CENTER FOR PHYSICAL SCIENCES AND TECHNOLOGY

LITHUANIAN'S INFORMATIVE INVENTORY REPORT 2011

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

Vilnius 2012

CONTENT

List of Figures

List of Tables

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, 2007 – 2011.

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, 2007-2011 was prepared by the expert team from Center for Physical sciences and Technology in co-operation with Air Division specialists, 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 (Tables 1-3; 1-6).

Table 1-3. Definition of Notation Keys

NFR09 code	Substance(s)	Reason for not estimated
1A4b ii	All substances, which reported NE	No activity data
2A5	All substances, which reported NE	No activity data
2A6	All substances, which reported NE	No activity data
2A7	All substances, which reported NE	No activity data
6C	All substances, which reported NE	No activity data
All, except listed above	All substances, which reported NE	No emissions factors

Table 1-4. Explanation to the Notation key IE

NFR09 code	Substance(s)	Included in NFR code
NFR code	Substance(s)	Included in NFR code
1A3a ii (i)	All substances, which reported IE	1A3a ii (ii)
1A4c iii	All substances, which reported IE	1A4c ii
1A5a	All substances, which reported IE	1A4a
1A5b	All substances, which reported IE	1A4a

Table 1-5. Sub-sources accounted for in reporting codes

NFR09 code	Substance(s) reported	Sub-source description
1 A 2 f	Fuel combustion in light industry and constructions	NOx, CO, NMVOC, SOx, NH3, TSP, PM10, PM25, Pb, Cd, Hg, PCB, DIOX, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, As, Cr, Cu, Ni, Se, Zn
1A2a, 1A2b	No activity or process	No substances
1 A 5 a	Stationary in military	NOx, CO, NMVOC, SOx, TSP, PM10, PM25, Pb, Cd, Hg, PCB, DIOX, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, As, Cr, Cu, Ni, Se, Zn
1 A 5 b	Mobile in military	NOx, CO, NMVOC, SOx, TSP, PM10, PM25, Pb, Cd, Hg, PCB, DIOX, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, As, Cr, Cu, Ni, Se, Zn

1 B 1 c	No activity or process	No substances
1 B 3		
2 A 7 d	Quarrying and mining of minerals, construction and demolition	No substances
2 B 5 a	Sulfuric acid, phosphate fertilizers, ammonium nitrate, urea, formaldehyde, polyethylene, polyvinylchloride, polypropylene, polystyrene, other chemicals production	NOx, CO, NMVOC, SOx, NH3, TSP, Hg
2 B 5 b		
2 C	No activity or process	No substances
2 G	No activity or process	No substances
3 A 3		No substances
4B2	No activity or process	No substances
4 B 13	No activity or process	No substances
4 G	No activity or process	No substances
4F	No activity or process	
6 D	No activity or process	No substances
7 A	No activity or process	No substances
7 B	No activity or process	No substances
11 C	No activity or process	No substances

Table 1-6. Basis for estimating emissions from mobile sources. Please tick off with X.

NFR09 code	Description	Fuel sold	Fuel used
1 A 3 a i (i)	International aviation (LTO)	X	

1 A 3 a i (ii)	International aviation (Cruise)	X	
1 A 3 a ii (i)	1 A 3 a ii Civil aviation (Domestic, LTO)		X
1 A 3 a ii (ii)	1 A 3 a ii Civil Aviation (Domestic, Cruise)		X
1A3b	**Road transport**	X	
1A3c	Railways		X
1A3di (i)	International maritime navigation	X	
1A3di (ii)	International inland waterways		
1A3dii	National navigation	X	
1A4ci	Agriculture		X
1A4cii	Off-road vehicles and other machinery		X
1A4ciii	National fishing	X	
1 A 5 b	Other mobile (Including military)		X

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 1-7. NFR codes of Key source categories are listed in the second columns of Table 1-7 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 1-7. Key source analysis for main pollutants 2011.

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 1-8). As a result, we assessed usage of notation key 'NE' influence to the key source analysis by main pollutants.

Table1-8. 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 were 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.

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.

---

* 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)

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.

1.7 Gothenburg protocol (GP)

The 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone The Executive body adopted the Gothenburg protocol (GP) on 30 November 1999. The Protocol entered into force on 17 May 2005. The objective of the 1999 Protocol was to control and reduce emissions of sulphur, nitrogen oxides, ammonia and volatile organic compounds that are caused by anthropogenic activities and are likely to cause adverse effects on human health, natural ecosystems, materials and crops, due to acidification, eutrophication or ground-level ozone as a result of long-range transboundary atmospheric transport. Once the Protocol is fully implemented, Europe's sulphur emissions should be cut by at least 63%, its NOx emissions by 41%, its VOC emissions by 40% and its ammonia emissions by 17% compared to 1990.

In May 2012 the protocol was amended to include, amongst other changes, new emission reduction commitments for 2020 for NO_x, NMVOC, SO_x, NH_3 and also $PM_{2.5}$. The amended protocol has not yet entered into force.

Changes in acidification, eutrophication and ground level ozone from the base year (2005) to the target year of the revised Gothenburg Protocol (2020) The revised Gothenburg Protocol defines emission reduction targets for 2020 with respect to 2005. For the first time, emission reduction commitments for fine particulate matter are included. In total, the emissions for the member states of the EU are expected to decline by 59% (SO_x), 42% (NO_x), 28% (NMVOC), 6% (NH_3) and 22% (PM) between 2005 and 2020.

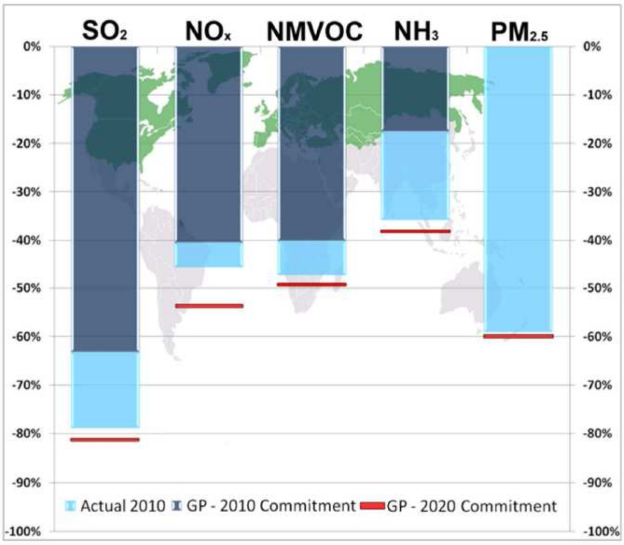

Fig. 1-7. Emission reduction targets for 2010 of the original Gothenburg Protocol compared to new 2020 commitments

Thirty-tree Parties* to the Convention have defined 2010 targets of NO_x, SO_x, NMVOC and NH_3 in the GP. Comparing the reported emissions with the 2010 ceilings, it seems that the total reduction targets for individual pollutants were reached at least for the group of countries, which ratified the GP. However, figures

* Parties with 2010 GP targets: Armenia, Austria, Belgium, Bulgaria, Belarus, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Liechtenstein, Lithuania, Luxembourg, Latvia, the Republic of Moldova, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, the United Kingdom and the Ukraine.

indicate that a number of countries were not fully successful in reducing their emissions and did not reach their individual ceilings.

NO_x emissions: 21 countries reported 2010 emissions lower than their GP targets. Twelve countries missed their NO_x GP targets: Luxembourg (+320%), Austria (+75%), Liechtenstein (+71%), France (+26%), Belgium (+22%), Germany (+22%), Norway (+18%), Ireland (+16%), Sweden (+9%), the Netherlands (+4%), Spain (+4%) and Denmark (+1%).

NO_x	2010 emissions [Gg]	GP ceilings [Gg]	Distance to ceiling
Belgium	221	181	22%
Bulgaria	115	266	-57%
Croatia	71	87	-19%
Cyprus	18	23	-22%
Czech Republic	239	286	-16%
Denmark	129	127	1%
Finland	167	170	-2%
France	1,080	860	26%
Germany	1,323	1,081	22%
Hungary	162	198	-18%
Latvia	34	84	-60%
Lithuania	58	110	-47%
Luxembourg	46	11	320%
Netherlands	276	266	4%
Norway	184	156	18%
Portugal	186	260	-28%
Romania	272	437	-38%
Slovakia	89	130	-32%
Slovenia	45	45	0%
Spain	890	847	5%
Sweden	161	148	9%
Switzerland	79	79	0%
United Kingdom	1,106	1,181	-6%
United States of America	—	6,897	—
EU-15	7,219	6,671	8%

NMVOC	2010 emissions [Gg]	GP ceilings [Gg]	Distance to ceiling
Belgium	105	144	-27%
Bulgaria	91	185	-51%
Croatia	76	90	-15%
Cyprus	11	14	-19%
Czech Republic	151	220	-31%
Denmark	86	85	1%
Finland	116	130	-10%
France	852	1,100	-23%
Germany	1,053	995	6%
Hungary	109	137	-21%
Latvia	65	136	-52%
Lithuania	69	92	-25%
Luxembourg	9	9	-2%
Netherlands	151	191	-21%
Norway	140	195	-28%
Portugal	175	202	-13%
Romania	445	523	-15%
Slovakia	62	140	-55%
Slovenia	35	40	-13%
Spain	656	669	-2%
Sweden	197	241	-18%
Switzerland	89	144	-38%
United Kingdom	789	1,200	-34%
United States of America	—	4,972	—
EU-15	5,670	6,600	-14%

