wear and road abrasion emissions

Tyre, brake wear and road abrasion emissions are estimated according to mileage of separate road transport categories. Mileage of road transport categories was estimated according to statistical fuel consumption data, fuel consumption factors calculated by COPERT IV and mileage data estimated by Institute of Transport. The resulting mileage data (Table 2-19) is used as activity rates for estimating tyre, brake wear and road abrasion emissions.

Table 2-19. Road transport mileage by categories, [km].

Category	Mileage
Passenger cars	7 502 454 100
Light duty vehicle	1 566 991 000
Heavy duty vehicle	1 887 711 951
Buses	752 344 000
Motorcycles	5 632 879
Mopeds	10 176 919

TSP, PM_{10} and heavy metal emission factors for tyre, brake wear and road abrasion were taken from [18] literature and reported in Tables 2-20, 2-21, 2-23. $PM_{2.5}$ emission factors were taken from [7] reference and reported in Table 2-22.

Table 2-20. TSP emission factors for tyre, brake wear and road abrasion [18].

Transport category	Emission factor (g/km)		
	Tyre wear	Brake wear	Road abrasion
Motorcycles	0.0028	0.0037	0.0030
Passenger cars	0.0064	0.0073	0.0075
Light duty vehicles	0.0101	0.0115	0.0075
Heavy duty vehicles and buses	0.0270	0.0320	0.0380

Table 2-21. PM_{10} emission factors for tyre, brake wear and road abrasion [18].

Transport category	Emission factor (g/km)		
	Tyre wear	Brake wear	Road abrasion
Motorcycles	0.0028	0.0020	0.0030
Passenger cars	0.0064	0.0033	0.0075
Light duty vehicles	0.0101	0.0052	0.0075
Heavy duty vehicles and buses	0.0270	0.0130	0.0380

Table 2-22. $PM_{2.5}$ emission factors for tyre, brake wear and road abrasion [7].

Transport category	Emission factor (g/km)		
	Tyre wear	Brake wear	Road abrasion
Motorcycles	0.0001	0.0003	0.0016
Passenger cars	0.0003	0.0022	0.0042
Light duty vehicles	0.0003	0.0022	0.0042
Heavy duty vehicles and buses	0.0020	0.0071	0.0209

Table 2-23. Heavy metal fraction of tyre, brake wear and road abrasion TSP emission [18].

Heavy metal	Tyre wear [mg/kg TSP]	Brake wear [mg/kg TSP]	Road abrasion [mg/kg TSP]
As	0.8	10.0	0
Cd	2.6	13.2	1
Cr	12.4	669	40
Cu	174	51112	12
Ni	33.6	463	20
Pb	107	3126	15
Zn	7434	8676	35

2.2.2. Off-road transport

This chapter includes estimation methodology for emissions of off-road transport (mobiles in NFR sectors 1A2f, 1A3a, 1A3c, 1A3d, 1A4c), i.e. railway, air and water transport, also agriculture and constructional machines. Emissions from off-road transport were estimated according to statistical fuel consumption and some statistical transport activity data (i.e. airplane's landing and taking-off number).

A simple methodology for estimating emissions is based on total fuel consumption data, which have to be multiplied by appropriate bulk emission factors. Therefore, the equation to be applied in this case is:

$$E_i = FC \cdot EF_i \qquad (3)$$

were E_i - mass of emissions of pollutant i during inventory period; FC - fuel consumption; EF_i - average emissions of pollutant i per unit of fuel used.

SO_2 emission factors were calculating using multiplier proposed in [9] methodology and multiplying it by the fuel sulphur content. The calculation results are listed in Table 2-24.

Table 2-24. Emission factors for SO_2, [kg/GJ].

Fuel	Fuel sulphur content,	Multiplier	Emission factor
Aviation gasoline	0.01	0.5	0.005
Residual oil	2.2	0.488	1.073

TSP, PM_{10} and $PM_{2.5}$ emission factors of navigation were taken from [8] reference and reported in Table 2-25. Emission factors of other main pollutants were inserted into the emission inventory database directly from the national emission factors database, which was compiled using emission factors proposed in [8] methodology. Emission factors for PM_{10} and $PM_{2.5}$ were calculated according to particle size distribution given in [7] reference (Table 2-26).

Table 2-25. TSP, PM_{10} and $PM_{2.5}$ emission factors for navigation, [g/GJ].

Fuel	TSP	PM_{10}	$PM_{2.5}$
Diesel	28.6	28.3	27.7
Gas-oil	28.6	28.3	27.7
Residual oil	125	123	121

Table 2-26. Particle size distribution, [% PM].

Fuel	PM_{10}	$PM_{2.5}$
Diesel	96	90
Residual oil	99	97
Gasoline, kerosene	99	84

Emissions from airplanes landing and take-off (LTO) of international flights were estimated according to statistical number of take-offs. Separate airplanes models take-offs contributions to total take-offs were taken from flight control centre of Vilnius airport. Take-offs in Vilnius international airport takes 95 % of total take-offs in Lithuania's international airports. Statistical number of take-offs is treated as number of LTO's. Airplane model specific emission factors and fuel consumption factors per LTO were taken from [5] reference and listed in Table 2-27.

Table 2-27. Airplanes emission factors for LTO, [g/LTO]. Airplanes models take-offs contributions to total take-offs are written in brackets.

Airplane model	CO	NO_x	NMVOC	SO_2	Fuel consumption, [kg/LTO]
Boeing 737 (65 %)	11831	8300	666.8	825.4	825.4
Fokker 50 (25 %)	728.1	1268	0	125.7	125.7
Dash 8 (5 %)	1140.2	2427	0	211.7	211.7
Saab 2000 (5 %)	826	1040	35.6	146.7	146.7

Heavy metal emission factors for diesel and gasoline engines, also from residual fuel oil and distillate oil fuel (gas-oil) used in navigation was taken from [5] reference (Table 2-28).

Table 2-28. Heavy metal emission factors, [g/t].

Pollutant	Emission factors			
	Diesel	Gasoline	Distillate oil fuel (gas-oil)	Residual oil
As	0	0	0.05	0.5
Cd	0.01	0.01	0.01	0.03
Cr	0.05	0.05	0.04	0.2
Cu	1.7	1.7	0.05	0.5
Hg	0	0	0.05	0.02
Ni	0.07	0.07	0.07	30
Pb	0	0	0.1	0.2
Se	0.01	0.01	0.2	0.4
Zn	1	1	0.5	0.9

POP's emission factors were taken from [5] reference, in which emission factors from diesel and four-stroke petrol engines are proposed (Table 2-29). These emission factors are used for all off-road transport consuming diesel or gasoline.

Table 2-29. POP's emission factors for diesel and four-stroke gasoline engines, [μg/kg].

Substance	Diesel engines	Four-stroke gasoline engines
Benzo(b)fluoranthene	50	40
Benzo(a)pyrene	30	40

2.3. Fugitive emissions from fuels

Fugitive NMVOC emission from crude oil extraction and gasoline distribution were estimated (NFR sectors 1B2). Emissions from oil storage and handling at petroleum refining plant were reported according to Stock Company "Mažeikių Nafta" submission. Fugitive NMVOC emission from crude oil distribution was estimated according to data on extracted statistical oil and emission factors derivated from [18] reference. Fugitive NMVOC emission from gasoline distribution was estimated according to statistical gasoline consumption (including distribution losses) and emission factors derivated from [18] reference. In reference [18] technical properties and compliance to Directive 94/63/EC of tanks in Lithuania were evaluated and NMVOC emissions in 2006 year were estimated. Derivated emission factors from [18] reference are listed in Table 2-30.

Table 2-30. Fugitive NMVOC emission factors.

	Fuel	Losses from storage [g/t fuel]	Losses from loading [g/t fuel]
Marine terminal "Butinge"	Crude oil	48.51	5279.35
Terminals	Gasoline	1.52	3964.31
	Diesel	19.36	21.31
Service stations	Gasoline	-	1857.49
	Diesel	-	96.95

3. INDUSTRIAL PROCESSES

The economic structure of Lithuania has gone through noticeable changes. During the period of 1992–1994, the share of industry in the GDP dropped from 35.5 % to 20.4 %, while the share of trade in the GDP structure grew from 4.5 to 23.5 %. Since 1992, economic recession resulted in the reduction of energy consumption, but the latter was slower than the decline in GDP. Therefore, energy demand of the national economy during this period was growing in relative terms. It is evident that the production output varied between different industries. As the most serious decline was observed in the production of electronic equipment, machinery, metalworking, the likelihood of reaching the former levels of production is quite low for these sectors. Since 1991, Lithuania's export to the western countries has increased from 5.1 % to 54.6 % of total exports. It should be noted that the share of imports from these countries into Lithuania has also increased from 9.8 % to 67.1 % of the total imports. The main trading partners of Lithuania are Russia, Germany, Belarus, Latvia, Ukraine, the Netherlands, Poland, and Great Britain.

This chapter covers emissions from industrial processes (NFR sectors 2A, 2B, 2D). The food industry in Lithuania is dominated by meat production, diary and fish products. The fishing industry is concentrated in Klaipėda, and in 1993 this industry was the largest in the food sector. High prices of the primary food products have contributed to the decline of food industry.

Emissions from lime production, organic chemicals (i.e. polyethylene, polyvinylchloride, polypropylene, polystyrene) production and food and beverages (i.e. bear, wine, spirit, bread, cake, meat, fat, animal feed) production were estimated according to statistical production of commodities. Emissions from cement, sulphur from petroleum, sulphur acid, nitric acid, ammonia, ammonium nitrate, urea, phosphate fertilizer and formaldehyde production were reported according to submissions of large point sources.

Emissions from lime production, organic chemicals production and food and beverages production were estimated using emission factors proposed by [5] reference. Emission factors are listed in Tables 3-1, 3-2.

Table 3-1. TSP emission factor from industrial process, [g/Mg production].

Process	TSP emission factor
Lime production	2967

Table 3-2. NMVOC emission factors from organic chemicals and food production, [g/Mg production].

Process	NMVOC emission factor
Polyethylene production	5700
Polyvinylchloride production	1500
Polypropylene production	3000
Polystyrene production	2600
Wine production [g/m^3]	350
Bear production [g/m^3]	350
Spirit production [g/m^3]	150000
Animal feed production	1000

Bread production	4500
Cake production	1000
Fat (margarine) production	10000
Meat, fish, poultry production	300
Sugar production	10000

4. AGRICULTURE

This chapter covers emissions from manure management, direct soil emissions and application of mineral fertilizer (NFR sectors 4B, 4D1 and 4D1i). Emissions from manure management were estimated according to statistical livestock and poultry number. Direct emissions from soil were estimated according to statistical data on N-fertilizers produced and sold in Lithuania. Number of livestock and poultry, also mass of N-fertilizers used are reported in Excel template Table IV 2E.

Agriculture has always been a very important sector of Lithuania's economy, and like other economic sectors, it has undergone sudden changes and reforms since the country achieved independence. These changes include land privatisation and the introduction of market-based prices, which influenced a significant drop in agricultural production in 1992 and 1993.

4.1. Manure management

Number of livestock and poultry was taken from Department of Statistics and reported in Table 4-1 [1]. NH3 emission factors for livestock and poultry manure management was taken from literature [5] and used in estimations (Table 4-2).

Table 4-1. Number of livestock and poultry, [heads].

Livestock/poultry	Heads
Dairy	394700
Non-Dairy	376000
Sheep	52463
Goats	14717
Horses	48980
Sows	57617
Broilers	5202290
Laying hens	3823123
Other poultry	202000

Table 4-2. Manure management NH_3 emission factors, [g/head].

Livestock/Poultry	NH_3 emission factor
Dairy cows	29700
Other cattle	14800
Sheep	1340
Goats	1340
Horses	8200
Fattening pigs	6630
Sows	16430
Broilers	280
Laying hens	370
Other poultry	920

4.2. Direct soil emission

Direct NH_3 emission from soil was estimated according to statistics of produced and sold amount of N-fertilizers in Lithuania. It is not likely that imported N-fertilizers are used in Lithuanian agriculture as N-fertilizers are produced in Lithuania and feeds Lithuanian marked and great part of them are exported to European countries. It is assumed, that mass of N-fertilizers sold is equal to mass of N-fertilizers used in agriculture. NH_3 emission factor is taken from [5] reference (emission factor for nitrogen solution was taken) and used in estimations. The result is reported in Table 4-3.

Table 4-3. Direct soil NH_3 emission.

	N-fertilizer used, [Mg N]	Emission factor, [g NH_3/Mg N]
Urea	-	150000
Urea & ammonium nitrate	19465	80000
Other N fertilizer	172972,04	20000

4.3. Application of Mineral Fertilizer

The emission factors for the simple methodology are provided in Table 4.4. These are based largely on the estimates of [12-14].

Table 4-4. Simpler methodology estimates of total NH3 emissions from cultures due to fertilizer volatilization, foliar emissions and decomposing vegetation (second column). The estimates are compared with other literature values. Values are kg NH3-N volatilized per kg of N in fertilizers applied.

Fertilizer type	Present simpler methodology to apply
Estimates from	fertilizer and plants
Ammonium sulphate	0.08
Ammonium nitrate	0.02
Calcium ammonium nitrate	0.02
Anhydrous ammonia	0.04
Urea	0.15
Nitrogen solution (mixed urea and ammonium nitrate)	0.08
Combined ammonium phosphates (generally diammonium phosphate)	0.05
Mono-ammonium phosphate	0.02
Di-ammonium phosphate	0.05
Other complex NK, NPK fert	0.02

To calculate NH3 emissions from fertilized cultures in a country, the use of each fertilizer type (expressed as mass of fertilizer-N used per year), is multiplied by the appropriate emission factor, and the emissions for the different fertilizer types summed.