SO_x	2010 emissions [Gg]	GP ceilings [Gg]	Distance to ceiling
Belgium	67	106	-37%
Bulgaria	387	856	-55%
Croatia	41	70	-41%
Cyprus	22	39	-43%
Czech Republic	170	283	-40%
Denmark	14	55	-74%
Finland	67	116	-42%
France	262	400	-35%
Germany	449	550	-18%
Hungary	32	550	-94%
Latvia	3	107	-97%
Lithuania	38	145	-74%
Luxembourg	2	4	-45%
Netherlands	34	50	-32%
Norway	19	22	-12%
Portugal	67	170	-61%
Romania	372	918	-59%
Slovakia	69	110	-37%
Slovenia	10	27	-62%
Spain	435	774	-44%
Sweden	34	67	-49%
Switzerland	13	26	-51%
United Kingdom	406	625	-35%
United States of America	—	16,013	—
EU-15	2,405	4,059	-41%

NH_3	2010 emissions [Gg]	GP ceilings [Gg]	Distance to ceiling
Belgium	69	74	-7%
Bulgaria	51	108	-53%
Croatia	37	30	25%
Cyprus	5	9	-41%
Czech Republic	69	101	-32%
Denmark	75	69	8%
Finland	37	31	20%
France	645	780	-17%
Germany	548	550	0%
Hungary	65	90	-27%
Latvia	17	44	-61%
Lithuania	30	84	-64%
Luxembourg	5	7	-32%
Netherlands	122	128	-5%
Norway	23	23	-1%
Portugal	48	108	-56%
Romania	161	210	-23%
Slovakia	24	39	-37%
Slovenia	17	20	-13%
Spain	368	353	4%
Sweden	52	57	-9%
Switzerland	63	63	-1%
United Kingdom	284	297	-4%
EU-15	2,867	3,129	-8%

Distance of 2010 SO_x and NH_3 emissions (reported in 2012) to the Gothenburg Protocol ceilings

Fig. 1-7. Distance of 2010 NO_x, SO_x, NMVOC and NH3 to the GP ceilings

NMVOC emissions: GP targets for NMVOC were reached by almost all countries except for three: Germany (+6%), Denmark (+1 %) and Spain (only +0.3 % when considering only emissions reported for the EMEP grid domain).
SO_x emissions: All countries reported 2010 emissions lower than their GP targets.
NH_3 emissions: 28 countries reported 2010 emissions lower than their GP targets and seven countries reported emissions higher that their emission ceilings (Figure 3.2): Liechtenstein (+80%), Croatia (+25%), Finland (+20%), Denmark (+8%) and Spain (+4%).

This has lead to a major improvement in risk damage of acidification to ecosystems all over Europe. In 1990, 33% of the ecosystem area in Europe was at risk. In 2010, the unprotected area has decreased to 5% for Europe.

The newly revised GP includes national emission reduction commitments for the main air pollutants to be achieved in 2020 and beyond. The revised GP includes, for the first time, emission reduction commitments for fine particulate matter, the pollutant whose ambient air concentrations notoriously exceed air quality standards throughout Europe.

For 2020, the percentage reductions with respect to 2005 defined in the revised GP has been applied, see Table 1-7-1. For the 2020 run, ship emissions have been kept on the level of 2010 in order to estimate the effect of the redutions in the revised GP alone.

Table 1-7-1. 2005 emission levels (expressed in thousands of metric tonnes) and national emission reduction commitments in 2020 and beyond (expressed as percentage reduction from 2005 levels)

	SO2		NOX		NH3		VOC		PM 2.5	
	Emission levels 2005	Reduction from 2005 level	Emission levels 2005	Reduction from 2005 level	Emission levels 2005	Reduction from 2005 level	Emission levels 2005	Reduction from 2005 level	Emission levels 2005	Reduction from 2005 level
Belarus	79	20%	171	21%	136	7%	349	15%	46	10%
Croatia	63	55%	81	31%	40	1%	101	34%	13	18%
Norway	24	10%	200	23%	23	8%	218	40%	52	30%
Switzerland	17	21%	94	41%	64	8%	103	30%	11	26%
Austria	27	26%	231	37%	63	1%	162	21%	22	20%
Belgium	145	43%	291	41%	71	2%	143	21%	24	20%
Bulgaria	777	78%	154	41%	60	3%	158	21%	44	20%
Cyprus	38	83%	21	44%	5.8	10%	14	45%	2.9	46%
Czech Rep.	219	45%	286	35%	82	7%	182	18%	22	17%
Denmark	23	35%	181	56%	83	24%	110	35%	25	33%
Estonia	76	32%	36	18%	9.8	1%	41	10%	20	15%
Finland	69	30%	177	35%	39	20%	131	35%	36	30%
France	467	55%	1,430	50%	661	4%	1,232	43%	304	27%
Germany	517	21%	1,464	39%	573	5%	1,143	13%	121	26%
Greece	542	74%	419	31%	68	7%	222	54%	56	35%
Hungary	129	46%	203	34%	80	10%	177	30%	31	13%
Ireland	71	65%	127	49%	109	1%	57	25%	11	18%
Italy	403	35%	1,212	40%	416	5%	1,286	35%	166	10%
Latvia	6.7	8%	37	32%	16	1%	73	27%	27	16%
Lithuania	44	55%	58	48%	39	10%	84	32%	8.7	20%
Luxemburg	2.5	34%	19	43%	5.0	1%	9.8	29%	3.1	15%
Malta	11	77%	9.3	42%	1.6	4%	3.3	23%	1.3	25%
Netherlands	65	28%	370	45%	141	13%	182	8%	21	37%
Poland	1,224	59%	866	30%	270	1%	593	25%	133	16%
Portugal	177	63%	256	36%	50	7%	207	18%	65	15%
Romania	643	77%	309	45%	199	13%	425	25%	106	28%
Slovakia	89	57%	102	36%	29	15%	73	18%	37	36%
Slovenia	40	63%	47	39%	18	1%	37	23%	14	25%
Spain	1,282	67%	1,292	41%	365	3%	809	22%	93	15%
Sweden	36	22%	174	36%	55	15%	197	25%	29	19%
UK	706	59%	1,580	55%	307	8%	1,088	32%	81	30%
Eu[a)]	7,828	59%	11,355	42%	3,813	6%	8,842	28%	1,504	22%

a) The sum of the exact emission levels in 2005 by EU Member States, as reported

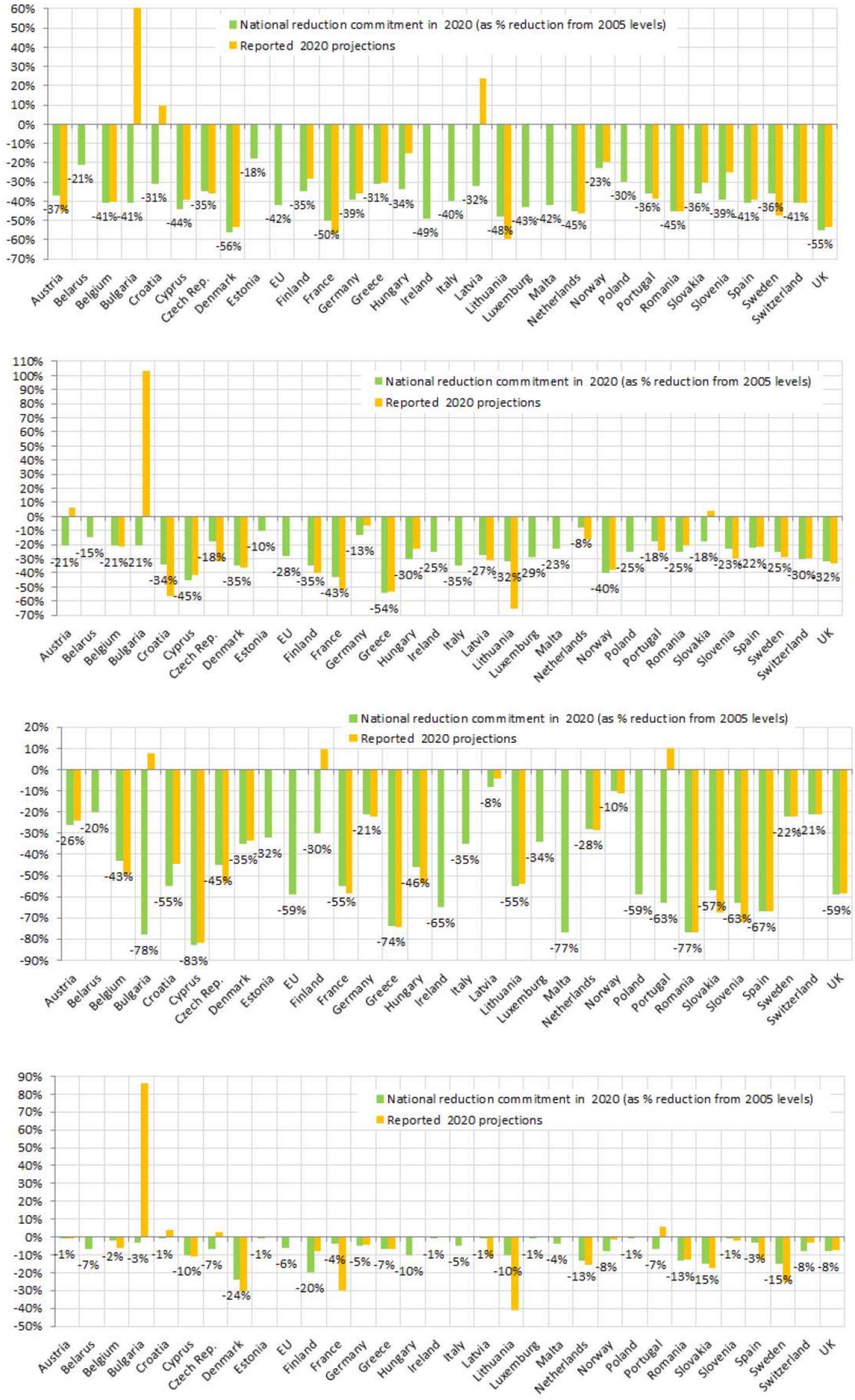

Fig. 1-7-1. Comparison of national NO_x, NMVOC, SO_x and NH3 reduction commitments with reported 2020 projections

1.7.1 **NO_x**

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

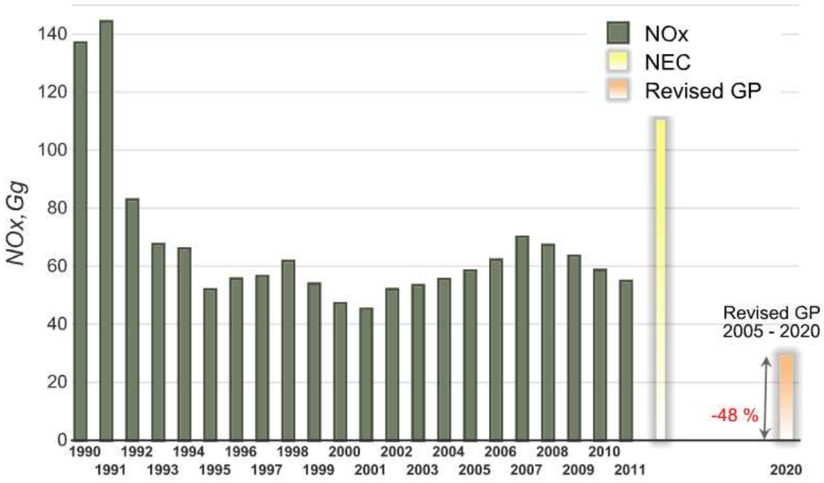

Figure 1-6-1. National total emission trend for NO_x, 1990-2011

1.7.2. **NMVOC**

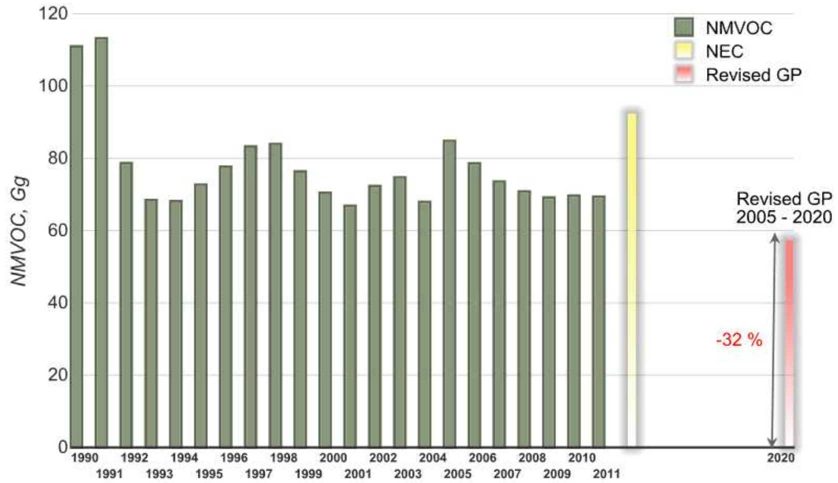

Figure 1-6-2. National total emission trend for NMVOC, 1990-2011

1.7.3. **SO_2**

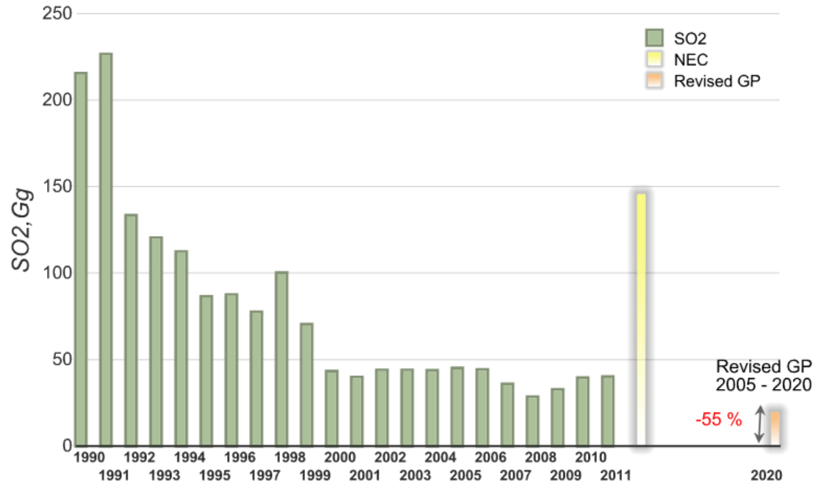

Figure 1-6-3. National total emission trend for SO_2, 1990-2011

1.7.4. **NH_3**

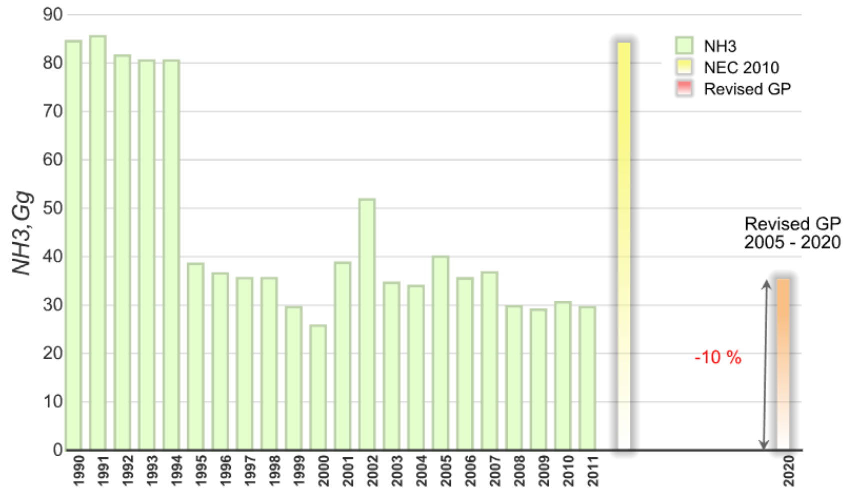

Figure 1-6-4. National total emission trend for NH_3, 1990-2011

1.8 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).

1. ENERGY

NFR 1.A.1.a Public electricity and heat production includes pollutants emission data from large point sources (LPS) reported by operators and from diffuse sources.

NFR 1.A.1.b Petroleum refining**.** Emissions are calculated on the basis of measurements or the combined method by producers (ORLEN Lietuva) (measurements plus calculations).

NFR 1.A.1.c The manufacture of solid fuels includes fuel data reported by statistics Lithuania.

2.1. Public electricity and heat production (1.A.1.A)

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 economic crisis, which slightly reflected in the country's emissions.

2.1.1. Source category description

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 EPA under Ministry of Environment. Emissions from area sources are estimated according to statistical fuel consumption data (Statistics Lithuania).

2.1.2 Methodological issues

The Tier 2 approach was appliesd with the activity data and the country-specific emission factors according to a country's fuel usage and installed combustion technologies.

2.1.3. Emission factors

Country-specific emission factors (see ANNEX 1) for SO_x, NO_x, CO, NMVOC, NH_3, 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.

2.1.4. Uncertainty

The uncertainty in national fuel combustion is 2 %. Monte Carlo methos was applied to evaluate the uncertainty of emission factors.

2.2. Petroleum refining (1.A.1.B)

Refineries process crude oil into a variety of hydrocarbon products such as gasoline, kerosene and etc. UAB ORLEN Lietuva[1] is the only petroleum refining company operating in the Baltic States. Oil refinery processes approximately 10 million tons of crude oil a year. The company is the most important supplier of petrol and diesel fuel in Lithuania, Latvia and Estonia. Motor gasoline, jet kerosine, gas/diesel oil, residual fuel oil, LPG and non-liquefied petroleum gas used in Lithuania are produced by the oil refinery UAB ORLEN Lietuva. Imports of the fuels specified above comprise only a minor fraction of the fuels used in Lithuania.

2.3. Manufacture of solid fuel and other energy industries (1.A.1.C)

[1] http://www.orlenlietuva.lt

Emissions in this sector arise from fuel combustion in manufacturing of solid fuels and other energy industries.

2.4. Methodological issues and emission factors

2.4.1. 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 2-9 and 2-10).

Table 2-9. 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 2-10. 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 2-11).

Table 2-11. 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 2-12). Moreover, different transport means are distinguished: motor cars, railways, water transport, air transport and agricultural machines.

Table 2-12. 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.

2.4.2. 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 2-13).