5. SOLVENT AND OTHER PRODUCT USE

NMVOC emission from industrial and non-industrial paint application, metal degreasing, application of glues and adhesives, use of domestic solvent were estimated (NFR sector 3). Emission from solvent and other product use were estimated according to number of population and NMVOC emission factor in [g/inhabitant] units given in [5]. Derived and used in estimation NMVOC emission factors are listed in Table 5-1.

Table 5-1. Solvent and other product use NMLOJ emission factors, [g/inhabitant].

Activity	NMVOC emission factor
Industrial paint application	4500
Non industrial paint application	400
Metal degreasing	640
Application of glues and adhesives	600
Domestic solvent use	800

6. OTHER SOURCES AND SINKS

6.1 Biogenic emission

There are four major factors controlling natural BVOC emissions: landscape average (species-specific) emission potential ε (µg $g^{-1}h^{-1}$), foliar biomass density D (g (dry weight) m^{-2}), and environmental correction factor γ (nondimensional). Emission fluxes (µg m^{-2} h^{-1}) can then be modeled by:

$$F = \varepsilon D \gamma, \tag{1}$$

Environmental correction factor for isoprene and monoterpene

The environmental correction factor for isoprene emissions is [16]:

$$\gamma_{ISO} = C_T C_L\,, \tag{2}$$

here C_T is the temperature correction and C_L is the light correction.

The light correction has the form:

$$C_L = \frac{\alpha C_{L1} L}{\sqrt{1+\alpha^2 L^2}}\,, \tag{3}$$

here L is the photosynthetically active photon flux density (PPFD), µmol photons m^{-2} s^{-1}, α = 0.0027 and C_{L1} = 1.066 are empirical coefficients.

The temperature correction is:

$$C_T = \frac{\exp\left(\frac{C_{T1}(T - T_S)}{RT_S T}\right)}{C_{T3} + \exp\left(\frac{C_{T2}(T - T_M)}{RT_S T}\right)}, \qquad (4)$$

here T is the leaf temperature in K, T_S *is* the leaf temperature under standard conditions (303.15 K), R is the universal gas constant, C_{T1} = 95 000 J mol^{-1}, C_{T2} = 230 000 J mol^{-1}, C_{T3} = 0.961, and T_M = 314 K are empirical coefficients given by [17].

The environmental correction for monoterpene emissions is:

$$\gamma_{TERP} = \exp(\beta(T - T_S)), \qquad (5)$$

here β = 0.09 C^{-1} is an empirical coefficient.

This correction factor is also generally used for other VOCs (Oxygenated volatile organic compounds (OVOCs)), because experimental data on the OVOC emissions are still too scarce to facilitate the development of specific emission algorithms.

Table 6-1. Average values of integrated environmental correction factors, G-iso and G-mts for 6 and 12 month growing seasons (unit= hours).

Γ-mts = Γ-ovoc		Γ-iso	
6-month	12-month	6-month	12-month
675	813	516	613

Table 6-2. Land use emission factors and area [g/ha] [19].

Land cover category	Area, [ha]	NMVOC emission factors, [g/ha]
Urban	7488	898.69
Dry crop	2223305	2366.74
Irrigated crop	828061	3952.09
Crop grass	428134	3098.44
Crop wild land	522490	19594.06
Grassland	880	2495.47
Shrub land	224026	17875.26
Shrub grass	3591	36192.32
Deciduous forest	413773	53218.23
Coniferous forest	724834	84671.95
Mix forest	719636	52248.64

6.2 Forest and Other Vegetation Fires

Emissions are obtained in a two-step process:

(i) Estimate the emissions of carbon from the burned land.

(ii) Estimate the emissions of other trace gases using emission ratios with respect to carbon.

The basic calculation of the mass of carbon emitted, M(C), follows the methodology of [18]:

$$M(C) = 0.45 \times A \times B \times \alpha \times \beta, \qquad (1)$$

where 0.45 is the average fraction of carbon in fuel wood, "A" is the area burnt (m^2), "B" is the average total biomass of fuel material per unit area (kg/m^2), " α " is the fraction of the above average above-ground biomass relative to the total average biomass B, " β " is the burning efficiency (fraction burnt) of the above-ground biomass.

The "α" and "β" fractions assumed for this biome are derived from the Spanish CORINAIR 1990-93 inventories. Values of B, "α" and "β" are given for relevant biomes in Table 6.3.

Table 6-3. Values of B, "α" and "β".

	Biomass (kg/m^2)	Aboveground biomass fraction	Burning efficiency
	B	"α"	"β"
Boreal forest	25	0.75	0.2

Table 6-4. Fired forest area and emission factors (g/ha) for emissions [20].

Fired forest area, [ha]	**Pollutant**	**Emission factor, [g/ha]**
112.4	CO	3881000
	NH3	30000
	NMLOJ	354000
	NOX	135000
	SO2	30000

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SECTION II

CRITICAL LOADS OF OXIDIZED SULPHUR, OXIDIZED AND NUTRIENT NITROGEN

1. INTRODUCTION

This report presents recent results of the calculations of critical loads and exceedances of nitrogen and sulphur compounds in Lithuania.

2. METHODS AND DATA SOURCES

The starting point for calculating critical loads of nutrient N by the SMB (Simple Mass Balance) model is the mass balance of total nitrogen for the soil compartment under consideration (inputs=sinks+outputs):

$$N_{dep} + N_{fix} = N_{AD} + N_i + N_u + N_{de} + N_{eros} + N_{fire} + N_{vol} + N_{le}; \quad (1)$$

where N_{dep} is the total N deposition, N_{fix} is the N "input" by biological fixation, N_{ad} is N adsorption, N_i is the long-term net immobilization of N in soil organic matter, N_u is the net removal of N harvested vegetation and animals, N_{de} is flux of N to the atmosphere due to denitrification, N_{eros} are N losses through erosion, N_{fire} are N losses in smoke due to (wild or controlled) fires to the atmosphere, N_{vol} are N losses to the atmosphere via NH_3 volatilization, and N_{le} is leaching of N below the root zone.

The following assumptions lead to a simplification of Eq. (1): nitrogen adsorption, e. g., the adsorption of NH_4 by clay minerals, can temporarily lead to an accumulation of N in the soil, however it is stored/released only when the deposition changes, and can thus be neglected in steady-state considerations; nitrogen fixation is negligible in most (forest) ecosystems, except for N-fixing species; the loss of N due to fires, erosion, and volatilization is small for most ecosystems in Europe, and therefore neglected. Alternatively, one could replace N_i by $N_i + N_{eros} + N_{fire} + N_{vol} - N_{fix}$ in the subsequent equations. The leaching of ammonium (NH_4) can be neglected in all forest ecosystems due to (preferential) uptake and complete nitrification within the root zone (i.e., $NH_{4,le} = 0$, $N_{le} = NO_{3,le}$). Under these simplifying assumptions Eg. (1) becomes:

$$N_{dep} = N_i + N_u + N_{de} + N_{le}. \quad (2)$$

From this equation a critical load is obtained by defining an acceptable limit to the leaching of N, $N_{le(acc)}$, the choice of this limit depending on the 'sensitive element of the environment' to be protected. If an acceptable leaching is inserted into Eq. (2), the deposition of N becomes the critical load of nutrient nitrogen, $CL_{nut}(N)$:

$$CL_{nut}(N) = N_i + N_u + N_{de} + N_{le(acc)}. \quad (3)$$

In deriving the critical load of nutrient N as Eq. (3), it is assumed that the sources and sinks do not depend on the deposition of N. This is unlikely to be the case and thus all quantities should be taken 'at critical load'. However, to compute, e.g., 'denitrification at critical load' one needs to know the CL, the very quantity one wants to compute. The only clean way to avoid this circular reasoning is to establish a functional relationship between deposition and the sink of N, insert this function into Eq. (2) and solve for the deposition (to obtain the critical load). This has been done for denitrification: in the simplest case denitrification is linearly related to the net input of N (De Vries et al., 1993, 1994):

$$N_{de} = \begin{cases} f_{de} \cdot \left(N_{dep} - N_i - N_u\right) if \;\; N_{dep} > N_i + N_u \\ 0 \qquad\qquad\qquad\qquad\qquad else \end{cases}, \qquad (4)$$

where f_{de} $(0 \leq f_{de} < 1)$ is the so-called denitrification fraction, a site-specific quantity. This formulation implicitly assumes that imobilization and uptake are faster processes than denitrification. Inserting this expression for N_{de} into Eq. (2) and solving for the deposition leads to the following expression for the critical load of nutrient N:

$$CL_{nut}(N) = N_i + N_u + \frac{N_{le(acc)}}{1 - f_{de}}. \qquad (5)$$

The acceptable N leaching (in eq/ha/yr) is calculated as:

$$N_{le(acc)} = Q \cdot [N]_{acc} \qquad (6)$$

where $[N]_{acc}$ is the acceptable N concentration (eq/m^3) and Q is the precipitation surplus (in m^3/ha/yr). Values for acceptable N concentration are given in Table 1(De Vries et al., 2007).

Table 1. Critical (acceptable) N concentrations in soil solution for calculating $Cl_{nut}(N)$ (De Vries et al., 2007).

Impact	$[N]_{acc}$, mgN/L
Vegetation changes (data established in the Netherlands)[1]:	
Coniferous forest	2.5–4.0
Deciduous forest	3.5-6.5
Grass lands	3.0
Heath lands	3.0–6.0
Other impacts on forests:	
Nutrient imbalances	0.2–0.4
Elevated nitrogen leaching/N saturation	1.0
Fine root biomass/root length	1.0–3.0
Sensitivity to frost and fungal diseases	3.0–5.0

[1]Note that these values should be used with caution, e.g., in areas with high precipitation.

Dutch and Ineson (1990) reviewed data on rates of denitrification. Typical values of N_{de} for boreal and temperate ecosystems are in the range of 0.1–3.0 kgN/ha/yr (=7.1–214.3 eq/ha/yr), where the higher values apply to wet(ter) soils; rates for well drained soils are generally below 0.5 kgN/ha/yr.

The long-term annual N imobilization of nitrogen was set to 0.2–0.5 kgN/ha/yr (14.3–35710 eq/ha/yr). Considering that the imobilization of N is probably higher in warmer climates, values of up to 1 kgN/ha/yr (71.4 eq/ha/yr) could be used for N_i, without causing unsustainable accumulation of N in the soil.

Critical loads of *S*, *CL(S)*, and *N, CL(N)*, can be computed by defining a critical *ANC* leaching, ANC_{le}:

$$CL(S) + CL(N) = BC^*_{dep} - Cl^*_{dep} + BC_w - Bc_u + N_i + N_u + N_{de} - ANC_{le,crit}, \qquad (7)$$

where *BC* is the sum of base cations, where the subscripts *w* and *u* stand for weathering and net growth uptake, $ANC_{le,crit}$ is Acid Neutralizing Capacity.

Critical loads of sulphur and nitrogen, both contributing to acidification of ecosystems, and their exceedances were derived and mapped in a large scale exercise for forest soils (deciduous, coniferous and mixed forest), natural grassland, acidic fens, heathland and mesotrophic peat bogs in Lithuania. Each ecosystem has its specific sensitivity against the air pollutants, which is expressed by the critical load value. To identify this, the geographical information from CORINE land cover database has to be overlapped with spatial information on soil and climate. In combination with the General Soil Map of Lithuania and climate data conclusions on the vegetation structure of the land cover types can be drawn and the net biomass production can be derived.

The EMEP Eulerian acid deposition model output has been used as deposition of nitrogen and sulphur compounds in Lithuania.

Every year, emission data per sector from Lithuania to the LRTAP Convention were compiled at a national level and were reported through the EMEP program. The emission data were reported in the Nomenclature For Reporting (NFR) source categories. There are 120 NFR categories in the reporting templates, including both detailed categories to facilitate reporting under the Convention. The national inventory is based on national statistics and country specific, technology dependent emission factors according to the EMEP/CORINAIR Emission Inventory Guidebook. In addition, new routines and standards for validating emission data have recently been adopted (UNECE, 2005). The background data (activity data and emission factors) for estimation of the Lithuanian emission inventories are collected and stored in databases.

3. CRITICAL LOAD AND EXCEEDANCES MAPS

Annual critical loads and total (dry and wet) deposition velues of oxidized sulphur, oxidized and nutrient nitrogen were figured on 50×50 km^2 EMEP grid. Critical loads for Lithuania ecosystems were evaluated by using GIS model LandUse. During the evaluation of critical loads the ditributions over the teritory of Lithuania of coniferous, deciduous and mixed woods, annual average temperature, average annual precipitation and soil map were taken in to account.