Table 2-13. 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

2.4.3. PAH and other POP's

Emission factors for PAH were derived from [10] reference, resulting emission factors are reported in Table 2-14. Emission factors for dioxins/furans were taken from [6] reference and emission factors for PCB's were taken from [9] reference (Table 2-14).

Table 2-14. 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 2-15. 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

2.5. Manufacturing Industries and Construction (1.A.2)

Emissions from 1.A.2 sector are calculated using fuel consumption data from the Statistics Lithuania and some industrial manufactures prepared within Annual questionnaires.

2.5.1. Iron and steel (1.A.2.a)

There is no iron and steel industry in Lithuania. All emissions are reported as not occurring.

2.5.2. Non-Ferrous Metals (1.A.2.b)

There is non-ferrous metals industry in Lithuania. All emissions are reported as not occurring.

2.5.3. Chemicals (1.A.2.c)

The chemical industry is the second largest manufacturing industry in Lithuania. It produces a number of different products such as chemicals, plastics, solvents, petrochemical products, cosmetics etc. During the latter decade it has been noticed an intensive development of this industry. Natural gas is the main fuel used in chemical industry in Lithuania. During 1990-2011 periods it has contained 85-99% of total fuel used in industry.

2.5.4. Pulp, Paper and Print (1.A.2.d)

The pulp, paper and print industry is an important branch of manufacturing industry in Lithuania.

2.5.5. Food Processing, Beverages and Tobacco (1.A.2.e)

Food processing, beverages and tobacco industry has old traditions in Lithuania. Currently this branch of the manufacturing industry consists of the following important structural parts – production of meet and its products, preparation and processing of fish and its products, preparation, processing and preservation of fruits, berries and vegetables, production of dairy products, production of grains, production of strong and soft drinks as well tobacco. During economic crisis the decline rates have been the lowest (3,9% a year). During the last decade food processing industry has passed a rapid restructuring process, when number of active economic entities in the main branches of food industry (except in fruit and berries industry) has noticeably decreased. However, the share of large companies has increased.

2.5.6. Source-specific planned improvements

No source-specific improvements have been planned

2.6. TRANSPORT (1.A.3)

2.6.1 Source category description

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.

2.6.2. Road transport (1.A.3.b)

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.

2.6.2.1. 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 2-16.

Table 2-16. 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 2-17).

Table 2-17. 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 2-18 - 2-22.

Table 2-18. 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 2-19. 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 2-20. 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 2-21. 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 2-22. 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

2.6.2.2.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 2-23.

Table 2-23. 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 2-24). LPG doesn't contain heavy metal; therefore there are no heavy metals emissions from road transport using LPG.

Table 2-24. 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

2.5.2.3. 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 2-25. 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 2-25. 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

2.6.2.4. Gasoline evaporation (1A.3.2.5).

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 2-26).

Table 2-26. 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

2.6.2.5. 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 2-27) is used as activity rates for estimating tyre, brake wear and road abrasion emissions.

Table 2-27. 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 2-28, 2-29, 2-31. $PM_{2.5}$ emission factors were taken from [7] reference and reported in Table 2-30.

Table 2-28. 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 2-29. 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 2-30. $PM_{2.5}$ 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 2-31. 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

2.6.2.6. Source-specific planned improvements

No source-specific improvements have been planned

2.7 Aviation (1.A.3.a.i-ii)

2.7.1. Source category description

The present-day Vilnius International Airport is a state owned enterprise under the Ministry of Transport and Communications. It is the largest of the four major airports in Lithuania by passenger traffic.

Lithuanian Airlines (branded later as FlyLAL) was established as the Lithuanian flag carrier following independence in 1991 and inherited the Vilnius-based Aeroflot fleet of Tupolev Tu-134, Yakovlev Yak-40, Yak-42 and Antonov An-24, An-26 aircraft, but rapidly replaced these Soviet-era aircraft types with modern Boeing 737 and Boeing 757 jets and Saab 340, Saab 2000 turboprops. Operations were suspended effective 17 January 2009 as a result of growing financial difficulties. With the collapse of FlyLAL, the airport lost its scheduled services to Amsterdam, Budapest, Istanbul, Madrid and Tbilisi. FlyLAL used to operate to Dublin, Frankfurt, London, Milan and Paris in competition with Aer Lingus, airBaltic or Lufthansa.

In 2010, the number of take-offs and landings at Lithuanian airports by aircraft of both Lithuanian and foreign airlines amounted to 37.7 thousand, which is by 20.6 per cent more than in 2009. The number of take-offs and landings by aircraft on commercial flights totaled 35.4 thousand, or 93.8 per cent of all flights. In 2010, the number of passengers who arrived at and departed from Lithuanian airports amounted to 2.3 million, which is by 22.2 per cent more than in 2009. The majority of passengers arrived from and departed to the United Kingdom (20.5 per cent), Germany (12 per cent), Denmark (9.1 per cent), Latvia (8.7 per cent), and Ireland (7.4 per cent). The number of passengers on scheduled flights totalled 2 million, or 88.4 per cent of all passengers, which is by 31.5 per cent more than in 2009. 15.4 per cent of all passengers arrived and departed by the aircraft of Lithuanian airlines.

In 2011, the number of take-offs and landings at Lithuanian airports by aircraft of both Lithuanian and foreign airlines amounted to 39.5 thousand, which is by 4.8 per cent more than in 2010. The number of take-offs and landings by aircraft on commercial flights totalled 37.2 thousand, or 94.2 per cent of all flights.

In 2011, the number of passengers who arrived at and de-parted from Lithuanian airports amounted to 2.7 million, which is by 17.9 per cent more than in 2010. The majority of passen-gers arrived from and departed to the United Kingdom (20.7 per cent), Germany (10.6 per cent), Latvia (8.8 per cent), Denmark (6.6 per cent), and Ireland (6.6 per cent). The number of passengers on scheduled flights totalled 2.4 million, or 90.8 per cent of all passengers, which is by 21.1 per cent more than in 2010. 7.6 per cent of all passengers arrived and departed by the aircraft of Lithuanian airlines.

2.7.2. Emission factors

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 2-32.

Emission factors are presented in ANNEX 1. National emission factors.

Table 2-32. 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

2.7.3. Methodological issues

Emissions calculations from the LTO cycle are based on the Tier 2 method and cruise emission calculations Tier 1 (EMEP/EEA air pollutant emission inventory guidebook 2009). For the LTO phase, fuel consumed and the emissions of pollutants per LTO cycle are based on representative aircraft type group data. The energy use by aircraft is calculated for both domestic and international LTOs by multiplying the LTO fuel consumption (jet fuel and aviation gasoline) factor for each representative aircraft type by the corresponding number of LTOs. In order to calculate domestic and international LTO emissions, the number of LTOs for each aircraft type is multiplied by the respective emissions per LTO.

Emissions calculations from the LTO cycle are based on the Tier 2 method and cruise emission calculations Tier 1 (EMEP/EEA air pollutant emission inventory guidebook 2009).

2.7.4. Source-specific planned improvements

No source-specific improvements have been planned

2.8. Railways (1.A.3.c)

2.8.1. Source category description

In 2011, the operational length of railways amounted to 1767.6 km. The length of electrified lines remained unchanged (122 km).

In 2011, compared to 2010, the number of railway vehicles decreased: that of locomotives – by 2.2 per cent, wagons – by 0.3 per cent, coaches (including diesel and electric railcars) – 20.5 per cent. Most locomotives (77 per cent), 84 per cent of coaches (including diesel and electric railcars) and 93.5 per cent of wagons were produced 15 and more years ago.

In 2011, goods transport by rail amounted to 52.3 million tonnes, which is by 8.9 per cent more than in 2010. National goods transport by rail amounted to 15 million tonnes, which is by 6.6 per cent more than in 2010; international goods transport by rail amounted to 37.3 million tonnes, which is by 9.8 per cent more than in 2010. In 2011, 32.5 per cent of all goods carried (17 million tonnes) were coke and refined petro-leum products. Chemicals, chemical products and man-made fibres, rubber and plastic products, nuclear fuel carried amoun-ted to 14 million tonnes, or 26.7 per cent, metal ores and other mining and quarrying products, peat, uranium and thorium – 5.3 million tonnes, or 10.2 per cent.

The major share of goods was carried from Belarus (64.4 per cent) and Russia (26.9 per cent). Most goods from Lithuania were carried to Latvia (21.4 per cent), Belarus (17.8 per cent), and Ukraine (16.2 per cent).

Tonne-kilometres amounted to 15 088 million, which is by 12.3 per cent more than in 2010. In 2011, the number of passengers carried by rail totalled 4.7 million, which is by 6.7 per cent more than in 2010. In 2011, passenger-kilometres amounted to 389.1 million, which is by 4.3 per cent more than in 2010. In 2011, compared to 2010, national passenger transport increased by 7.6 per cent, international transport – by 3 per cent. In 2011, compared to 2010, the number of arriving passengers increased by 24.2, that of departing passengers – 17.4 per cent. The majority of passengers departed to (48.1 per cent) and arrived from (50.7 per cent) Belarus.

2.8.2. Emission factors

Compound	EF	content	Fuel (diesel oil)
NO_x	1100	g	GJ
CO	470	g	GJ
NMLOJ	225	g	GJ
SO_2	93.68	g	GJ
KD	101.2	g	GJ
KD_{10}	97.2	g	GJ
KD_{25}	91	g	GJ
Cd	0.234	mg	GJ
DIOX	1	ng	GJ
BaP	0.703	mg	GJ
BbF	1.171	mg	GJ
Cr	1.17	mg	GJ
Cu	39.8	mg	GJ
Ni	1.64	mg	GJ
Se	0.234	mg	GJ
Zn	23.4	mg	GJ

2.8.3. Methodological issues

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

$$E_i = FC \cdot EF_i \qquad (2.8.3)$$

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.

2.8.4. Source-specific planned improvements

No source-specific improvements have been planned

2.9. Water borne navigation (1.A.3.d3i, 1.A.3.d3ii)

2.9.1.1 Source category description

The Nemunas River is navigable and used for commercial shipping between Kaunas and the Baltic seaport of Klaipeda, reached through a channel in the Kuronian Bay. East of Kaunas, about 204 km inland from Klaipeda, a hydropower dam with no lock prevents the development of inland shipping upstream.

Figure 2-1. National navigation ways

The channel is marked by navigation markers between Kaunas and the mouth of the river and by navigation lights on the Kuronian Bay. There is little barge traffic on the river, mainly timber and construction materials.

The activity data of national navigation was provided by Statistics Lithuania. International marine bunkers (international navigation) is defined as fuel delivered to ships of all flags that are engaged in international navigation. Fuel consumption by ships engaged in fishing and domestic navigation vessels is excluded (Memo item).

2.9.1. Emission factors

Emissions were calculated according to EMEP/CORINAIR methodology simpler approach.

2.9.2. Methodological issues

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

$$E_i = FC \cdot EF_i \qquad (2.9.3)$$

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.

2.9.3. Source-specific planned improvements

No source-specific improvements have been planned

2.10. Off-road transport

2.10.1. Source category description

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).

2.10.2. Methodological issues

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:

$$E_i = FC \cdot EF_i \qquad (2.10.2)$$

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.

2.10.3. Emission factors

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 2-33.

Table 2-33. 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 (Tables 2-34-35).

Table 2-34. 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 2-35. Particle size distribution, [% PM].

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

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 2-36).

Table 2-36. 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 2-37). These emission factors are used for all off-road transport consuming diesel or gasoline.

Table 2-37. 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

2.10.3. Source-specific planned improvements

No source-specific improvements have been planned

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 were estimated. Derivated emission factors from [18] reference are listed in Table 2-38.

Table 2-38. 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

3.1 Source category description

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.

Dominating industry in Lithuania is manufacturing. Manufacturing constituted 87% of the total industrial production (except construction) in 2011. Four most important sectors within Manufacturing cumulatively produced 78% of production:

- Manufacture of refined petroleum products (~30%);
- Manufacture of food products and beverages (~20%);
- Manufacture of wood products and furniture (~10%);
- Manufacture of chemicals and chemical products (~10%).

3.2 Methodological issues

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.

3.3 Emission factors

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 3-39, 3-40.

Table 3-39. TSP emission factor from industrial process, [g/Mg production].

Process	TSP emission factor
Lime production	2967

Table 3-40. 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

3.4. Source-specific planned improvements

No source-specific improvements have been planned

4. AGRICULTURE

4.1 Source category description

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.

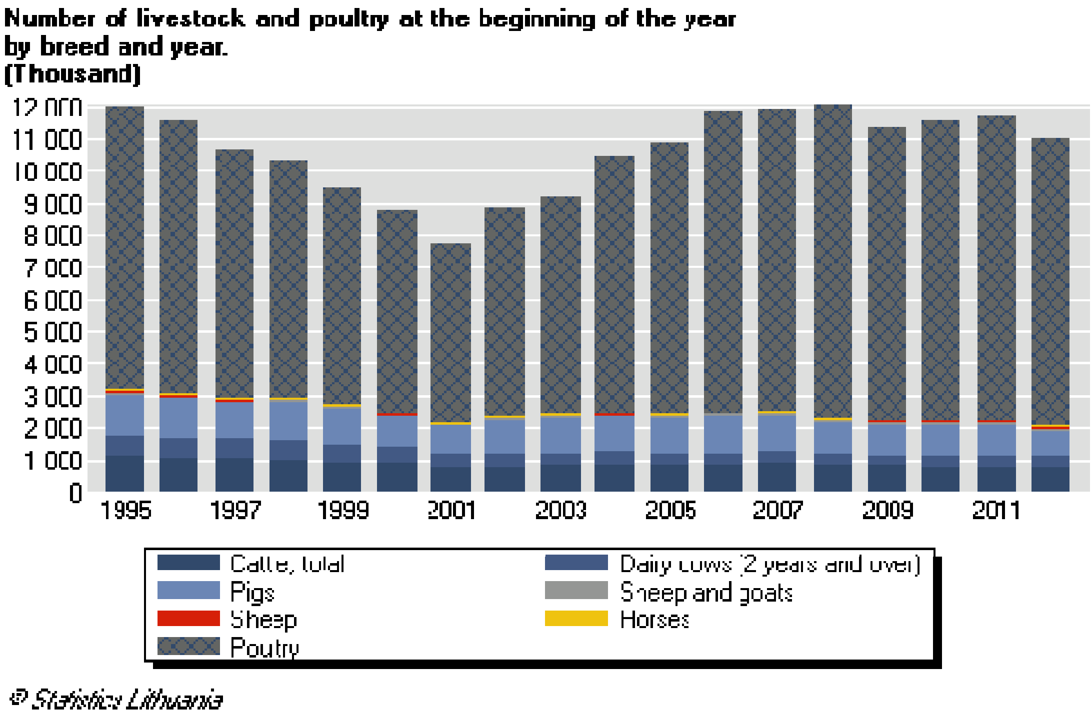

Figure 4-1-1. Number of livestock and poultry

4.2. Manure management

Number of livestock and poultry was taken from Department of Statistics and reported in Table 4-37 [1]. NH3 emission factors for livestock and poultry manure management was taken from literature [5] and used in estimations (Table 4-41, 4-42).

Table 4-41. 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 4-42. 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

4.3. 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 4-43.

Table 4-43. 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

4.4. Application of Mineral Fertilizer

The emission factors for the simple methodology are provided in Table 1-44. These are based largely on the estimates of [12-14].

Table 4-44. 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.

4.5. Source-specific planned improvements

No source-specific improvements have been planned

5. SOLVENT AND OTHER PRODUCT USE

5.1 Source category description

NMVOC emission from industrial and non-industrial paint application, metal degreasing, application of glues and adhesives, dry cleaning, use of domestic solvent were estimated (NFR sector 3).

5.2 Methodological issues

NMVOC emissions were calculated according to EMEP/CORINAIR methodology simpler approach based on per capita data for several source categories. Default per capita emission factors proposed in EMEP/CORINAIR guidebook were used, multiplying them by the number of inhabitants.

Emissions were calculated using annual average population data provided by the Statistics Lithuania (Table 5-45).

Table 5-45. Population and population density, [thous inhabitant].

Population and population density, beginning of the year

	Tūkst. — *Thous.*			Gyventojų skaičius 1 km^2 *Population per 1 km^2*
	iš viso *total*	mieste *urban areas*	kaime *rural areas*	
1990	3693,7	2513,9	1179,8	56,6
1995	3643,0	2458,2	1184,8	55,8
2000	3512,1	2357,1	1155,0	53,8
2005	3425,3	2281,4	1143,9	52,5
2009	3349,9	2240,5	1109,4	51,3
2010	3329,0	2229,5	1099,5	51,0
2011	3244,6	2171,2	1073,4	49,7
2012*	3199,8	2142,8	1057,0	49,0

5.3 Emission factor

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 5-46.

Table 5-46. Solvent and other product use NMLOJ emission factors, [g/inhabitant].

Activity	NMVOC emission factor
Industrial paint application	4500
Non industrial paint application	400
Dry cleaning	313
Metal degreasing	640

Application of glues and adhesives	600
Domestic solvent use	800

5.4. Source-specific planned improvements

No source-specific improvements have been planned

6. WASTE

6.1 Source category description

This chapter covers the NFR source category 6 Waste, including: 6.A Solid Waste Disposal on Land, 6.B Wastewater Handling and 6.C Waste Incineration.

In Lithuania emissions from Waste Sector originate from the following sources:
- solid waste disposal on land (6.A);
- wastewater handling (industrial and domestic/commercial wastewater)(6.B);
- human sewage(6.B.2.2);
- waste incineration (6.C).

Data of waste generation and disposal are collected from 1991, earlier data on waste disposal are not available. Data from 2001 are available on the website of the Lithuanian Environmental Protection Agency (EPA)[2].

Table 6-47. Average composition of MSW in Lithuania

Ingredient	Amount
Plastic	9%
Paper and cardboard	14%
Glass	9%
Metal	3%
Textile	4%
Biodegradable (kitchen) waste	42%
Composite packaging	2%
Construction and demolition waste	4%
Hazardous waste	2%
Leather, rubber	1%
Wood	2%
Sand, sweepings	4%
Other	4%

6.1.1 Solid Waste Disposal on Land (6.A)

No emission factors are available for this source. Small quantities of NMVOC and nitrate compounds are emitted. For NMVOC, US Environmental Protection Agency (USEPA) evaluates that 98.7 % of the landfill gas is methane and 1.3 % are other VOCs such as perchlorethylene, pentane, butane, etc. (USEPA, 1990). Also, PM emissions from waste handling are generated, but no estimate of emission factors is available.