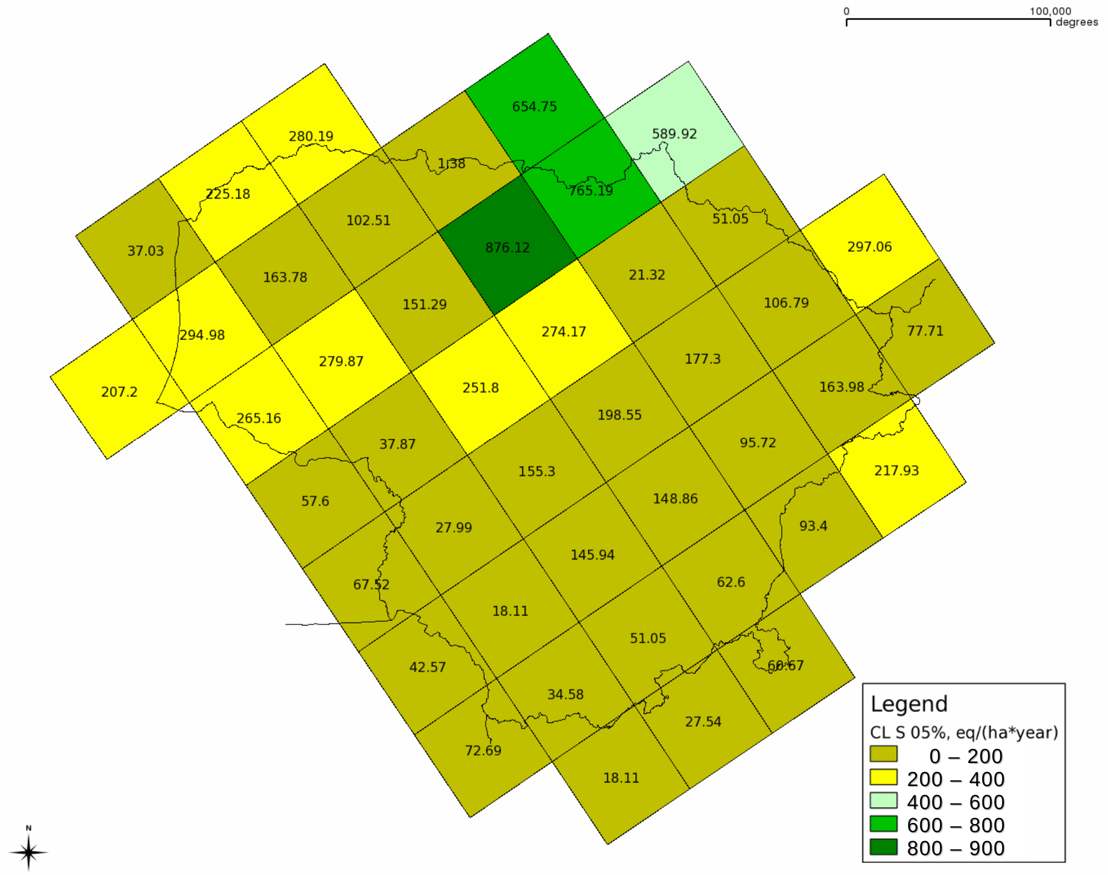

Fig. 3-1. Critical loads of oxidized sulphur (50×50 km^2), eq·ha^{-1}yr^{-1}.

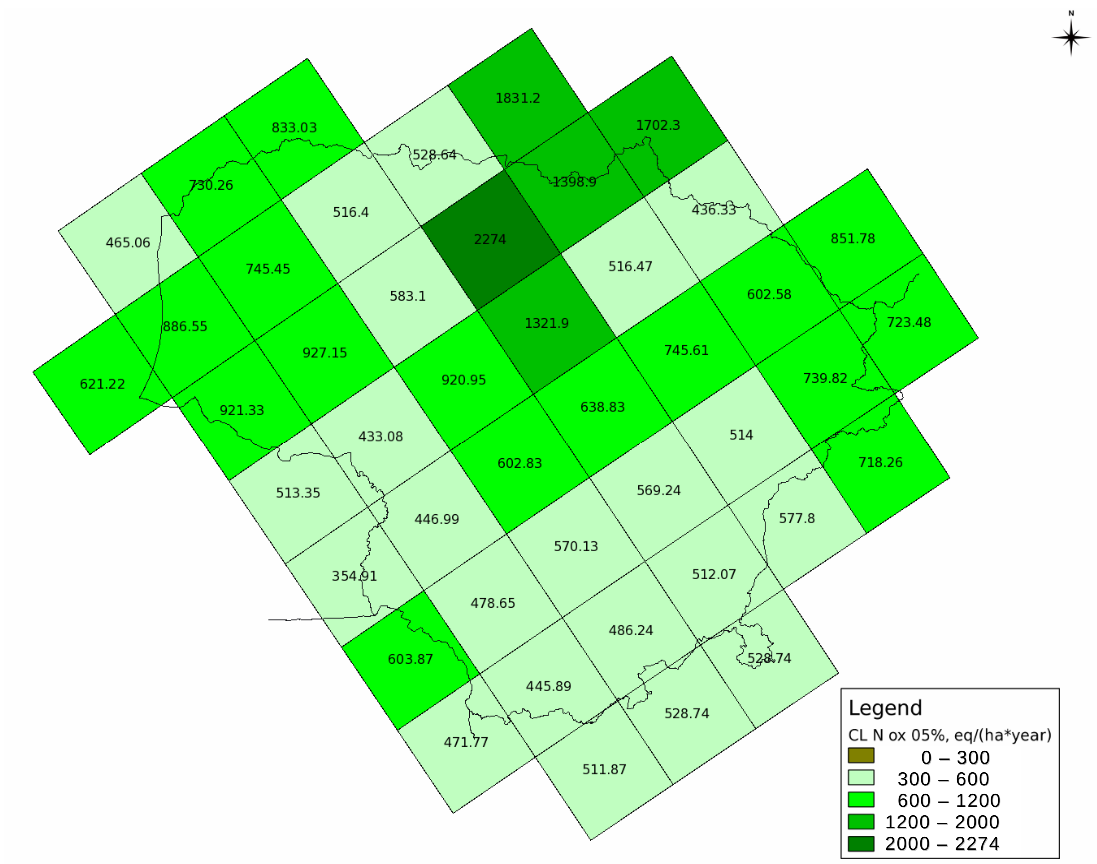

Fig. 3-2. Critical loads of oxidized nitrogen (50×50 km^2), eq·ha^{-1}yr^{-1}.

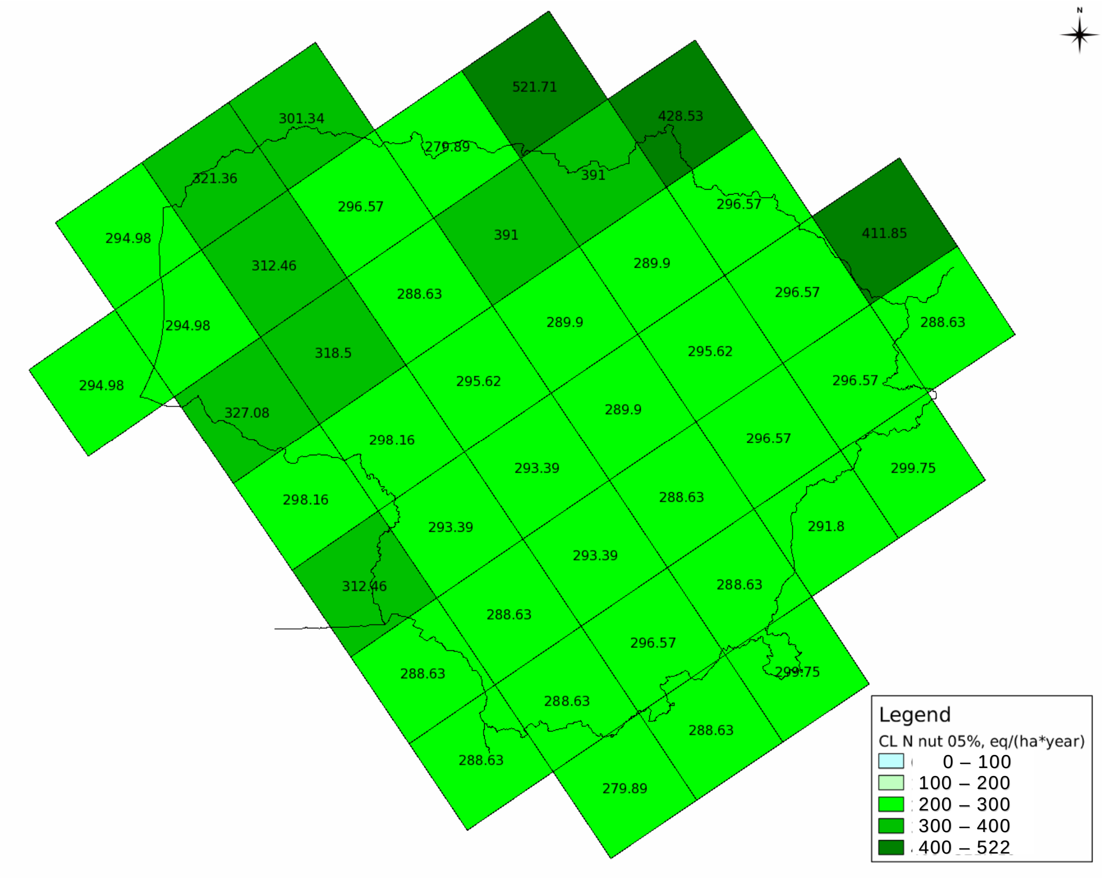

Fig. 3-3. Critical loads of nutrient nitrogen (50×50 km^2), eq·$ha^{-1}yr^{-1}$.

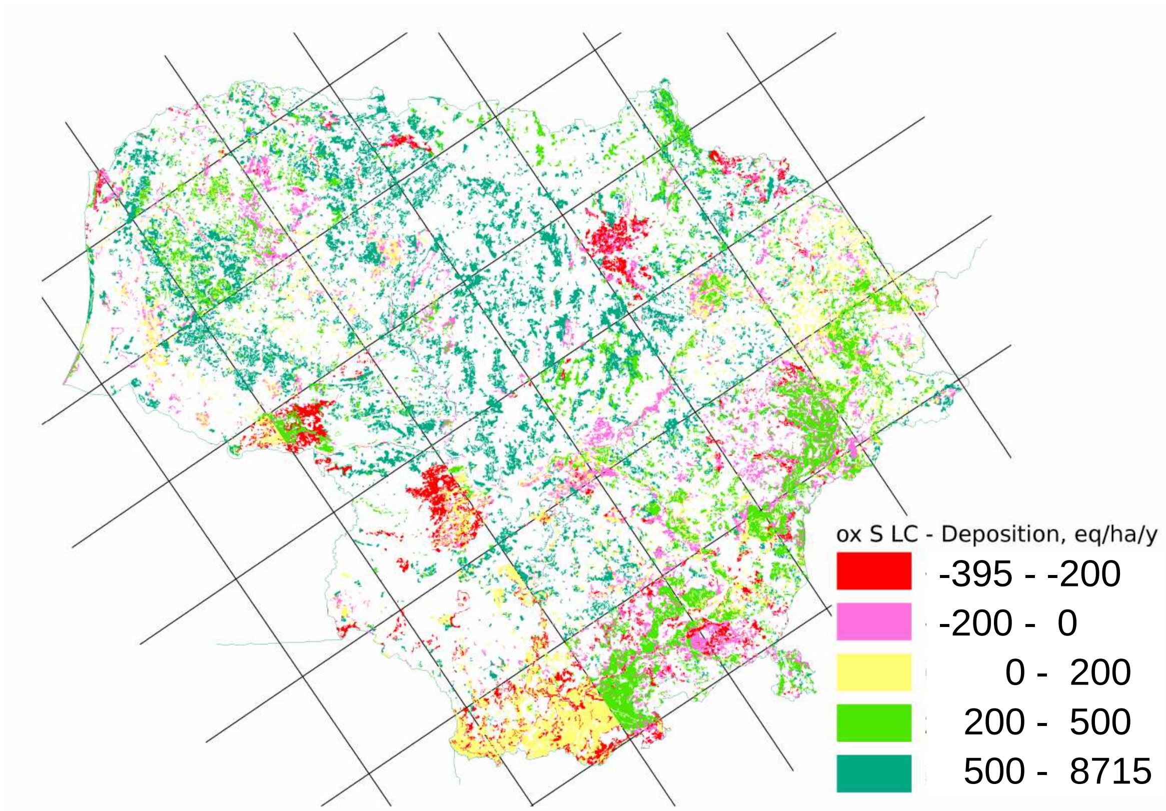

Fig. 3-4. Difference of critical loads and deposition of oxidized sulphur; negative values represent exceedances of critical load (50×50 km^2), eq·$ha^{-1}yr^{-1}$.

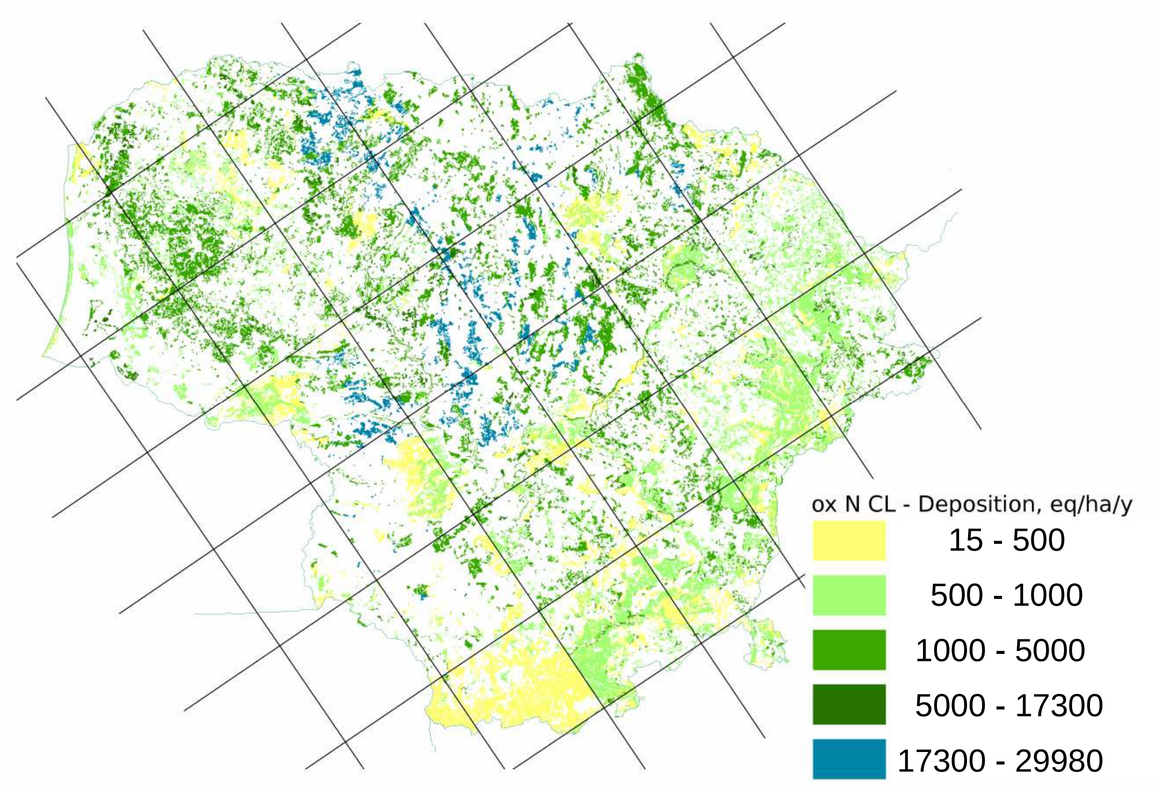

Fig. 3-5. Difference of critical loads and deposition of oxidized nitrogen; negative values represent exceedances of critical load (50×50 km^2), eq·ha^{-1}yr^{-1}.