[2]EPA website: http://gamta.lt/

6.2. Waste water handling (6.B)

6.2.1 Source category description

Data of wastewater composition and discharge are collected by the EPA from 1991. There are some very large fluctuations of data in the beginning of the monitoring period. This data was analyzed and some corrections were made.

6.2.2 Methodological issues

The Tier 1 approach for emissions from waste water handling uses the general equation:

$$E_{pollutant} == AR_{production} \times EF_{pollutant} \quad (6.2.2)$$

This equation is applied at the national level. The Tier 1 emission factors assume an averaged or typical technology and abatement implementation in the country and integrate all different subprocesses in the handling of waste water.

6.2.3 Emission factors

A default emission factor for NMVOC emissions from waste water handling has been derived from a Turkish study (Atasoy et al., 2004). This emission factor should be handled with care, since it may not be applicable to all waste water treatment plants. Furthermore, the emission factors reported in literature show a high variation.

Table 6-48. EF of waste water

Emission	Activity data	EF value	Emission factor unit
NH_3	Population using latrines	1.6	kg/pers/year
NMVOC	Amount of waste water produced	15	mg/m^3 waste water

6.3. Waste Incineration (6.C)

6.3.1 Source category description

Emissions from hazardous and clinical/hospital waste incineration without energy recovery are included in this category. Emissions from waste incineration fluctuate quite strongly. There were no dedicated waste incineration facility in Lithuania until 2006 and waste was incinerated on random basis in existing production facilities, which means that decisions on whether to incinerate or not was taken on ad hoc basis, therefore may fluctuate in quite wide range (it is worth noting that the total amount of incinerated waste is very small, even at its maximum).

New hazardous waste incineration facility (with nominal capacity 1000 kg per hour) with capacity 8000 tonnes waste per year was launched in 2010.

Hospital waste incineration facility with nominal capacity 200 kg per hour was put in operation in 2006 in Vilnius (Table 1-45).

6.3.2 Methodological issues

The simpler methodology relies on the use of a single emission factor for each pollutant species combined with a national hospital waste incineration statistic:
Total emission = mass of hospital waste incinerated (tonnes) x overall emission factor (emission per tonne of waste incinerated) (6.3.2)

6.3.3 Emission factors

N.B.: There are no emission factors available for PM2.5. The source is < 0.1 % of the total PM emissions for most countries.

Table 6-49. Activity data of waste, Gg

Year	Hazardous	Clinical Health care	Total
1990	2.43	0.01	2.44
1991	2.63	0.01	2.64
1992	0.73	0.01	1.74
1993	2.12	0.00	2.12
1994	0.64	0.01	0.65
1995	2.48	0.01	2.49
1996	0.83	0.02	0.85
1997	0.81	0.04	0.85
1998	0.78	0.17	0.98
1999	0.34	0.07	0.42
2000	1.12	0.00	1.12
2001	1.43	0.11	1.54
2002	1.35	0.02	1.37
2003	3.66	0.00	3.67
2004	1.86	0.04	1.90
2005	3.33	0.26	3.59
2006	3.09	0.19	3.28
2007	0.18	0.52	0.70
2008	0.02	0.69	0.71
2009	0.01	0.74	0.76
2010	0.82	0.69	1.51

6.4. Source-specific planned improvements

No source-specific improvements have been planned

7. OTHER SOURCES AND SINKS

7.1 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:

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

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:

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

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 7-50. 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 7-51. 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

7.2 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]:

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

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 7-52, 7-53.

Table 7-52. 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 7-53. 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

References

1. Department of Statistics (2012). Agriculture 2011. ISSN 1648-0368, p. 90.
2. Department of Statistics (2012). Fuel and Energy Balance 2011. ISSN 1648-0821, p. 54.
3. Department of Statistics (2012). Industrial Processes 2011. ISSN 1648-5777, p. 140.
4. Department of Statistics (2012). Transport and Communications 2011. ISSN 1648-0279, p. 180.
5. European Environment Agency (2009). EMEP/CORINAIR Emission Inventory Guidebook.
6. Institute of Environmental Protection (2004). Emission Inventory of SO2, NO2, NH3, CO, PM, NMVOC, HM's, and POP's in Poland in 2002.
7. International Institute for Applied Systems Analysis (2002). Modelling Particulate Emissions in Europe.
8. Jaskelevičius. B. (1997) Emision factors of organic fuel combustion products, Vilnius.
9. TNO (1995). TNO-Report TNO-MEP – 95/247: Technical Paper to the OSPARCOM-HELCOM-UNECE Emission Inventory of Heavy Metals and Persistent Organic Pollutants.
10. United States Environmental Protection Agency (1998). Locating and Estimating Air Emissions from Sources of Polycyclic Organic Matter.
11. United States Environmental Protection Agency (1998). Locating and Estimating Air Emissions from Sources of Polycyclic Organic Matter.
12. Asman, W.A.H., 1992. Ammonia emission in Europe: updated emission and emission variations. RIVM report 228471008. RIVM, Bilthoven, The Netherlands;
13. 1ECETOC, 1994. Ammonia emissions to air in western Europe. Technical Report 62. European Centre for Ecotoxicology and Toxicology of Chemicals, Brussels;
14. Sutton M.A., Place C.J., Eager M., Fowler D., Smith R.I. 1995b. Assessment of the magnitude of ammonia emissions in the United Kingdom. Atmospheric Environment 29, 1393- 1411
15. Seiler, W. and P. J. Crutzen, 1980. Estimates of gross and net fluxes of arbon between the biosphere and the atmosphere from biomass burning. Climatic Change 2, 207-247
16. Guenther A. B., P. R. Zimmerman, P. C. Harley, R. K. Monson and R. Fall, Isoprene and Monoterpene Emission Rate Variability – Model Evaluations and Sensitivity Analyses, J. Geophys.Res. Atmos. 98(D7), 12 609–12 617 (1993)
17. Guenther, A., J. Greenberg, D. Helmig, L. Klinger, L. Vierling, P. Zimmerman, and C. Geron (1996) Leaf, branch, stand and landscape scale measurements of volatile organic compound fluxes from U.S. woodlands. Tree Physiology, 16, 17-24.

18. ECOLAS, Devoldere, K., Van Hyfte, A., Callebaut, K. and Vermoote S. (2006). Proposed improvements for the system for emission control in Lithuania".

19. Vilniaus Universiteto Ekologijos institutas, LIETUVOS CORINE ŽEMĖS DANGA-2000, 2004.

20. Valstybinė miškotvarkos tarnyba, Lietuvos miškų ūkio statistika 2007, 2007.

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.
Changes in air concentrations and depositions from year to year are driven by changes in both emissions and meteorology. Between 2009 and 2010, emissions of SO_x,NO_x and NH_3 in the extended EMEP area decreased by 1.2 %, 5.5 % and 0.8 %, respectively. Individual countries have reported much larger changes. 2010 and 2011 was a relatively wet year in large parts of central, south-western and south-eastern Europe, especially in winter. In these areas, depositions slightly increased. In Lithuania 2011 was less emissions, in this reason critical loads was slightly less than in 2010. The calculated exceedances of critical loads and the ecosystem areas at risk in 2010 are presented in Figure 3 in the EMEP domain. In total, depositions of sulphur has decreased by ~1 %, whilst deposition of oxidized nitrogen and reduced nitrogen have decreased by 4 % and 0.6 %, respectively, which is very similar to the emission changes.

Between 2011 and 2010, emissions of SO_x, NO_x and NH_3 in the extended EMEP area decreased with 1.4 %, 6.7 % and 0.3 %, respectively. Due to decrease of emissions alone (excluding the meteorological variability), there were little change in sulphur deposition. Meteorological conditions have a significant effect on air concentrations and depositions of pollutants, controlling their transport, diffusion and dry and wet removal.

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:

$$N_{dep} = N_i + N_u + N_{de} + N_{le} \,. \tag{2}$$

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, $CL_{nut}(N)$:

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

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):

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

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:

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

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

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

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}:

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

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 into account.

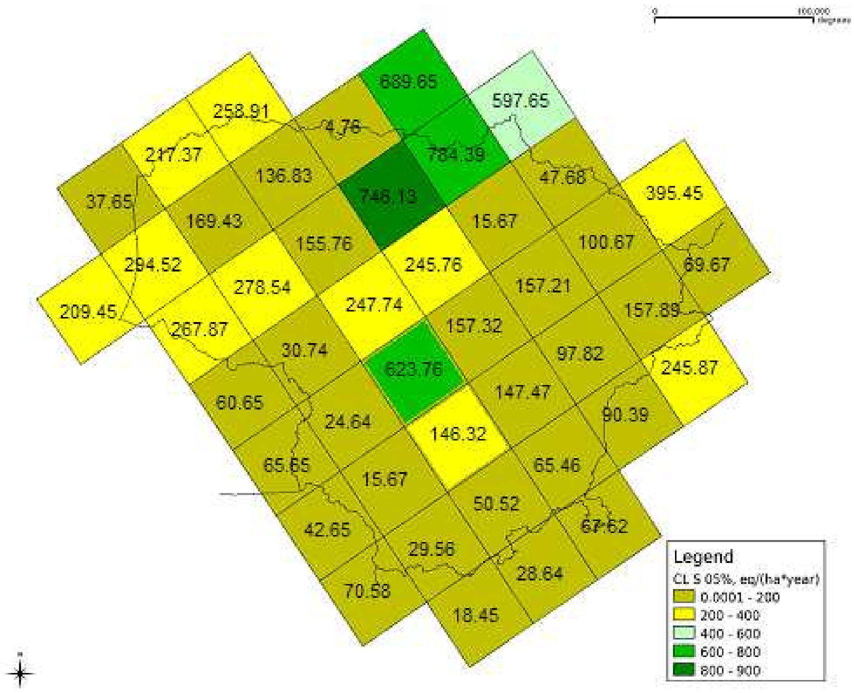

Fig. 3-1. Critical loads of oxidized sulphur (50×50 km^2), $eq \cdot ha^{-1} yr^{-1}$.