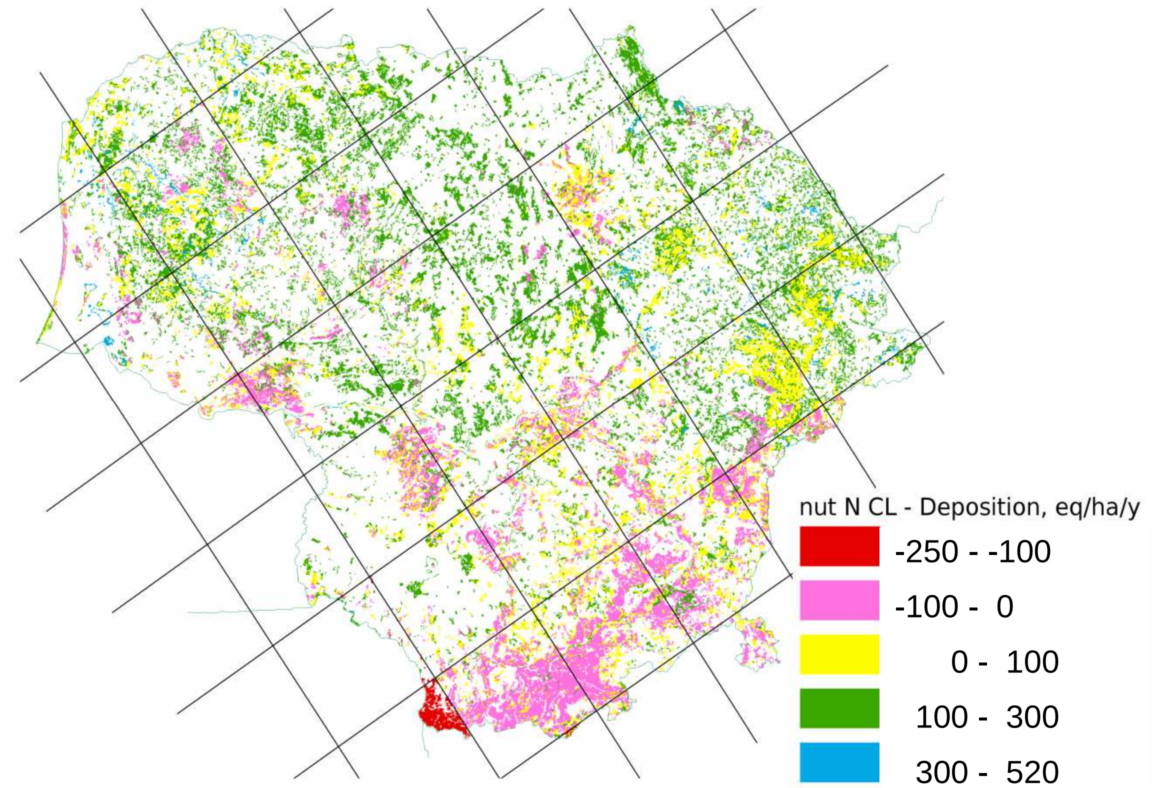

Fig. 3-6. Difference of critical loads and deposition of nutrient nitrogen; negative values represent exceedances of critical load (50×50 km^2), eq·ha^{-1}yr^{-1}.

Calculated critical loads values of oxidized sulphur, oxidized and nutrient nitrogen are shown in Figs. 1-3. Calculations of critical loads were made for 5th percentile, i.e. 95% of ecosystem can sustain such load. Oxidized sulphur critical load values of varied from 18 to 876 eq·ha^{-1}yr^{-1} (Fig. 1). The highest critical load values of oxidized sulphur were calculated for the northern and central parts of Lithuania, the lowest – for southern parts.

Critical load values of oxidized nitrogen varied from 354.9 to 22747.00 eq·ha^{-1}yr^{-1}(Fig. 2). The lowest critical load values of oxidized nitrogen were calculated for the southern part of Lithuania.

Critical load values of nutrient nitrogen varied from 279.89 to 521.71 eq·ha^{-1}yr^{-1}. Fig. 3 shows, that the highest critical load values of nutrient nitrogen were calculated for the northern and western parts of Lithuania, and the lowest – for southern parts.

The difference of critical loads and total depositions of oxidized sulphur, oxidized and nutrient nitrogen was calculated, whose negative values represent exceedances of critical load. Due to the time-dependence of atmospheric deposition of pollutants, exceedances are theoretically speaking only valid for a given moment in time (Hettelingh et al., 2009). Consequently the time, for which the exceedances have been calculated, has to be reported. We calculated the exceedances for the deposition data of year 2008, because the newer deposition data were not available. The calculated differences of critical loads and deposition of oxidized sulphur (-394.995 – 8714.808 eq·ha^{-1}yr^{-1}) are shown in the Fig. 4. As can be seen, critical loads of oxidized sulphur were mostly exceeding in the southern, southwestern and small northern parts of Lithuania.

The calculated differences of critical loads and deposition of oxidized nitrogen (14.904 – 29979.298 eq·ha^{-1}yr^{-1}) are shown in the Fig. 5. As can be seen, critical loads of oxidized nitrogen were not exceeded over all territory of Lithuania.

The calculated differences of critical loads and deposition of nutrient nitrogen (-248.474 – 519.299 eq·ha^{-1}yr^{-1}) are shown in the Fig. 6. As can be seen, the highest exceedances of critical loads of nutrient nitrogen were calculated for the southern part of Lithuania. The lowest exceedances of critical load of nutrient nitrogen were calculated for the northern parts of Lithuania.

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PART II

DISTRIBUTION OF THE CERTAIN POLLUTANT EMISSIONS FROM LITHUANIA IN 2010 ON 50×50 KM^2 EMEP GRID

Emission amounts of certain pollutants in each EMEP grid cell, entering or partly covering territory of Lithuania, are presented in the Figs. 1 – 18. In the grid cells, which cover country only partly, are present only emissions from Lithuania excluding contribution of foreign countries. Pollutant emission amount from each grid cell was calculated assuming that the pollutant flux to the atmosphere within the environmental region territory is surface regarding invariable quantity – independent from selected surface point and is equal to the region of displayed pollutant emission ratio with the region area. In the grid cells with more than one environmental area in the region the pollutant fluxes were calculated as weighted mean of these regions according to the region covered area in the cell.

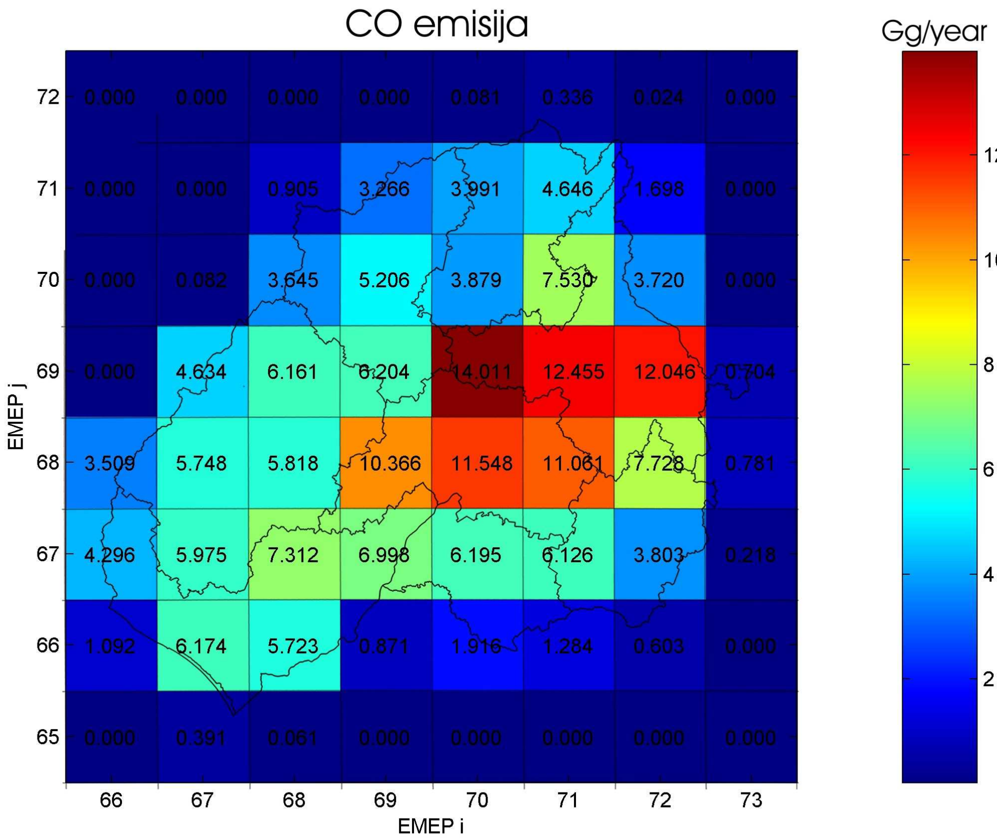

Fig. 1. Spatial distribution of carbon oxide (CO) emissions from Lithuanian surface and large point sources in 2010.

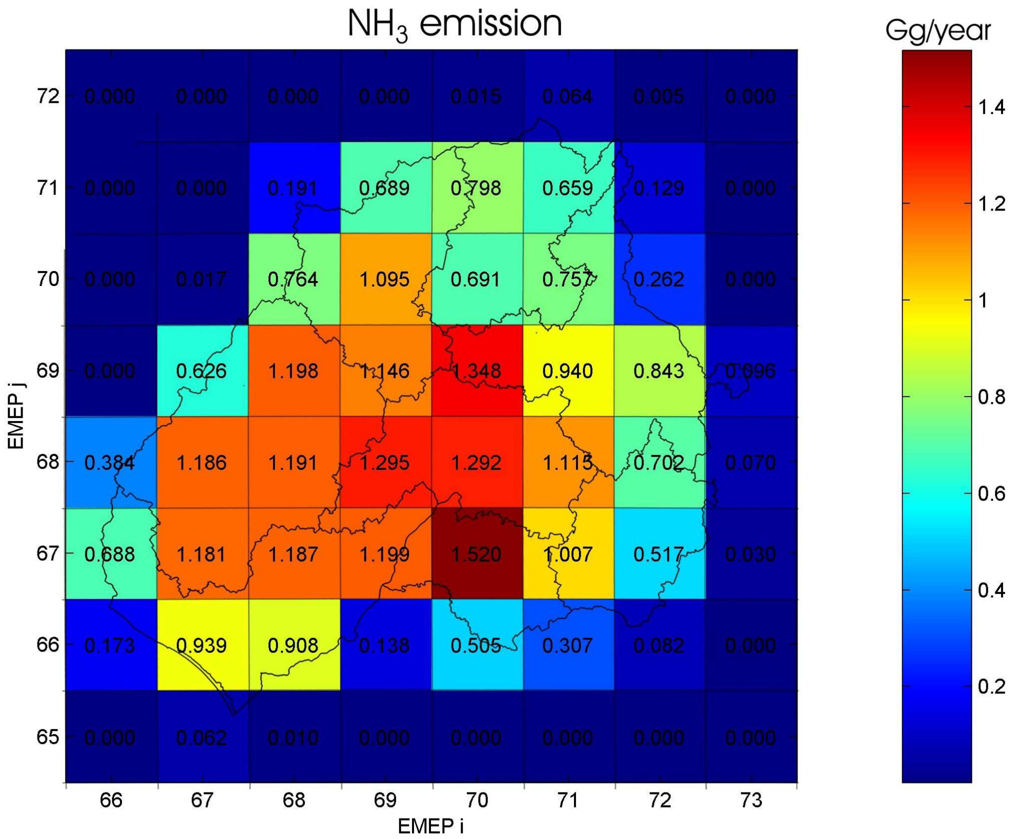

Fig. 2. Spatial distribution of ammonia (NH_3) emissions from Lithuanian surface and large point sources in 2010.

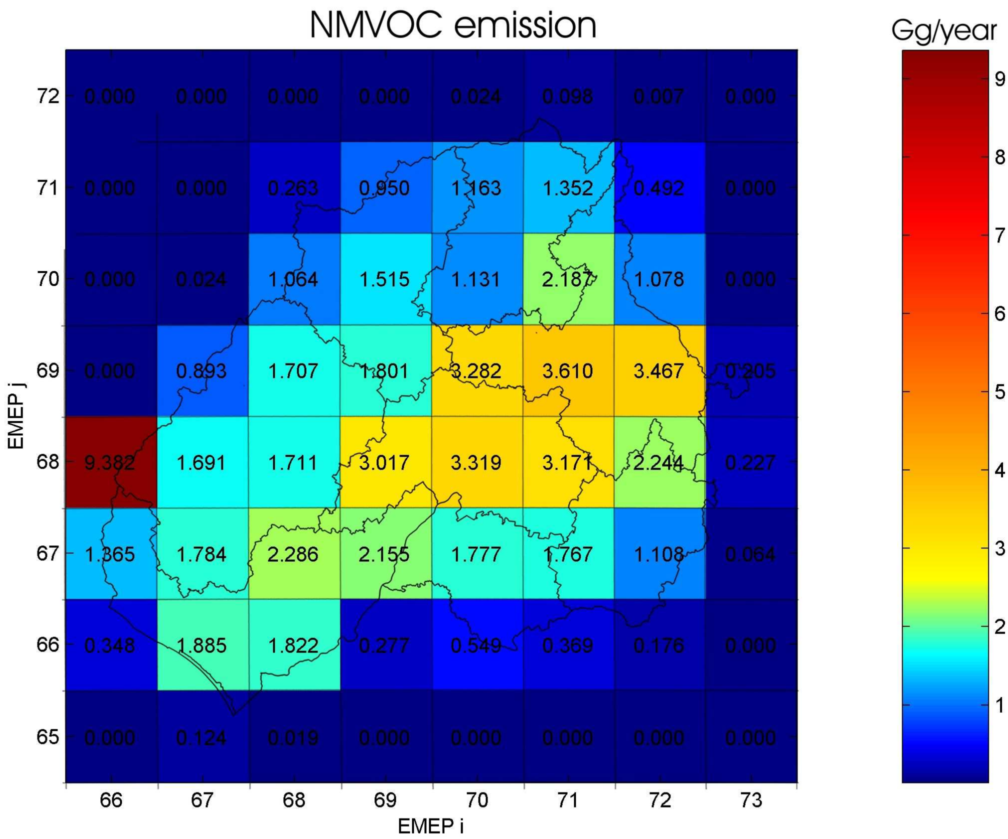

Fig. 3. Spatial distribution of non-methane volatile organic compounds (NMVOC) emissions from Lithuanian surface and large point sources in 2010.

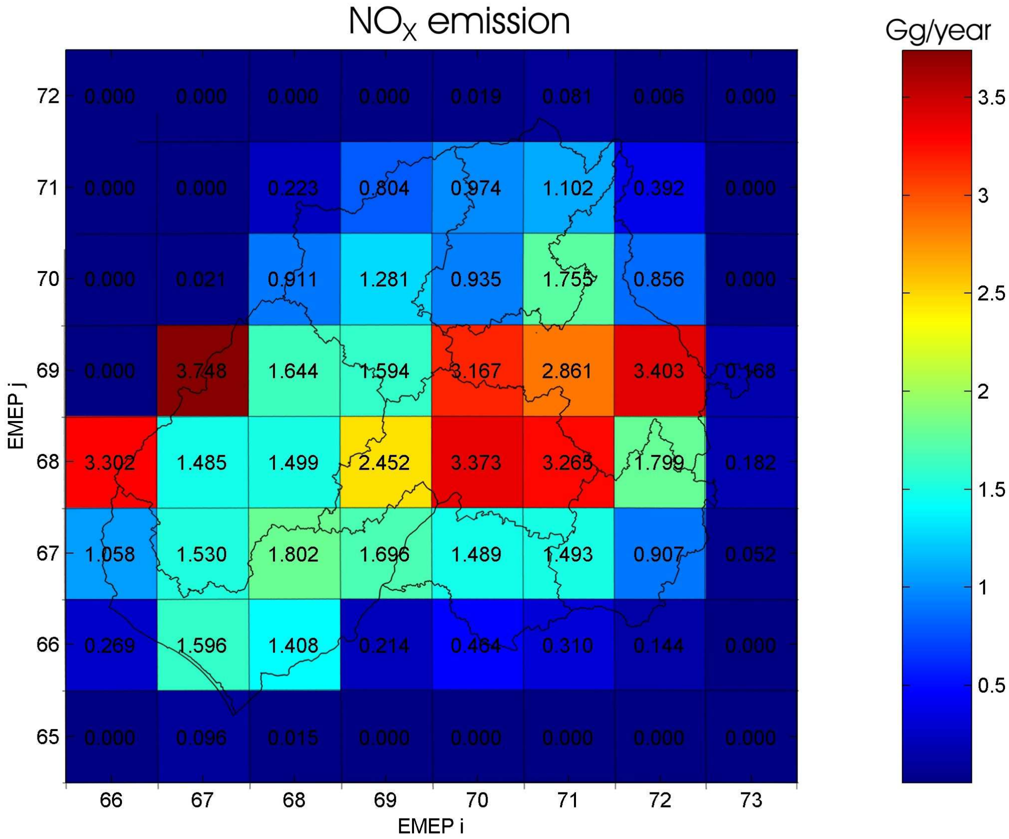

Fig. 4. Spatial distribution of nitrogen oxides (NO_x) emissions from Lithuanian surface and large point sources in 2010.

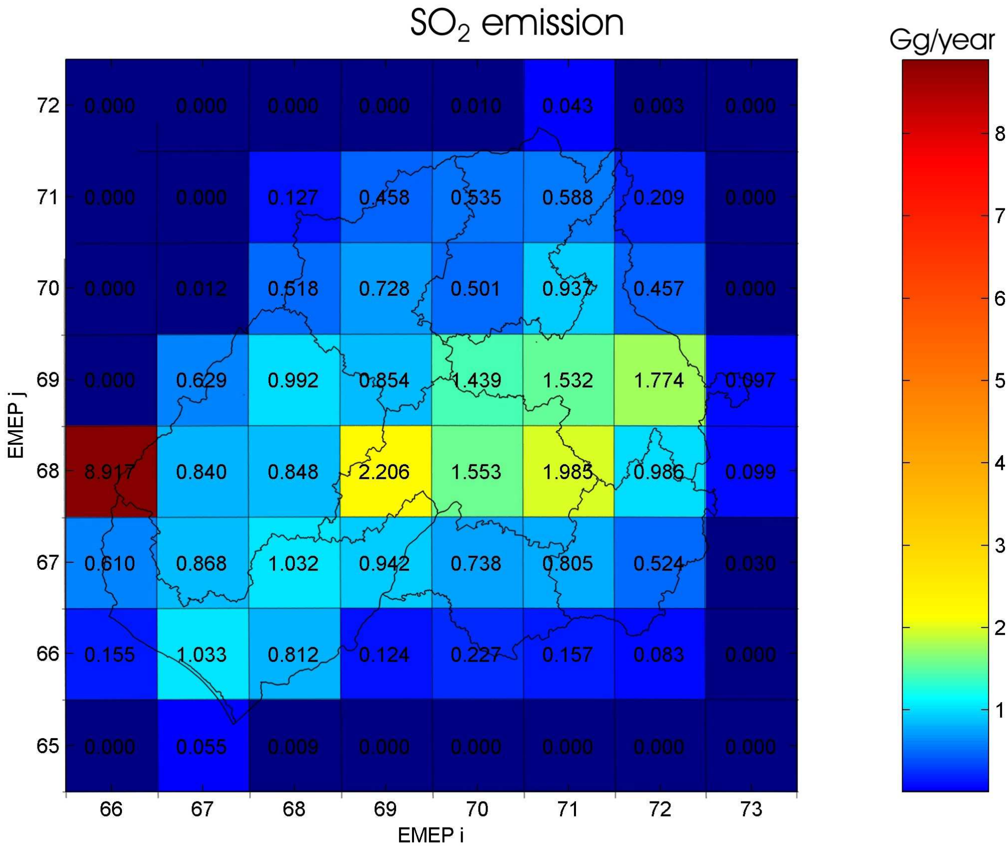

Fig. 5. Spatial distribution of sulphur dioxide (SO_2) emissions from Lithuanian surface and large point sources in 2010.

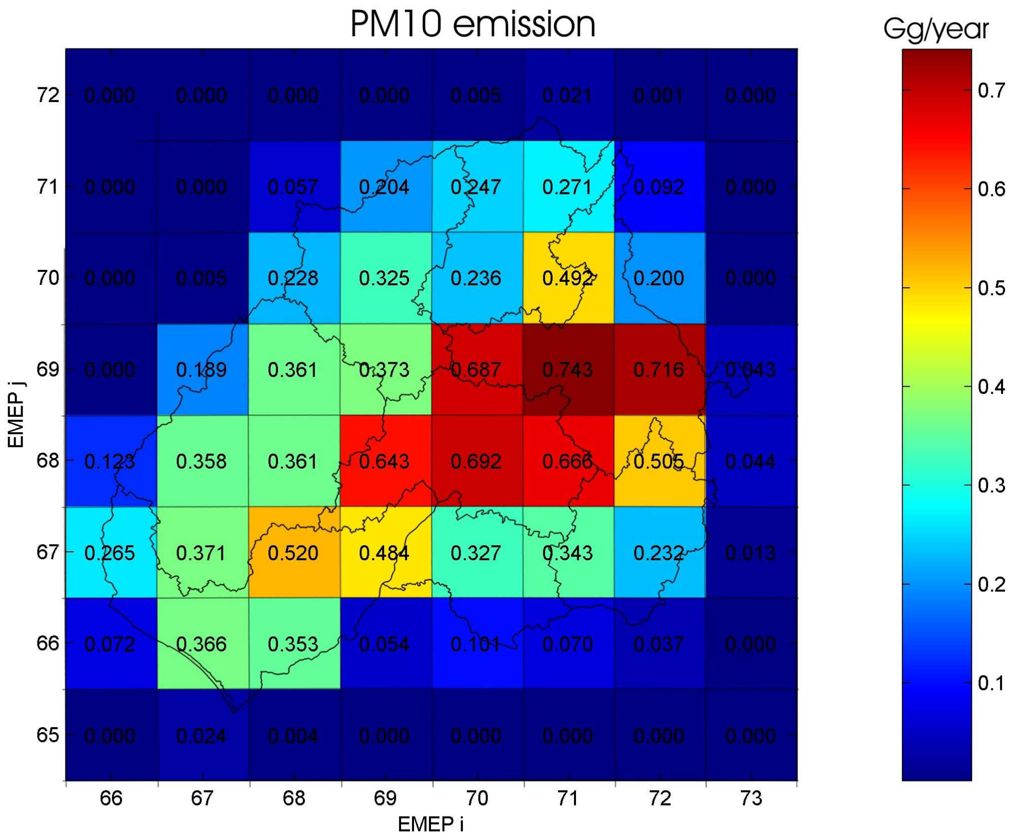

Fig. 6. Spatial distribution of PM10 emissions from Lithuanian surface and large point sources in 2010.

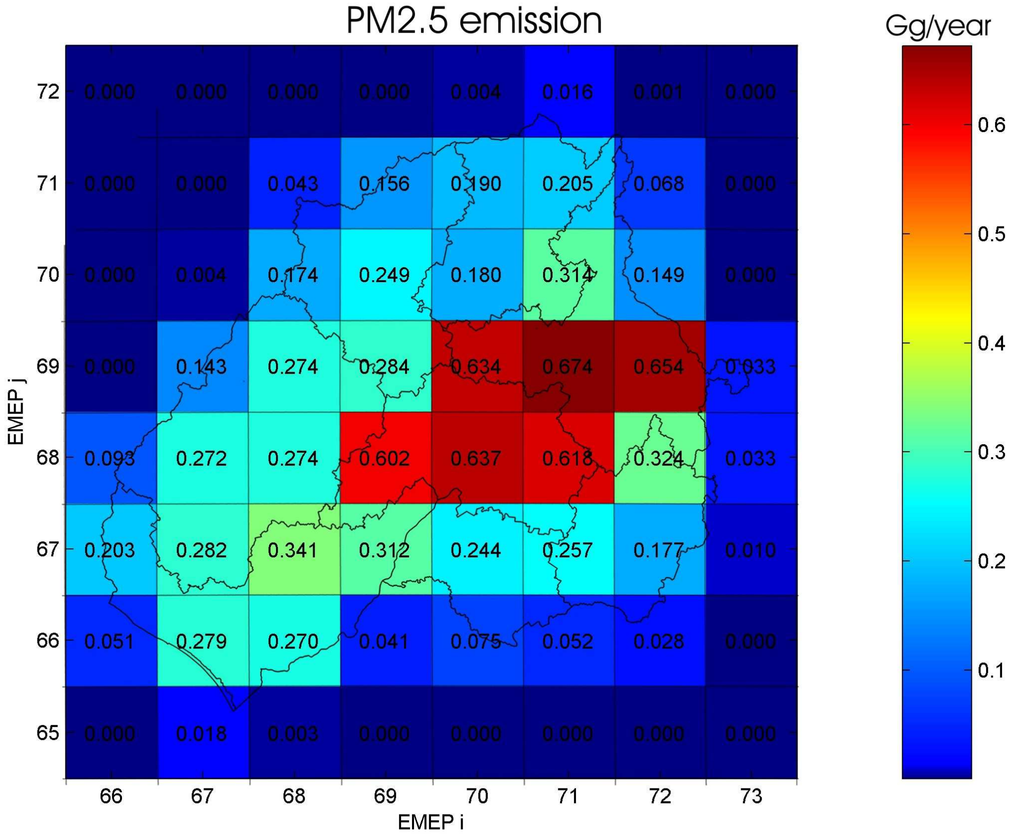

Fig. 7. Spatial distribution of PM2.5 emissions from Lithuanian surface and large point sources in 2010.