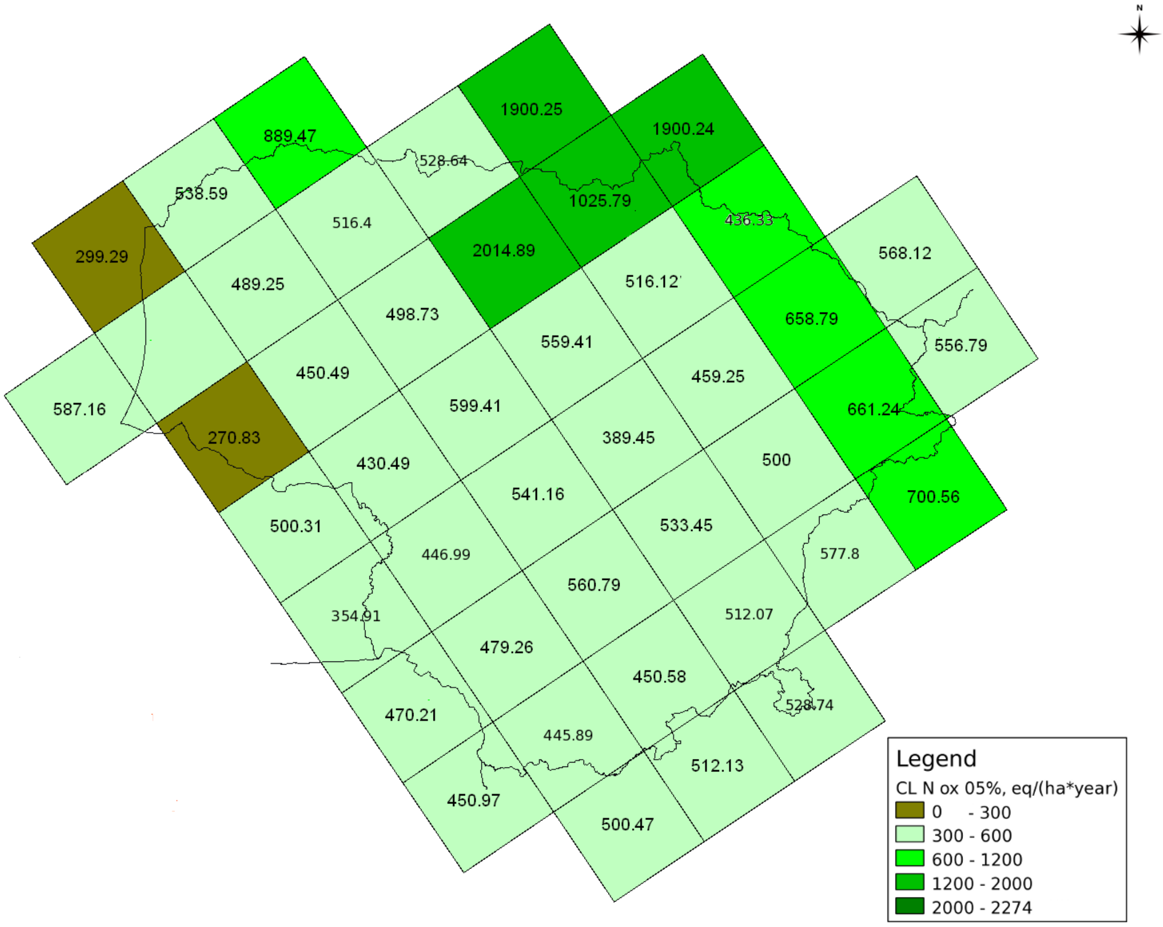

Fig. 3-2. Critical loads of oxidized nitrogen (50×50 km^2), eq·ha^{-1}yr^{-1}.

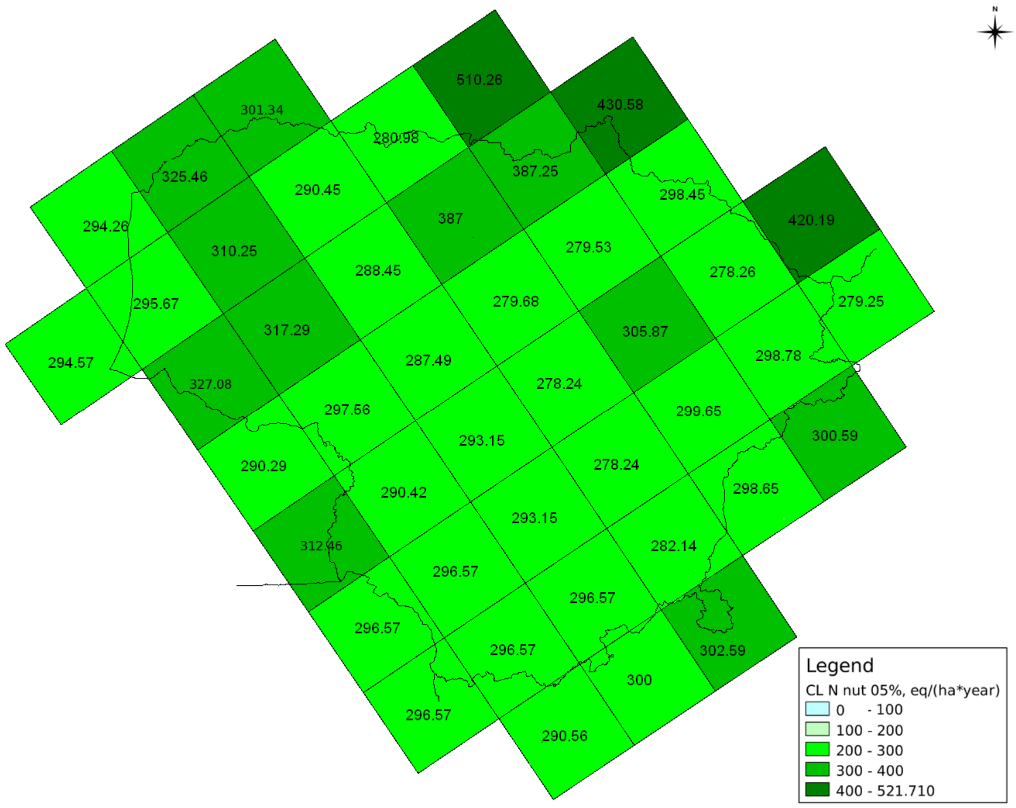

Fig. 3-3. Critical loads of nutrient nitrogen (50×50 km^2), eq·ha^{-1}yr^{-1}.

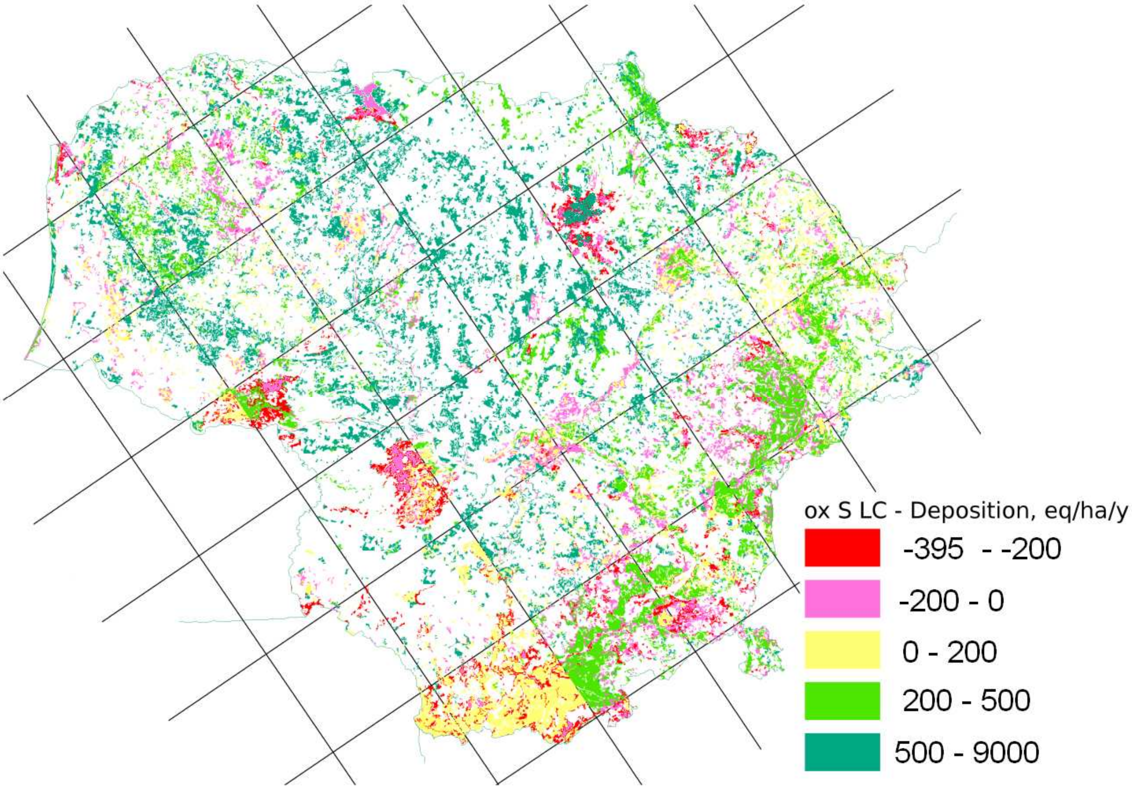

Fig. 3-4. Difference of critical loads and deposition of oxidized sulphur; negative values represent exceedances of critical load (50×50 km^2), eq·ha^{-1}yr^{-1}.