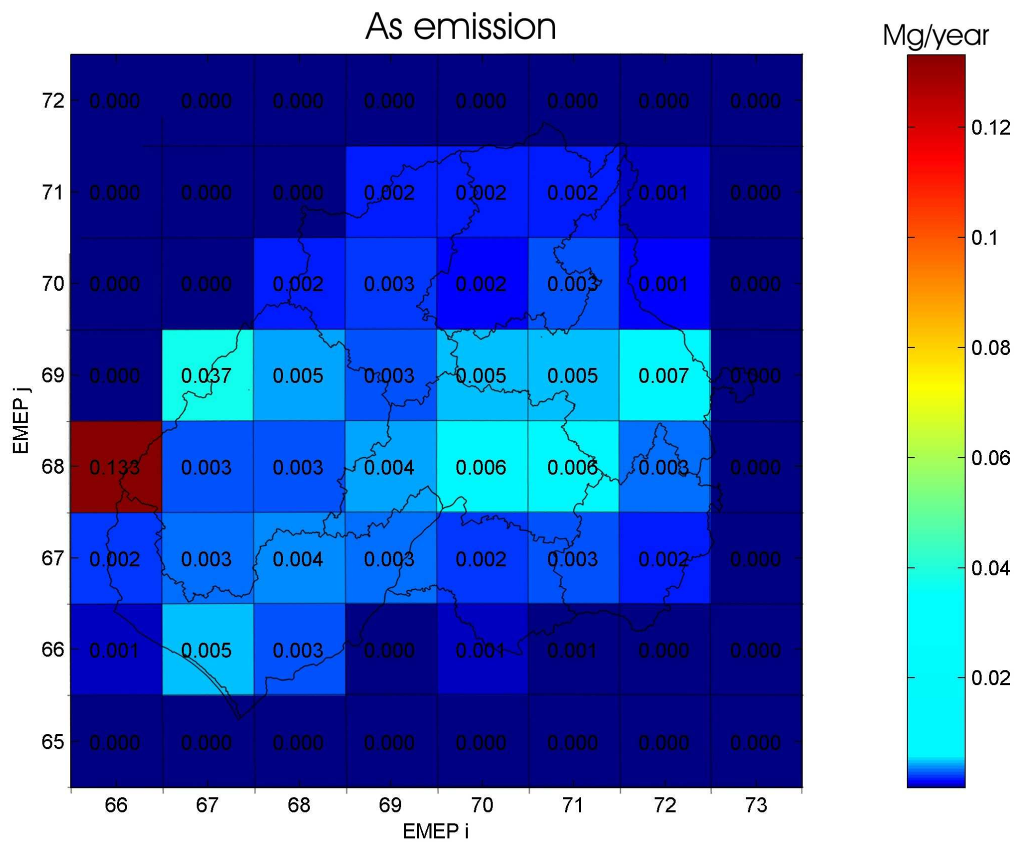

Fig. 8. Spatial distribution of arsenic (As) emissions from Lithuanian surface and large point sources in 2010.

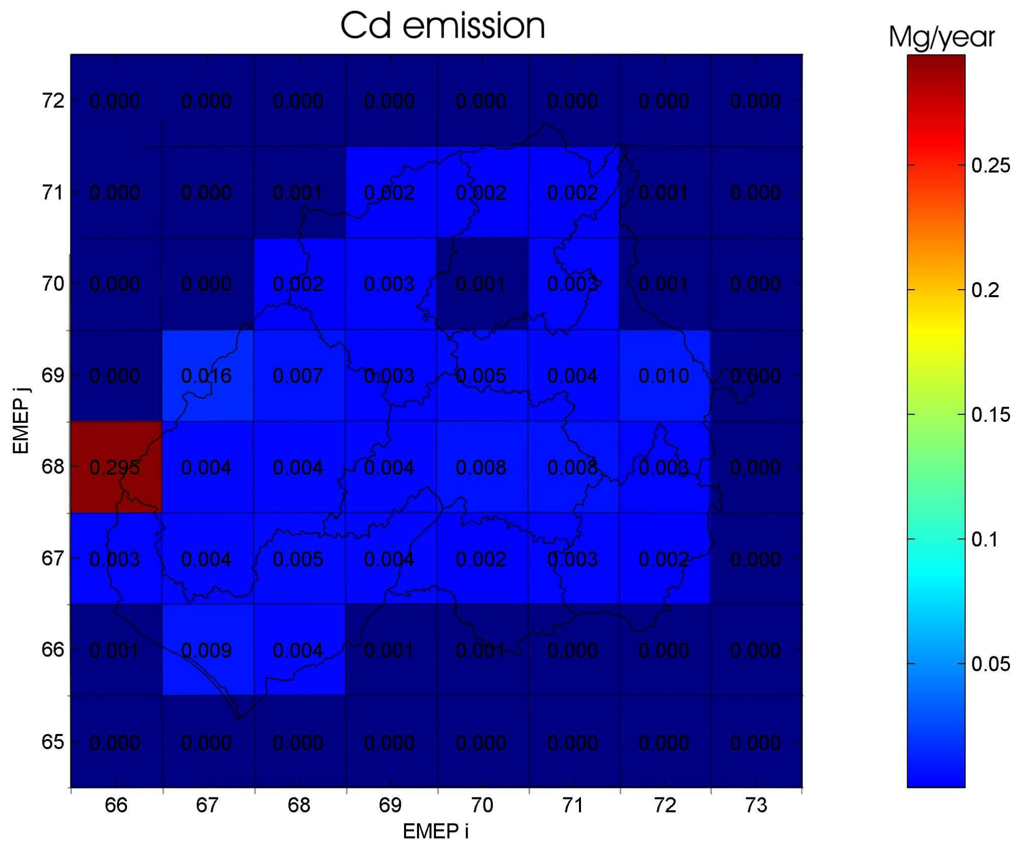

Fig. 9. Spatial distribution of cadmium (Cd) emissions from Lithuanian surface and large point sources in 2010.

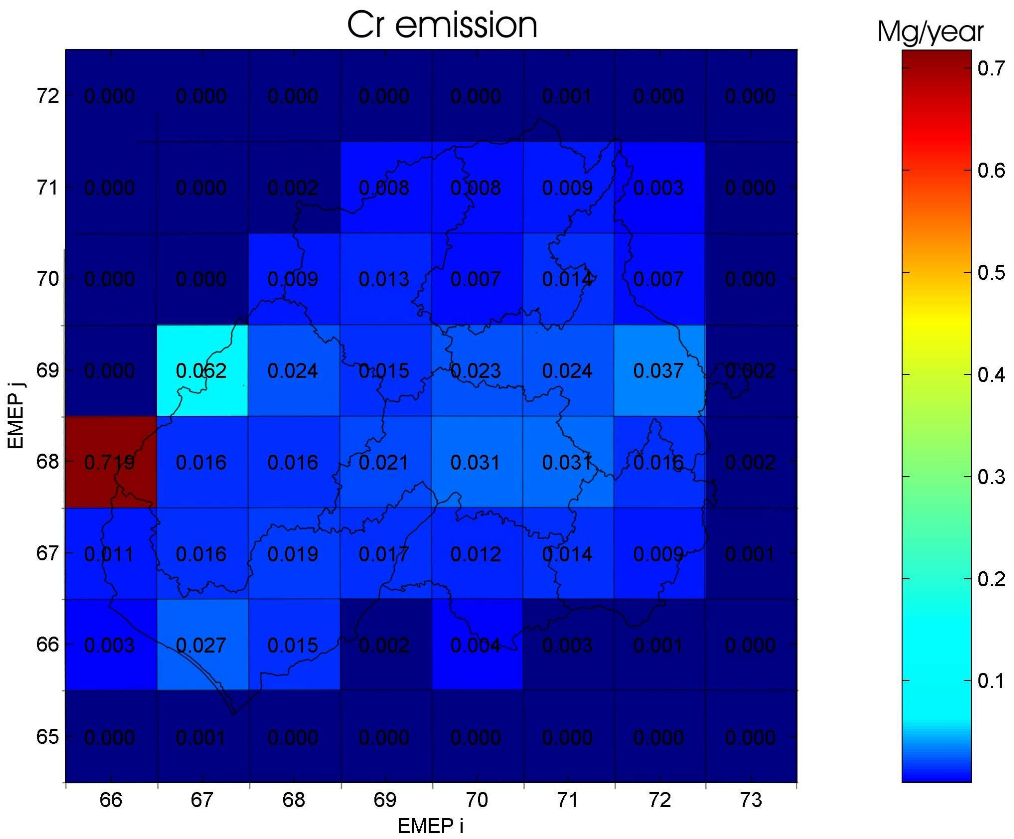

Fig. 10. Spatial distribution of chromium (Cr) emissions from Lithuanian surface and large point sources in 2010.

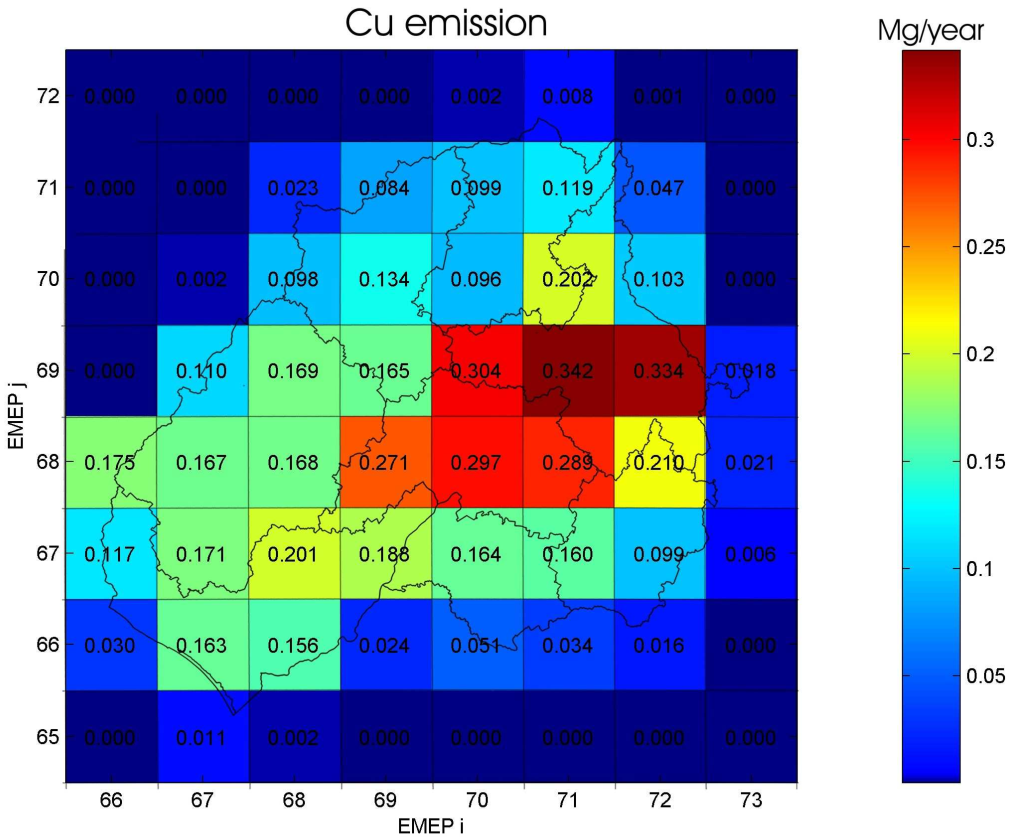

Fig. 11. Spatial distribution of copper (Cu) emissions from Lithuanian surface and large point sources in 2010.

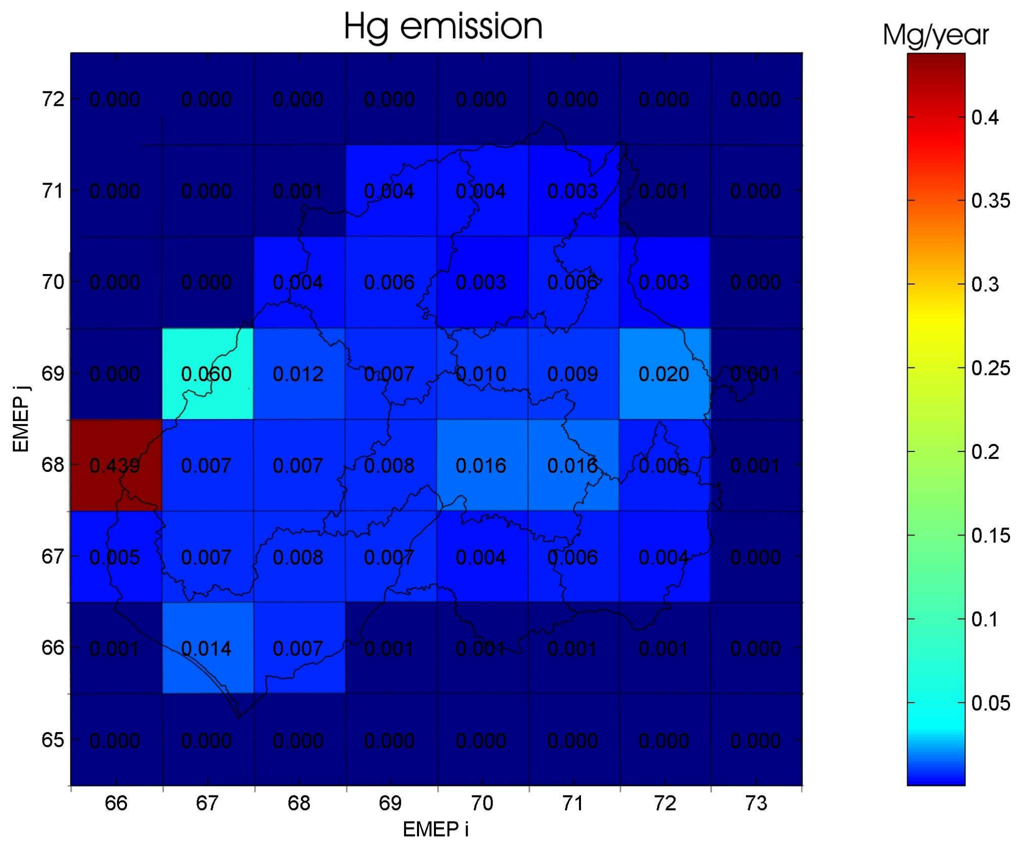

Fig. 12. Spatial distribution of mercury (Hg) emissions from Lithuanian surface and large point sources in 2010.

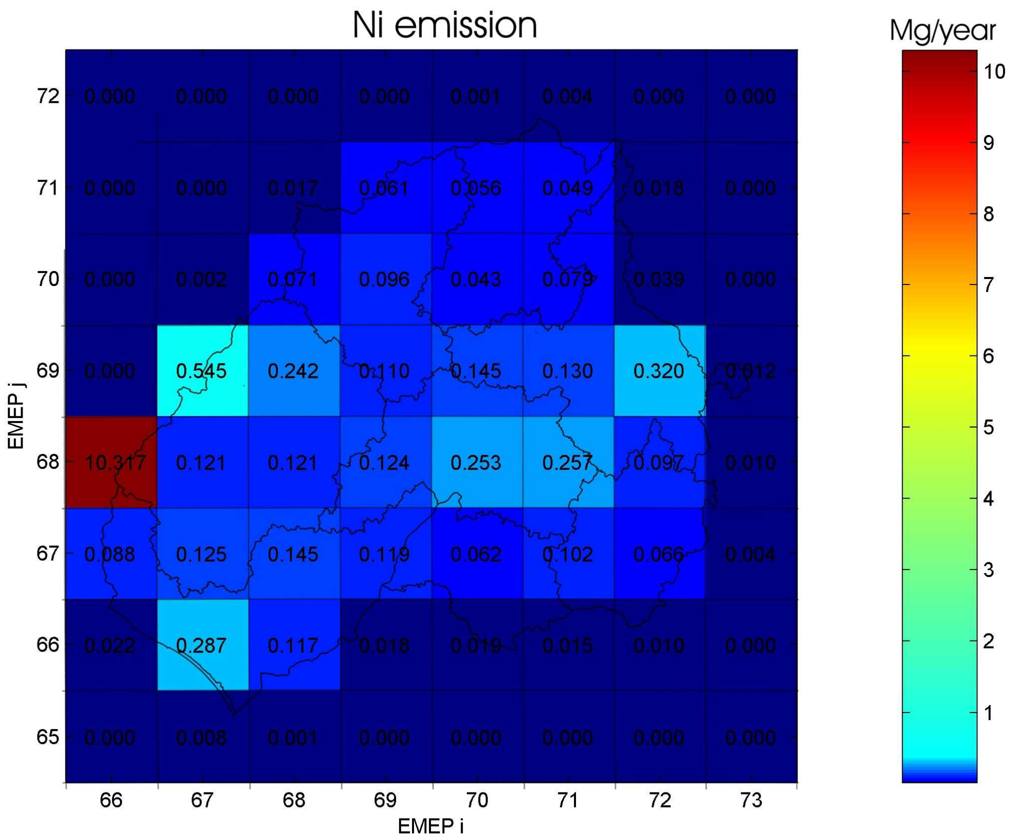

Fig. 13. Spatial distribution of nickel (Ni) emissions from Lithuanian surface and large point sources in 2010.

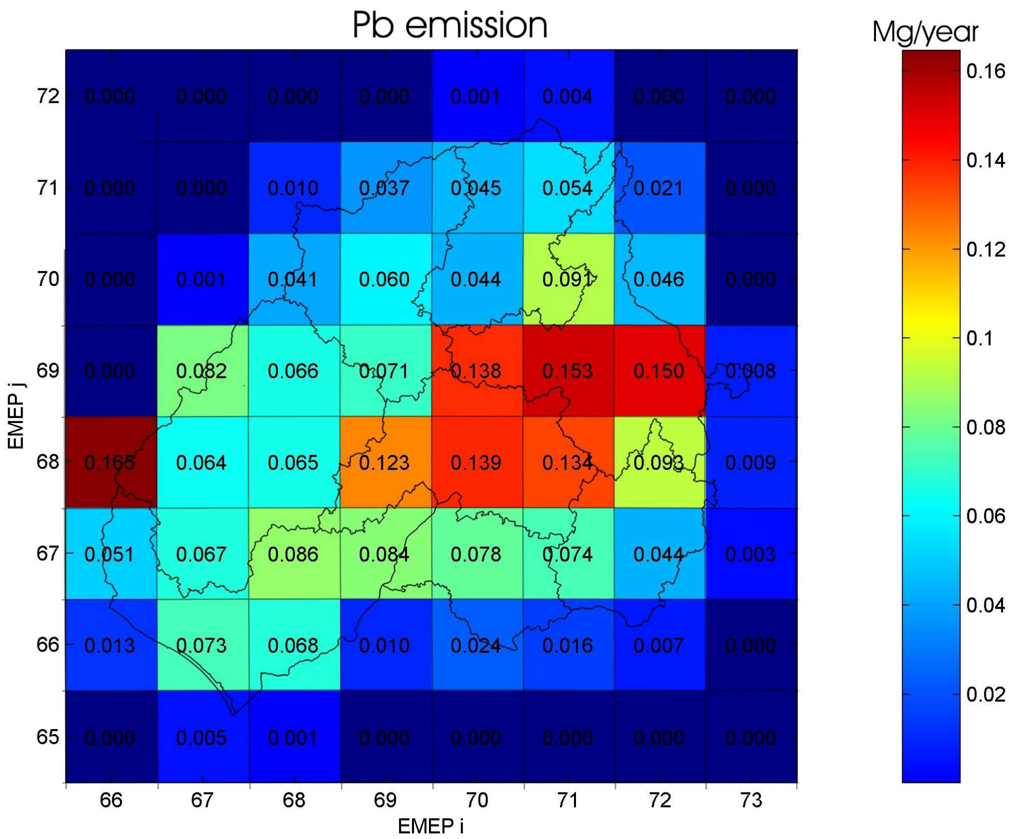

Fig. 14. Spatial distribution of lead (Pb) emissions from Lithuanian surface and large point sources in 2010.

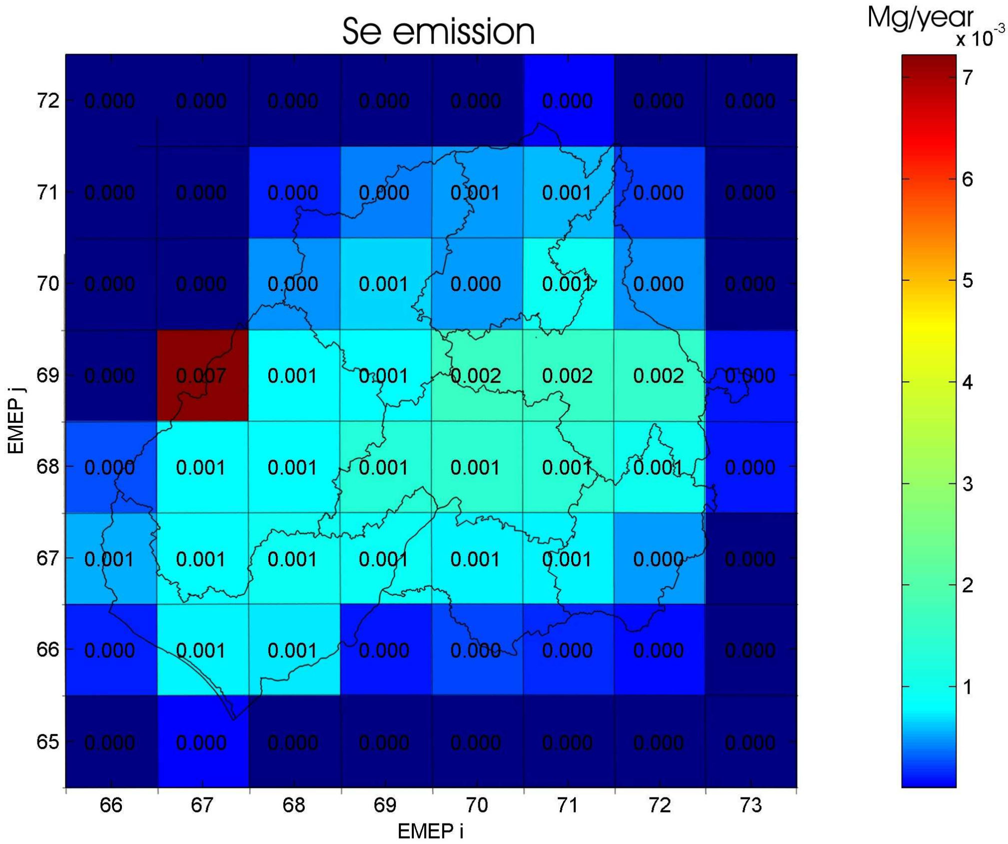

Fig. 15. Spatial distribution of nickel selenium (Se) emissions from Lithuanian surface and large point sources in 2010.

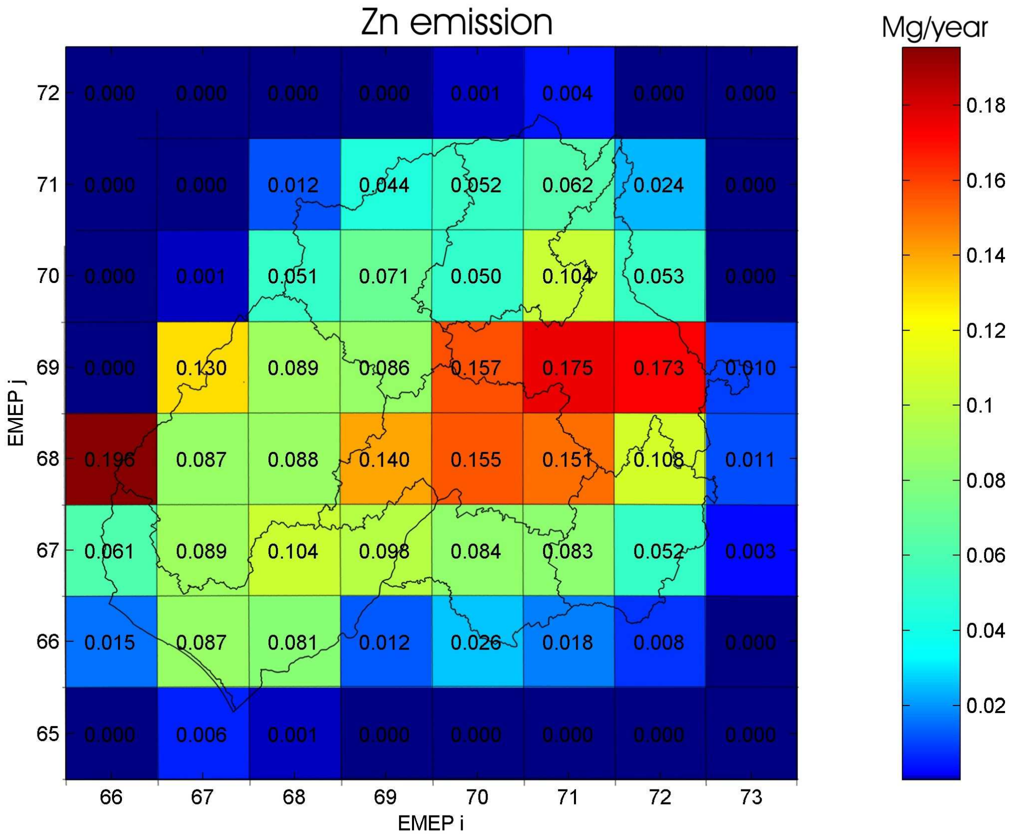

Fig. 16. Spatial distribution of zinc (Zn) emissions from Lithuanian surface and large point sources in 2010.

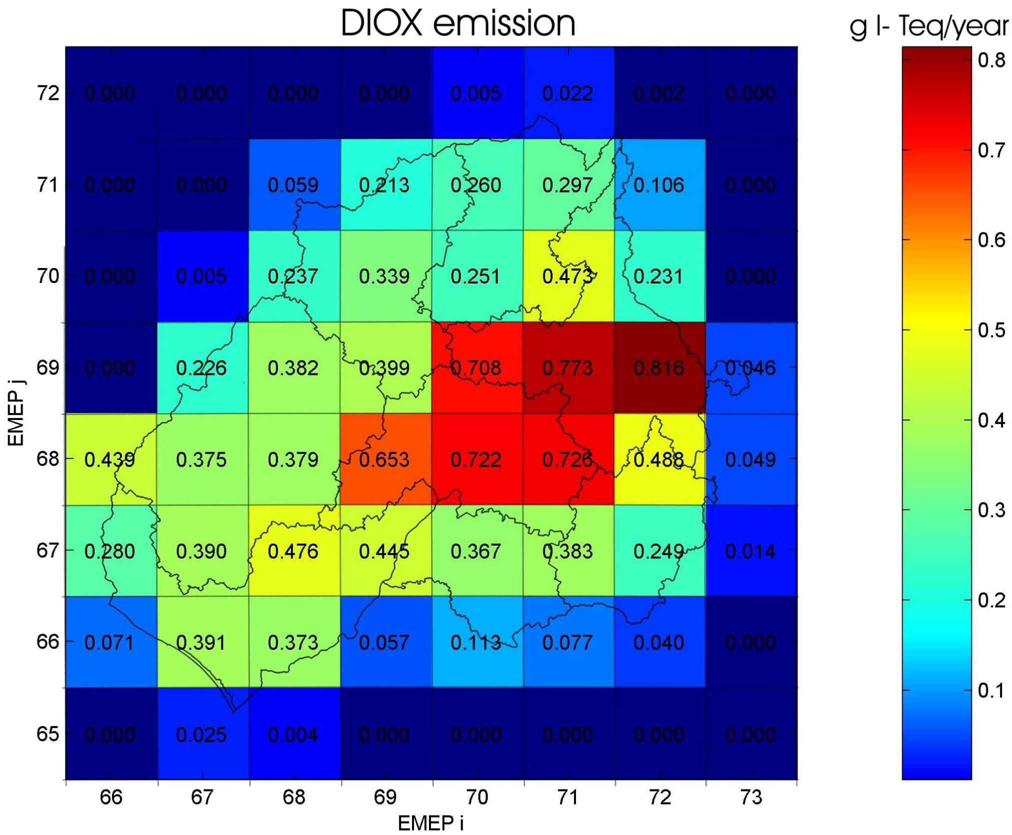

Fig. 17. Spatial distribution of dioxin and furan (DIOX) emissions from Lithuanian surface and large point sources in 2010.