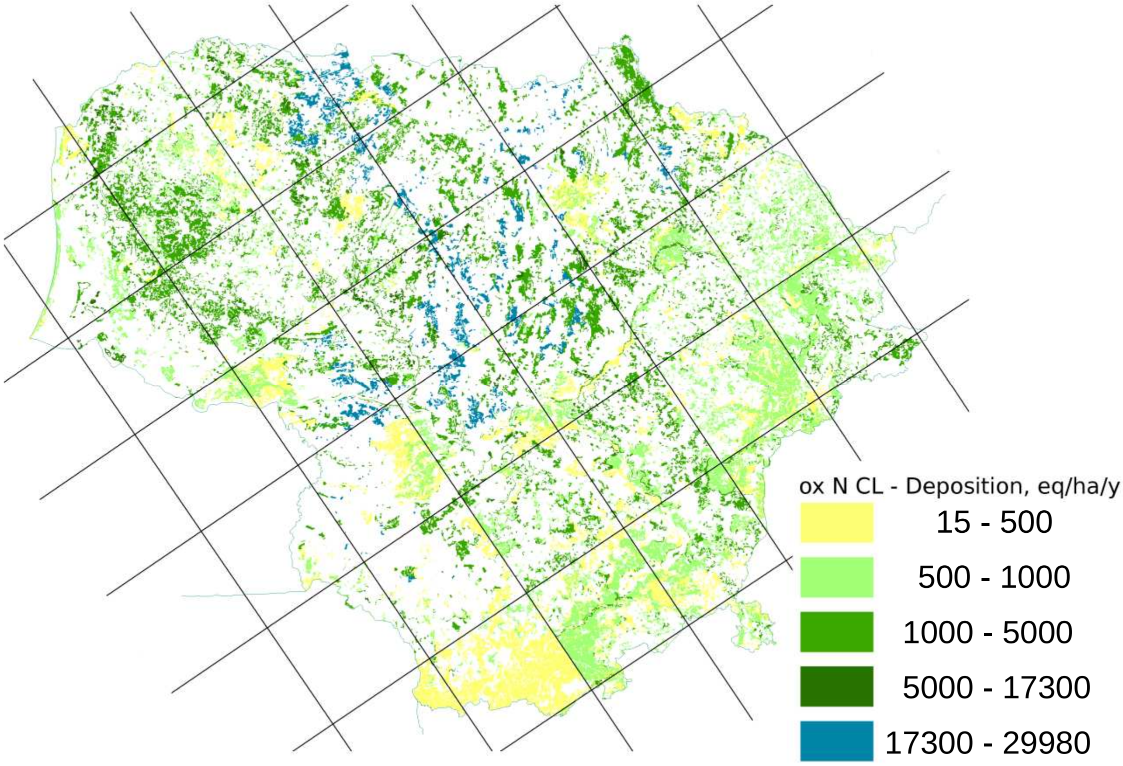

Fig. 3-5. Difference of critical loads and deposition of oxidized nitrogen; negative values represent exceedances of critical load (50×50 km^2), eq·ha^{-1}yr^{-1}.

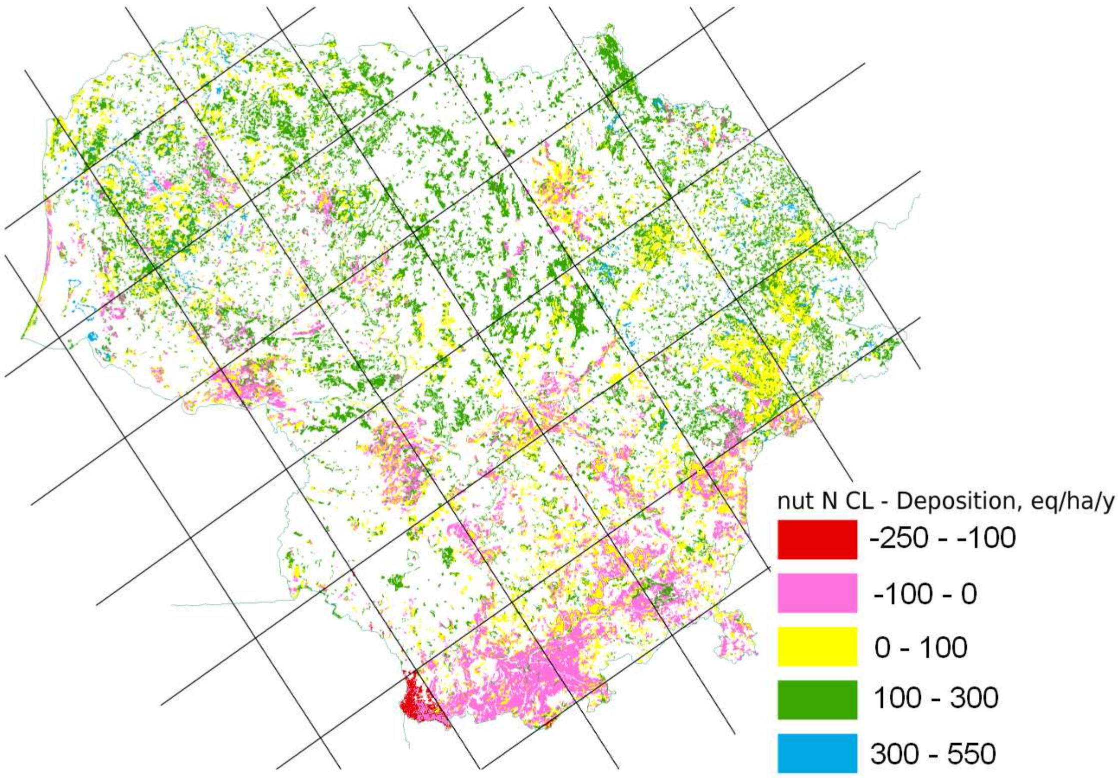

Fig. 3-6. Difference of critical loads and deposition of nutrient nitrogen; negative values represent exceedances of critical load (50×50 km^2), eq·ha^{-1}yr^{-1}.

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. 3-1). 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 0 to 2274 eq·ha^{-1}yr^{-1}(Fig. 3-2). The lowest critical load values of oxidized nitrogen were calculated for the southern part of Lithuania.

Critical load values of nutrient nitrogen varied from 0 to 521.71 eq·ha^{-1}yr^{-1}. Fig. 3-3 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 (-395 – 9000 eq·ha^{-1}yr^{-1}) are shown in the Fig. 3-4. 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 (15 – 29980 eq·ha^{-1}yr^{-1}) are shown in the Fig. 3-5. 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 (-250 – 550 eq·ha^{-1}yr^{-1}) are shown in the Fig. 3-6. 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.

References

De Vries, W., Posch, M., Reinds, G.J., Kämäri, J. (1993). Critical loads and their exceedance on forest soils in Europe, Report, 58, DLO Winand Staring Centre, Wageningen, The Netherlands, 116.

De Vries, W., Reinds, G.J. and Posch, M. (1994). Assessment of critical loads and their exceedances on European forests using a one-layer steady-state model, Water, Air and Soil Pollution, 72, 357 – 394.

De Vries, W., Kros, J., Reinds, G.J., Wamelink, W., van Dobben, H., Bobbink, R., Emmett, B., Smart, S., Evans, Ch., Schlutow, A., Kraft, P., Belyazid, S., Sverdrup, H., van Hinsberg, A., Posch, M., & Hettelingh, J.P. (2007). Developments in modelling critical nitrogen loads for terrestrial ecosystems in Europe, Alterra Report 1382, Wageningen, The Netherlands, 206 pp.

Dutch, J. and Ineson, P. (1990). Denitrification of an upland forest site, Forestry, 63, 363 – 377.

Hettelingh J.-P., Posch M., Slootweg J. (2009). Critical Load, Dynamic Modelling and Impact Assessment in Europe. CCE Status Report 2008. ISBN: 978-90-6960-211-0, 232 p. (http://www.rivm.nl/bibliotheek/rapporten/500090003.pdf)

UNECE (2005). Emission inventories and projections, progress report by the Co-Chairs of the Task Force, prepared in consultation with the secretariat. Draft methods and procedures for the technical review of air pollutant emission inventories reported under the Convention and its protocols, EB.AIR/GE.1/2005/7 (http://www.unece.org/env/eb/welcome.html).

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 %