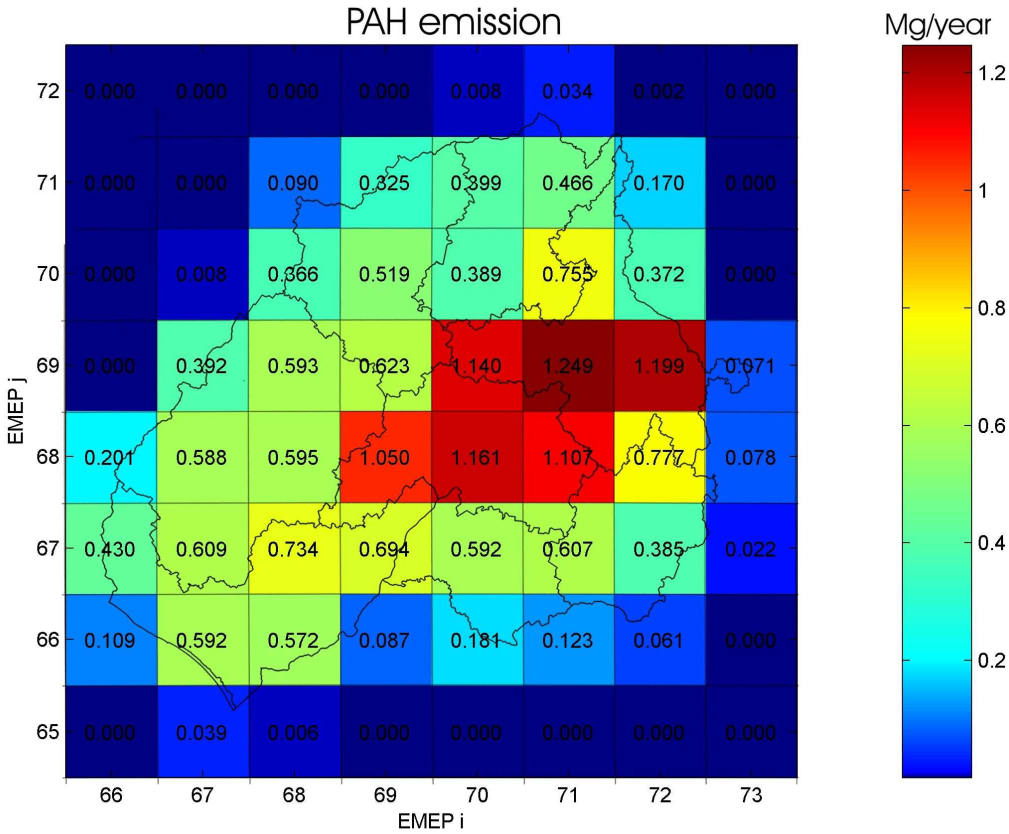

Fig. 18. Spatial distribution of polycyclic aromatic hydrocarbon (PAH) emissions from Lithuanian surface and large point sources in 2010.

ANNEX 1. National emission factors

No.	Fuel use category	**Fuel type: COAL** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMVOC	TSP
1.	Power plants	95	0.714xS%	0.36	0.097	0.015	0.002	0.015	0.04365xAs%
2.	Heat boiler houses	95	0.714xS%	0.36	0.097	0.015	0.003	0.015	0.04365xAs%
3.	Industry	95	0.714xS%	0.20	0.367	0.015	0.003	0.015	0.04365xAs%
4.	Small companies	95	0.714xS%	0.20	2.6	0.114	0.004	0.085	0.04365xAs%
5.	Households	95	0.714Xs%	0.15	4.8	0.300	0.040	0.114	0.04365xAs%
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	**Fuel type: FUEL WOOD** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMVOC	TSP
1.	Power plants	102	0.13	0.13	0.16	0.032	0.004	0.048	0.205
2.	Heat boiler houses	102	0.13	0.13	0.16	0.032	0.004	0.048	0.205
3.	Industry	102	0.13	0.13	0.16	0.032	0.004	0.048	0.205
4.	Small companies	102	0.13	0.10	2.5	0.196	0.003	0.230	0.205
5.	Households	102	0.13	0.05	5	0.400	0.003	0.600	0.205
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	Fuel type: NATURAL GAS Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMVOC	TSP
1.	Power plants	56.9	0.0003	0.160	0.020	0.0025	0.001	0.0025	0.0015
2.	Heat boiler houses	56.9	0.0003	0.160	0.025	0.0040	0.001	0.0040	0.0015
3.	Industry	56.9	0.0003	0.080	0.050	0.0040	0.001	0.0040	0.0015
4.	Small companies	56.9	0.0003	0.080	0.050	0.0050	0.001	0.0050	0.0015
5.	Households	56.9	0.0003	0.050	0.050	0.0050	0.001	0.0050	0.0015
6.	Transport								
6.1.	Road transport	56.9	0.0003	0.439	3.313	0.0192	0.001	0.5680	0.0020
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	Fuel type: ORIMULSION Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMVOC	TSP
1.	Power plants	81	1.93	0.24	0.13	0.003	0.0025	0.003	0.0919
2.	Heat boiler houses								
3.	Industry								
4.	Small companies								
5.	Households								
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	Fuel type: **GAS OIL** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMVOC	TSP
1.	Power plants	74	0.468xS%	0.150	0.130	0.0015	0.002	0.0015	0.0237
2.	Heat boiler houses	74	0.468xS%	0.150	0.150	0.0015	0.002	0.0015	0.0237
3.	Industry	74	0.468xS%	0.100	0.190	0.0015	0.002	0.0015	0.0237
4.	Small companies	74	0.468xS%	0.050	0.200	0.0015	0.002	0.0015	0.0237
5.	Households	74	0.468xS%	0.050	0.300	0.0015	0.002	0.0015	0.0237
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	Fuel type: **PETROL** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMVOC	TSP
1.	Power plants								
2.	Heat boiler houses								
3.	Industry								
4.	Small companies								
5.	Households								
6.	Transport		S = 0.05%						
6.1.	Road transport	73	0.022	0.666	7.4	0.0743	0.002	1.2562	0.0014
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	Fuel type: **KEROSENE** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMVOC	TSP
1.	Power plants								
2.	Heat boiler houses			0.1	0.1				
3.	Industry	74	0.022	0.100	0.100	0.0020	0.0015	0.002	0.011
4.	Small companies	74	0.022	0.050	0.190	0.0020	0.0015	0.002	0.011
5.	Households	74	0.022	0.050	0.190	0.0020	0.0015	0.002	0.011
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport	74	0.022	0.326	0.326	0.0010	0.0015	0.059	0.016
6.5.	Agricultural machines								

No.	Fuel use category	Fuel type: **OTHER PROCESSED FUEL** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMVOC	TSP
1.	Power plants	95	0.714xS%	0.36	0.097	0.015	0.002	0.015	0.04365xAs%
2.	Heat boiler houses	95	0.714xS%	0.36	0.097	0.015	0.003	0.015	0.04365xAs%
3.	Industry	95	0.714xS%	0.20	0.367	0.015	0.003	0.015	0.04365xAs%
4.	Small companies	95	0.714xS%	0.20	3.650	0.114	0.004	0.085	0.04365xAs%
5.	Households	95	0.714xS%	0.15	4.8	0.300	0.004	0.114	0.04365xAs%
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	Fuel type: **COMBUSTIBLE AUXILIARY ENERGY RESOURCES** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMVOC	TSP
1.	Power plants	78	0.468xS%	0.24	0.13	0.0035	0.0025	0.0035	0.25xAs%
2.	Heat boiler houses	78	0.468xS%	0.19	0.17	0.0035	0.0025	0.0035	0.25xAs%
3.	Industry	78	0.468xS%	0.15	0.20	0.0032	0.0025	0.0032	0.25xAs%
4.	Small companies	78	0.468xS%	0.15	0.20	0.0032	0.0025	0.0032	0.25xAs%
5.	Households	78	0.468xS%	0.15	0.30	0.0030	0.0025	0.0030	0.25xAs%
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	**Fuel type: CRUDE OIL** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMLOJ	TSP
1.	Power plants	78	0.488xS%	0.15	0.13	0.0015	0.002	0.0015	0.249xAs%
2.	Heat boiler houses	78	0.488xS%	0.15	0.15	0.0015	0.002	0.0015	0.249xAs%
3.	Industry	78	0.488xS%	0.1	0.19	0.0015	0.002	0.0015	0.249xAs%
4.	Small companies	78	0.488xS%	0.05	0.2	0.0015	0.002	0.0015	0.249xAs%
5.	Households	78	0.488xS%	0.05	0.3	0.0015	0.002	0.0015	0.249xAs%
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines	78	0.488xS%	1.171	0.468	0.0094	0.002	0.178	0.249xAs%

No.	Fuel use category	Fuel type: PEAT Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMLOJ	TSP
78	Power plants	102	0.3	0.3	0.032	0.032	0.004	0.048	0.164xAs%
2.	Heat boiler houses	102	0.3	0.3	0.032	0.032	0.004	0.048	0.164xAs%
3.	Industry	102	0.3	0.21	0.12	0.032	0.004	0.048	0.164xAs%
4.	Small companies	102	0.3	0.141	0.18	0.14	0.004	0.13	0.164xAs%
5.	Households	102	0.3	0.141	4.3	0.389	0.004	0.225	0.164xAs%
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	Fuel type: OTHER NATURAL FUEL Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMLOJ	TSP
78	Power plants	102	0.18	0.13	0.16	0.032	0.004	0.048	0.17xAs%
2.	Heat boiler houses	102	0.18	0.13	0.16	0.032	0.004	0.048	0.17xAs%
3.	Industry	102	0.18	0.13	0.16	0.032	0.004	0.048	0.17xAs%
4.	Small companies	102	0.18	0.1	2.5	0.196	0.003	0.23	0.17xAs%
5.	Households	102	0.18	0.05	5	0.4	0.003	0.6	0.17xAs%
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	Fuel type: **HEAVY FUEL OIL** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMLOJ	TSP
78	Power plants	78	0.488xS%	0.24	0.13	0.0035	0.0025	0.0035	0.249xAs%
2.	Heat boiler houses	78	0.488xS%	0.19	0.17	0.0035	0.0025	0.0035	0.249xAs%
3.	Industry	78	0.488xS%	0.15	0.2	0.0032	0.002	0.0032	0.249xAs%
4.	Small companies	78	0.488xS%	0.15	0.2	0.0032	0.0025	0.0032	0.249xAs%
5.	Households	78	0.488xS%	0.15	0.3	0.003	0.0025	0.003	0.249xAs%
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport	78	0.488xS%	1.46		0.002		0.0648	0.260xAs%
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	Fuel type: **DIESEL FUEL OIL** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMLOJ	TSP
			S=0.2 % S=0.05%						
78	Power plants	74	0.094/0.023	0.15	0.13	0.0015	0.002	0.0015	0.0237
2.	Heat boiler houses	74	0.094/0.023	0.15	0.15	0.0015	0.002	0.0015	0.0237
3.	Industry	74	0.094/0.023	0.1	0.15	0.0015	0.002	0.0015	0.0237
4.	Small companies	74	0.094/0.023	0.05	0.2	0.0015	0.002	0.0015	0.0237
5.	Households	74	0.094/0.023	0.05	0.3	0.0015	0.002	0.0015	0.0237
6.	Transport								
6.1.	Road transport	74	0.094/0.023	0.534	0.57	0.0033	0.004	0.113	0.1012
6.2.	Railway transport	74	0.094/0.023	1.1	0.47	0.005	0.003	0.225	0.1012
6.3.	Water transport	74	0.094/0.023	1.16	0.258	0.003	0.003	0.111	0.1012
6.4.	Air transport								
6.5.	Agricultural machines	74	0.094/0.023	1.171	0.468	0.0094	0.002	0.178	0.1012

No.	Fuel use category	**Fuel type: AVIATION GASOLINE** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMLOJ	TSP
78	Power plants								
2.	Heat boiler houses								
3.	Industry								
4.	Small companies								
5.	Households								
6.	Transport		S=0.01%						
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport	72	0.005	0.196	1.268	0.0869	0.002	0.8182	0.0116
6.5.	Agricultural machines								

No.	Fuel use category	**Fuel type: LIQUEFIED PETROLEUM GAS** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMLOJ	TSP
78	Power plants								
2.	Heat boiler houses	65		0.16	0.01	0.0025	0.0015	0.0025	
3.	Industry	65		0.16	0.01	0.0025	0.0015	0.0025	
4.	Small companies	65		0.1	0.041	0.0025	0.0015	0.0025	
5.	Households	65		0.1	0.05	0.001	0.001	0.0021	
6.	Transport								
6.1.	Road transport	65		0.898	1.61	0.0192	0.002	0.3585	
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	**Fuel type: OTHER PRODUCTS OF REFINERY** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMLOJ	TSP
78	Power plants	74	0.468xS%	0.15	0.13	0.0015	0.002	0.0015	0.024
2.	Heat boiler houses	74	0.468xS%	0.15	0.15	0.0015	0.002	0.0015	0.024
3.	Industry	74	0.468xS%	0.1	0.19	0.0015	0.002	0.0015	0.024
4.	Small companies	74	0.468xS%	0.05	0.2	0.0015	0.002	0.0015	0.024
5.	Households	74	0.468xS%	0.05	0.3	0.0015	0.002	0.0015	0.024
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

No.	Fuel use category	**Fuel type: SHALE OIL** Emission factor, kg/GJ							
		CO_2	SO_2	NO_x	CO	CH_4	N_2O	NMLOJ	TSP
78	Power plants	74	0.37	0.15	0.13	0.0015	0.002	0.0015	0.024
2.	Heat boiler houses	74	0.37	0.15	0.15	0.0015	0.002	0.0015	0.024
3.	Industry	74	0.37	0.1	0.19	0.0015	0.002	0.0015	0.024
4.	Small companies	74	0.37	0.05	0.2	0.0015	0.002	0.0015	0.024
5.	Households	74	0.37	0.05	0.3	0.0015	0.002	0.0015	0.024
6.	Transport								
6.1.	Road transport								
6.2.	Railway transport								
6.3.	Water transport								
6.4.	Air transport								
6.5.	Agricultural machines								

Here: S% - sulphur content of fuel %
As% - ash content of fuel %